Resource Inquiry Accounting

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Abstract

All socio-technical platforms must account for resources. When engineering anything, its object composition, and the composition of the environment where objects are distances from one another, must be accounted for. Resources are one necessary element for which to account when planning a project and operationalizing a product. Resources are accounted for through a global resource survey. In the market, resources are property. Spatial resources (true resources) are objects (i.e., made of matter/shape). Informational "resources" (digital resources) are data (i.e., made of bits). Human "resources" (contributors) are individuals (i.e., made of consciousness). Consciousness uses spatial and informational resources in order to sustain its embodiment and to develop itself.

Graphical Abstract

Image Not Yet Associated

1 Resource accounting and inquiry

NOTE: *A failure to plan for resource use can be oppressive, if not fatal to individuals and the planet.*

Daily activities in a habitat involve resource movements (i.e., the movement of objects in and through habitats, and therein, through peoples' usage/consumption). Resource Inquiry represents the continuous process of accounting for [the qualities and qualities of] common heritage resources (materials) by surveying the habitat for all their existence in real-time (when possible). This general process is known as **resource accounting** and it is an inquiry into the resources themselves: their qualities and quantities; their location (and proximity to need); and their strategic availability. There exists an [systems] environment of resources that may be accounted for. This inquiry involves a system of teams and information sensors (detectors and instruments) with the purpose of monitoring and tracking the location, consumption and regeneration rates, and the trending availability of resources. Resources are a physical referent and a calculable source of information (e.g., a community can calculate the most abundant mineral with the greatest conductivity for a particular engineering purpose). The qualities of resources must be defined if they are to be accounted for accurately in our information system. During the resource inquiry process 'resource surveys' lead to 'resource inventories' that represent the available resources for fulfillment of the community's needs. The resource inquiry process determines the **availability** of a resource through a continuous global-community surveying of resources. Resources are transformed and transported.

A simplistic view of the resource accounting system is:

1. What resources are required?
2. What resources are available?
3. What resources will be or should be available?

It is essential to monitor resources appropriately as they move through the habitat as:

1. Raw resources.
2. Intern assembled product ("means of production").
   A. Assembles final production products.
3. Final assembled user product (habitat|personal / common) for the different sectors of the economy/ habitat.
   A. Final product.

If resources are to be applied toward the efficient and responsible (i.e., sustainable) lifecycle of goods and services, then an accurate accounting of resources is a requirement. If the community does not know what resources it has, then how can the community take commonly agreed upon action? How will it achieve Strategic Access to goods and services? Only after a community has an *accurate account* of resources and information pools, then it can begin arriving at *accurate* economic decisions (i.e., this is a basis of a resource-based economy). Hence, decision alternatives (and actions) become available only when their corresponding resources are known and available. In other words, tasks become viable when their required resources are available.

This is an inquiry into the **resource availability** of a solution's resource requirements. Here, the rates of resource usage and regeneration are tracked and trended to remain in a state of dynamic equilibrium with our environment. If resources are consumed faster than they are regenerated, then the system is functionally unsustainable. A sustainable community must know, at least:

1. What options are available with the resources that are available? What are the possibilities for using the resources currently available?
2. Have different plans been developed to show alternative usages for the available resources?
3. What plans for resources are being developed simultaneously?
4. What resources are required?
5. What are the substitutable resources?
6. What resources are available?
7. What resources will be available?
8. When will resources be available?
9. What are the qualities of the resources?

Nature, the Earth, is a finite and increasingly knowable sum. Unless we conserve the planet there isn't going to be any "the economy". Nature provides all kinds of services that are essential to the planet and to our survival. These services and their total relationship in an ecological system must be accounted for in any valid economic system. Such services are not "externalities", they are "essentials".

Resources and their usage when handled improperly by a civilization can culminate in some large problems despite technological advancement. In community we do not structure the flow of our material resources into "waste dumps" and "trash tips". Once again it must be said that, a system is what it does, not what we want it to do. If a system produces an accumulation of waste, then it is doing so through a [constructed] design.

We exist in some form of symbiotic relationship with our natural environment. This is an essential understanding for a community of humans driven toward a more meaningful purpose, their betterment. We exist in an interrelationship with the many [symbiotic organisms that inhabit Earth] from which our community is derived through availability and access to resources.

The resource inquiry system functions to:

1. Account for common heritage resource by recognizing their Habitat System's allocation, their access designation, and their location. Where is the resource located?
2. Identify what effort of expenditure will be required to transport the resource to where it is required? This question involves the field of study and inquiry known as [energy] 'logistics'.
3. Identify the [comparative] qualities of each resources?
4. Identify whether a particular resource meets the qualities required of it by the solution design?
5. Identify the 'condition' of the resource? This may require a resource analysis to determines its conditions.
6. Identify the regeneration periodicity and rate of consumption, which are both necessary in the calculation of dynamic equilibrium. This information provides trending data and informs predictability.
7. Identify whether the resource is available or unavailable and when it will become available and with what degree of certainty.
8. Identify when the resource will become available.
9. Identify where the resource will become available.
10. Identify alternative resources with similar or improved qualities.
11. Identify the continued operational resource cost required by the currently operational solution?
12. Identify the 'steady state' or 'dynamic equilibrium' where the environmental conditions of needed resources are held more or less constant by negative feedback systems operating within the ecosystem. A state of dynamic equilibrium may be optimally maintained through real-time electronic feedback [sensory] instruments used to monitor the priority of urgently needed resources.

In the Community, all common heritage resources are logged, tracked and accounted for via the **resource accounting system**. The Resource Accounting System includes, but is not limited to, the activities of classification (e.g., attributes & qualities), location, designation, regeneration and consumption rates, and availability data. The Resource Accounting System monitors the trending of resources. Here, it is recognized that systems that require fewer resources for the same level (or quality) of output are increasing in their efficiency [in context].

Resource regeneration must never dip below what is sufficient for each Habitat system to maintain a state of dynamic equilibrium. Not doing so puts the very survival of our community at risk.

> **NOTE:** *Once humanity began to interact on a global scale, then the entire global ecology necessarily comes into focus. And, once humanity begins to share on a global scale, then the entire global community necessarily comes into focus.*

1.1 User resource accounting

All global users must be accounted for within the decision system. Herein, it is relatively possible to account for, track, and relatively predict how much of each resource each person will consume from before they are born until they die.:

1. Relative resource consumption per person per year of lifetime.
   A. An individual's resource usage and occupation over their lifetime.
2. Total consumption over the lifetime of a person for a resource.

1.2 Material-resource typing

Resources are made/composed of materials. Resources can be classified according to the type of matter, its rarity (on the planet) and acquisition complexity:

1. **Mineral resources:**
   A. **Inorganic mineral resources (non-carbon mineral resources).**
      1. Rarity on planet.
         i. High rarity.
         ii. Low rarity.
      2. Acquisition complexity (including energy input necessary):
         i. High energy requirements.
         ii. Medium energy requirements.
         iii. Low energy requirements.
   B. **Organic mineral resources (carbon-mineral resources).**
      1. Rarity on planet.
         i. High rarity.
         ii. Low rarity.
      2. Acquisition complexity (including energy input necessary):
         i. High energy requirements.
         ii. Medium energy requirements.
         iii. Low energy requirements.
2. **Non-mineral resources (biological resources):**
   A. **Living biological matter.**
      1. Rarity on planet.
         i. High rarity.
         ii. Low rarity.
      2. Acquisition complexity (including energy input necessary):
         i. High energy requirements.
         ii. Medium energy requirements.

iii. Low energy requirements.

B. **Dead biological matter.**
  1. Rarity on planet.
    i. High rarity.
    ii. Low rarity.
  2. Acquisition complexity (including energy input necessary):
    i. High energy requirements.
    ii. Medium energy requirements.
    iii. Low energy requirements.

Resources may also be broadly categorized according to their inertness (i.e., their non-reactivity to electromagnetism and fission):

1. **Living organisms (i.e., biotics, organic, life).**
2. **Mineral elements.**
  A. **Inert materials (not EM interfaceable and not fissionable, inert minerals):** are substances that are chemically inactive or resistant to chemical reactions under specific conditions.
  B. **EM interfaceable material (i.e., electromagnetic materials, conductors and semi-conductors, EM minerals):** are substances that possess properties suitable for interacting with the "light" along the ropes that inter-connect all atoms.
  C. **Fissionable materials (i.e., radioactive materials):** are substances capable of undergoing nuclear fission, a process where the nucleus of an atom splits into smaller parts, releasing a tremendous amount of energy.

NOTE:*The whole human population lives in a world where electrical machines do a significant amount of the necessary work; and, all the machines require power as well as minerals.*

1.3 Material-resource surveying

A resource is any useful object (including the service as an arrangement of objects) that produced that object. All resources can be surveyed and statistically analyzed. A global resource survey must be conducted to appropriately account for that which is available to construct. By accounting for resources and engineered habitat service designs, it is possible to optimally plan for human need fulfillment. Here, all possible resources have physical locations, quantities, and qualities.

The surveying of resources occurs via multiple different mediums through the material existence of the habitat system. Some of the [proximity] surveying (sensor) instruments are automated, and other surveying instruments require manual input. Notably, we as individuals can share our observed record of the availability of a resource in a particular location; and when we coordinate at scale we can also perform this function at scale. Bees are known to communicate resource availability information, and we call their communication a “waggle dance”. Resource surveying in community naturally includes our shared surveys of our environment through a common linguistic interface.

For manual purposes the community uses input survey devices (or proximity survey sensors) in spatial location so that users and caretakers can input their observations of the area in some high degree of real-time (i.e., while they are still in the area).

INSIGHT: *Every time a resource allocating system allocates a specific resource to a person (allocatable identity), this changes the system. And, the actions of the individual person (allocatable identity) also affect the future state of the whole resource system.*

Technically, anything (i.e., any object) being used in service and/or as part of the composition for another thing (i.e., another object) is a resource. All functional systems are composed of objects as 'resources' -- technologies are composed of resource, the planet is composed of resources, and living things are composed of resources. Effectively, any material (physical) thing (Read: object) could be a resource.

MAXIM: *When you know what resources you have, then you know what actions you can take.*

A global resource survey must account for resources globally, and classify them appropriately to a humane standard of human need fulfillment:

1. What are the types of resource.
2. What land is available and at what purity and quality?
3. What chemicals are available and at what purity and quality?
4. What materials for production are available and at what quality?
5. What are the productive technologies and what are they composed of?
6. How are the productive technologies organized to service human need fulfillment (in a habitat)?
7. How are the deliverables of the productive technologies used?
8. What is recoverable at the end? What is recoverable after the resource has been fully used?

NOTE: *In the market-State, resources are typically traced/ogged by means of a Certificate of Authenticity (CoA; a legal record). A certificate of authenticity is a document guaranteeing the authenticity of a resource and allowing (to some degree) the history of the resource to be tracked.*

1.3.1 Resource readiness quality level (RRQL)

A.k.a., Resource readiness level (RRL), resource *sustainability levels (RSL).*

There is not a widely recognized or standardized Resource Readiness Level (RRL) system analogous to the Technology Readiness Level (TRL) system used to assess the maturity of technologies. However, it is possible to assess the readiness or maturity level of resources, especially in the context of sustainability, circularity, and resource efficiency. In these contexts, factors such as the availability and environmental impact of extracting and using certain resources could be evaluated through a readiness level framework. Elements that could be assessed in a Resource Readiness Level framework might include (note: RRL analysis connects resource inquiry to the environmental assessment inquiry):

1. **Availability:** The abundance or scarcity of a resource and the ease of accessing it.
   A. Indicator: Geological abundance.
   B. Metrics: Reserves-to-production (R/P) ratio, geographical distribution.
2. **Extraction impact:** The environmental and social impacts associated with extracting the resource.
   A. Indicator: Environmental degradation.

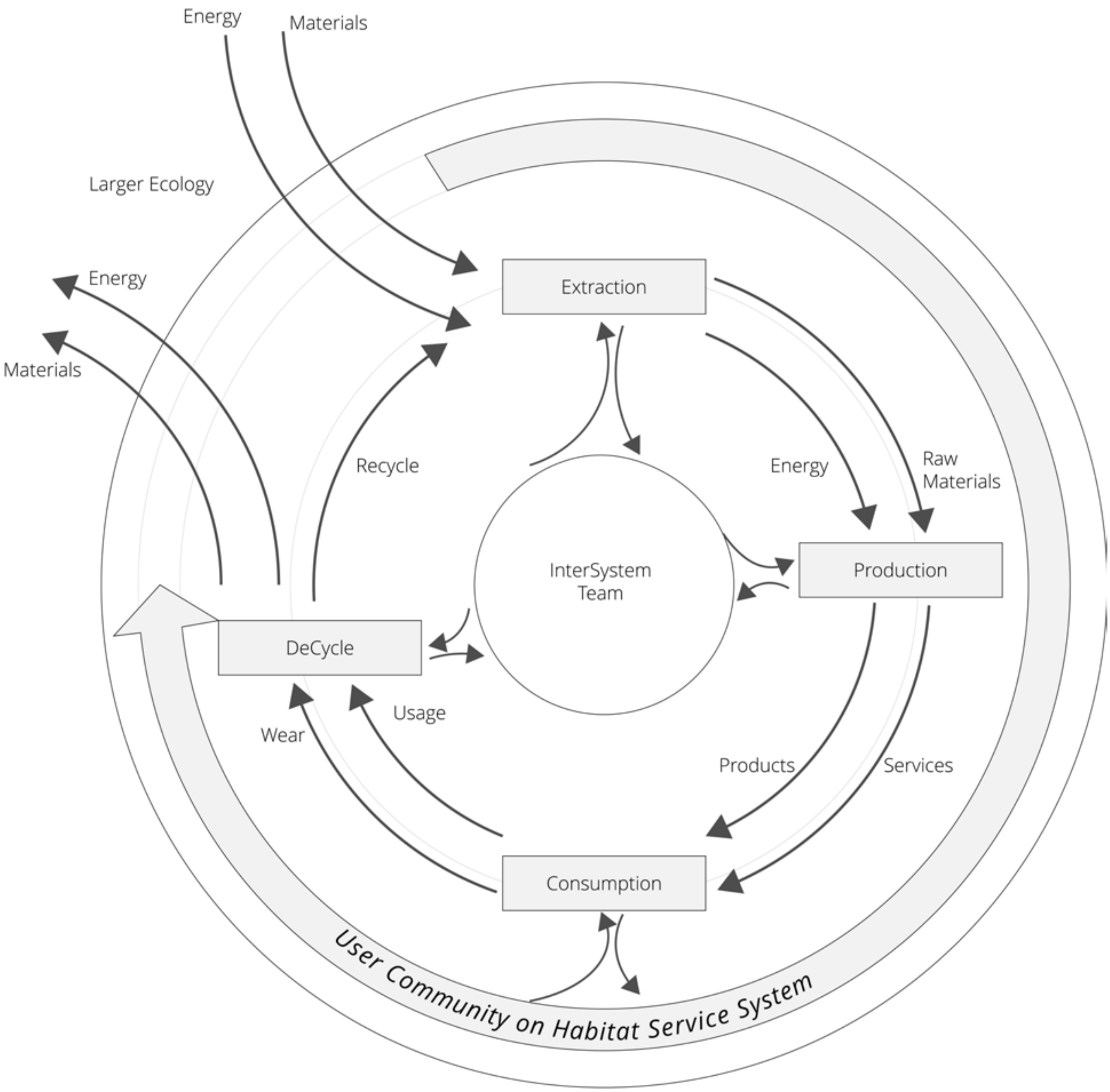

Figure 33. *The engineering of a real-world material cycle of resources for human "consumption" through team contribution.*

   B. Metrics: Habitat disruption score, water usage, CO_2 emissions per unit extracted.
3. **Processing and manufacture:** The energy and resources required to process and manufacture products from the raw resource.
   A. Indicator: Energy and resource intensity.
   B. Metrics: Energy consumed per unit processed, waste generated per unit product.
4. **Recyclability and reusability:** How easily the resource can be recycled or reused, including considerations of quality loss and economic feasibility.
   A. Indicator: Lifecycle sustainability.
   B. Metrics: Percentage of material recyclable or reusable, quality retention rate after recycling.
5. **Substitutability (a.k.a., alternatives):** The ease with which the resource can be substituted with a less impactful alternative.
   A. Indicator: Alternative material viability.
   B. Metrics: Performance comparison index with substitutes, economic cost ratio of substitute materials.

All resources are listed in a resource assessment table that identifies:

1. Resource name (material name).
2. Sources of each resource/material.
3. Extraction, processing and manufacturing methods (techniques) for each resource/material
4. Environmental and safety data sheet (MDS) for each resource/material.
5. Alternatives and substitutes [for each resource/material].

1.4 Material-resource inquiring

From a materials science perspective, the process of materialization involves the "call" of [factual] information from the following categories associated with a resource:

1. **Statistical certainty call:** Science provides certainty.
2. **Resource location call:** Objects as "resources" have real-world, physical, existent locations and occupations.
3. **Physical experiments call:** Materials have properties.
4. **Material composition call:** Materials may be combined into material compositions to change the expression of [material] properties.
5. **Potential assembly call:** Material compositions may be connected to perform technical functions as a technology module.
6. **System call (a.k.a., Service call):** Material configurations [as technology modules] may be integrated into service through a service system.

1.5 Material-resource integrity

A.k.a., Material continuity.

Due to the entropic nature of material reality, all material that is formed into an intend functional system has a state of functional integrity (material change impacts function) and non-functional integrity (material change does not impact functionality).

1.5.1 Surfaces

A.k.a., Geometric surface.

Surfaces need to be carefully selected. Take a painted building for example. Would you rather see the buildup of "dirt" and get rid of it, or use a material that either did not allow for the buildup of dirt and/or did not show the buildup of dirt? Here, dirt is that which has been unintentionally added to or taken away from a surface (i.e., dirt is that which is out of place on a surface). So, dirt could be the buildup of particulate matter on a surface, or it could be deposits from the erosion/corrosion of the surface over time.

A surface has likely been selected because of its various properties. These properties are altered by dirt. Hence, the surface will need to be restored so that it is expressing the original properties desired of it, which may necessitate a [surface] **restoration cycle**.

> **NOTE:** *Losing function is losing the capacity to do something. As a space "wears", its structure can lose its capacity to carry on its function.*

1.6 Material-resource societal integration

> **NOTE:** *Once a society builds past its causative environmental limits, then collapse becomes inevitable.*

There are at least four factors that facilitate a determination of the quality of a resource. These factors represent categorical information and form the acronym 'SANE'. When we "bring in" a resource into our habitat service system we can evaluate it more accurately in terms of its following identifications:

1. **Saturation:** (1) How quickly the resource's integration will fulfill the required need. And, (2) The predicted 'lifespan' of the resource; how long the resource is capable of fulfilling its functional purpose (i.e., remaining in the system in its intended function) before needing to be replaced, re-cycled and de-composed.
2. **Signaling [Aggression]:** How well the resources integration signals healthy functioning [capacity] and minimizes conflict, aggression, and dis-ease

in ourselves and the ecological environment. For example, putting lead in paint has the signaling impact of producing poorer quality functioning in those humans exposed to it, which may lead to a lower intellectual ability to coordinate decisive action, and thus, possibly increase social conflict. Also, for instance, foods that cause brain inflammation are more likely to result in the expression of physical aggression by the "inflamed" [neurophysiology of the] individual.

3. **Nutriment:** How many essential requirements (or needs) the resource is capable of fulfilling.
4. **Efficiency:** (1) The efficiency by which the resource can be regenerated, recycled, and decomposed. And, (2) how efficiently the resource moves through its service lifespan and is not converted into a "toxic" and unusable resource (i.e., "waste" product).

It may be of interest to note here that these four categorical factors for resource evaluation were taken and modified from the SANE acronym for calorie evaluation described in a book by Johnathan Bailor (2015) entitled, "The Calorie Myth: How to Eat More, Exercise Less, Lose Weight, and Live Better". Bailor devised the acronym SANE to represent the four factors of calorie quality. Therein,

1. S = satiety: how quickly a calorie satisfies you and for how long.
   A. How quickly is a need met by society's socio-technical (a.k.a., socio-economic system)?
2. A = aggression: how quickly and severely a food causes your blood sugar to rise.
3. N = nutrition: the nutritional quality of the calorie, quality trumping quality.
4. E = efficiency: how efficiently the body processes the calorie.

1.7 Material-resource quality control

There are significant differences between quality control in industry and in community. These differences are socio-economic in nature. In industry, the quality control process is as follows: people create things for another group of people; another group of people review and assess the first people's creations. In community, the quality control process is as follows: users openly and collaboratively create things for themselves while interfacing with a unified information model.

In industry, the outputs of processes must constantly be assessed and reviewed due to the presence of significant unknowns (i.e., due to the drive to conceal inputs, processes, and outputs for competitive advantage in the market). In community, the outputs of processes are significantly known due to the presence of a collaboratively developed, unified, and transparent information model. In community, inputs and processes and outputs are available for all to see, and for all to improve. In community, new outputs are tested prior to integration into the service system, whereupon they are tested again. And, once they are operational, we sense and otherwise monitor for signaled changes from the environment as feedback for improving and otherwise adapting (and evolving) our systems (i.e., our inputs, processes, and outputs).

In industry, independent reviews are essential. Competing entities are vying for finite market space, and so, "independent" entities are necessary to check the work of the other competing entities who are behaving for their own advantage. In community, all technical information is open source, and we recognize that we can behave in a way that is to everyone's advantage.

At the systems level, at the level of the Community's unified information model, we can all see and all check each others work. And, we work through our potential, purpose, and play. In industry, people work and compete for "income". In industry, due to the socio-economic consequences associated with reviews and assessments, they are generally taken as judgments. In community, the evolution of a model is seen as a benefit to all.

1.8 Material-resource designation classifications

NOTE: *Issues with unavailable resources must be re-designed or they will have to wait until the resource becomes available.*

Material resources need to be accounted for through classification.

1.8.1 Allocation and availability designations

There exist six resource availability designations (or designated classifications):

1. Unallocated and available.
2. Allocated and available.
3. Allocated and unavailable.
4. Periodically available.
5. Unavailable - acquirable externally.
6. Unavailable - under discover & development.

Resource may be classified according to their availability level:

1. Level of Availability - High abundance.
2. Level of Availability - Low abundance.
3. Level of Availability - Depleted.

1.8.2 Energy analysis and designation

INSIGHT: *Energy sustainability isn't only a behavioral issue, such as choosing to turn a light switch on/off or have a sensor turn it on and off; but enormous amounts of energy* *are predestined by the very design of the communities and cities themselves.*

Resources may be classified per a factor of their renewability quality:

1. Non-renewable resources (slow or no regeneration; external input into habitat service system).
2. Renewable resources (continuous or fast regeneration, external input into habitat service system).

Energy properties that distinguish one energy type from another include:

1. **Energy density** - how much energy (calculated) in a unit of volume.
2. **Power density** - how much energy (calculated) acquired from a unit of land or electrical generating machine.
3. **Spatial distribution** - refers to the geographical or spatial pattern of energy resources, generation, consumption, infrastructure, or availability across different regions or areas.
4. **Intermittence (intermittency)** - refers to the irregular or non-continuous nature of energy generation or supply. Alternating electric current is a highly controlled form of intermittence. Wind and solar are two examples of intermittent eletrical generation machines, wherein the intermittence is not-controlled by humans, but instead by solar system and climate.
5. **Energy return on energy investment (EROEI), energy return on investment (EROI), energy return on input (EROI)** - is a metric used to assess the efficiency and sustainability of energy production processes. It quantifies the ratio between the amount of usable energy acquired from a particular energy source and the energy expended or invested to obtain that energy. A high EROEI indicates that an energy source provides a significant surplus of usable energy compared to the energy needed to extract, refine, or produce it. Conversely, a low EROEI suggests that more energy is required to produce the energy source, potentially making it less economically or energetically viable.

   The formula for EROEI is:

   EROEI = Energy Invested / Usable Energy Obtained

   Annual return for renewables = EROEI / Operational Lifespan of Generator

   Note: Oil EROEI is returned over time from well to end use, renewables over lifetime.

Important energy usage related terms include, but may not be limited to:

1. **Energy return:** The total amount of usable energy obtained from a particular energy source, whether it be fossil fuels, renewable resources, or other sources.
2. **Energy investment:** The total amount of energy expended or invested in acquiring, extracting, refining, processing, and transporting an energy source. This includes the energy used in exploration, extraction, processing, transportation, and infrastructure development.
3. **EROEI threshold:** The minimum EROEI required for an energy source to be considered viable or sustainable. Different energy sources have varying thresholds; for example, conventional fossil fuels historically had high EROEI values, while some unconventional sources (e.g., tar sands, shale oil) have lower EROEI values.
4. **Net energy:** The surplus energy obtained from an energy source after subtracting the energy invested. It represents the energy available for societal use after accounting for the energy costs of obtaining that energy.
5. **EROI decline:** In some cases, the EROEI of certain energy sources might decrease over time due to factors like resource depletion, increased extraction costs, or technological complexities associated with extraction or production.
6. **Exergy analysis:** This concept evaluates the maximum useful work possible from energy systems, considering thermodynamics' second law and helping calculate the true 'value' of energy resources.
7. **Material flow statistical entropy analysis:** These calculations are used to assess the efficiency of recycling and the quality of recoveries from waste streams.
8. Thermodynamic accounting: Using formula and calculations that quantify the thermodynamic efficiency and sustainability of various processes.
9. **Potential energy** - is sitting energy in a barrel, reservoir, or ground.
10. **Kinetic energy** - is the objects in motion.

CLARIFICATION: *In common parlance the word "renewability" is applied to both resources and technologies; however, technologies are not renewable (a misnomer), they are re-buildable. Renewable energy using technologies (e.g., solar, wind, and water) have to be rebuilt every set number of years (because, they have a life-span and wear out).*

1.8.3 Substitutability

A.k.a., Alternatives, alternative resources.

The concept of substitutability, or the consideration of alternative resources, is crucial in the context of decisioning (Read: economics and resource allocation). Substitution analysis refers to an analytical evaluation of different possible uses for resources at any given time, focusing on the current moment rather than being hindered by past decisions. Once a decision has been made and executed—such as planting pear trees instead of apple trees—the options available for utilizing those resources are set along a certain path. In other words, to plant pear instead of apple trees—the pathways for using those resources become fixed to a certain extent (as in, occupying a fixed/continuous area on the landscape, and fixed, as in, used/past labor, tools, and energy). The trees that have been planted will produce specific fruits, and the resources (time, land, labor) devoted to them cannot be reallocated to produce something else in the short-term (i.e., 5-10 years, covering 2-3 master habitat planning cycles of 3-4 years).

The consideration of substitutability becomes most relevant when discussing the distribution of already produced goods, like the pears from the pear trees. At this point, the production costs and the decisions that led to the growing of pears instead of apples are fixed ("sunk") costs; they are in the past and cannot be recovered or altered. The trees need time, space, and resources to grow and produce useful products. These trees then become "fixed" (continuous) in the habitat as part of the cultivation system (for some genetically given lifespan, or until a priority demand arises that requires their removal). At this point, the initial decisions and the potentials they represented become historical facts; they are no longer variable.

There are various potential applications for the same set of resources at any given moment. Substitutability underlines the economic principle of potential ("opportunity cost"), which is the potential ("cost") of the next best alternative foregone. When deciding what resources to allocate or goods to produce, the potential benefits and negatives ("opportunity cost") of choosing one option over another is a crucial consideration. However, once the goods are produced, the potentials ("opportunity costs") associated with their production become irrelevant to their distribution. The decisioning process shifts from considering production alternatives to focusing on distribution alternatives.

To clarify, there are two decision dimensions in concern to substitutability (one on the production side, and one on the distribution/user side):

1. **Substitutability in production:** Substitutability of resources in an object assembly.
2. **Substitutability in distribution:** Substitutability of products in demand (e.g., apple versus pear).

In concern to production, the consideration of what to cultivate next (e.g., pears or apples) is guided by an adaptive, responsive approach to the local habitat residents' preferences and evolving conditions. Local habitats conduct cyclical master planning that involves a continuous re-assessment of the habitat's capacities, human demands, fixed/continuous ("sunk") resources, etc. In this framework, the decision to transition from growing pears to another fruit—or any other agricultural product—is not merely a reaction to immediate human demand/signals or past productions, but a strategic choice informed by a holistic view of long-term ecological balance, food security, and the well-being of the community.

In this context, substitutability is not just about replacing one type of fruit with another based on current demand, but about understanding and leveraging the dynamic interplay between various factors that affect the local habitat and the fulfillment of individuals therein. The planning process becomes a collaborative effort that engages local and regional residents, and InterSystem team decision working groups.

1.8.4 Scarcity analysis and designation

INSIGHT: *In any general service, and in health in particular, if you don't meet or exceed critical [micro]nutrient sufficiency there will exist a lessening or worsening of function.*

'Resource scarcity' exists when a resource is simultaneously unavailable and part of the design specification of an unresolved issue. Some resource scarcity issues are of an urgent nature, such as life support incidents, and others are of a non-urgent nature.

Instances of resource scarcity may be resolved in the following ways:

1. The design changes to use less of a resource or not use the resource at all.
2. The resource becomes available.
3. A novel resource becomes available.
4. Another resource is substituted for the initially required resource. Here, substitutability refers to substituting one set of resources for another.
5. The design/service becomes unavailable due to an inability to acquire the resource or acquire a sufficient amount of the resource.

In community, if a particular resource is becoming scarce, then the system will alert the materials scientists (teams), and those in the larger community who have selected to receive said alerts, of the trending resource scarcity, and an alternative material solution will require development. If there isn't enough of a given resource; then there is an incentive (a motivation) to find an alternative so that the desired system can continue to do what we want it to do. Resource shortage (or scarcity) provides a motivating incentive to those to whom the resource scarcity imposes a possible artificial limit. In particular, resource scarcities to the 'continuous loop' services of the life and technology support system represents a threat to the survival of the community, and are a priority.

If resource scarcity exists then the technical process of 'resource development' exists. **Resource development** is the process of developing alternative resources through the interdisciplinary field of 'material sciences'. Resource development involves the development (or creative innovation) of novel resources to overcome resource scarcity issues. An emergency might require immediate development of a novel resource, and therein, the incident response operational process organizes an interdisciplinary team from the service systems to solve the problem.

Remember that the Decision System involves 'resource accounting' in the design of the habitat's service systems. By doing so, the generated (or engineered) state of resource scarcity is minimized or nullified. What remains is what is technically possible.

We know what resource inputs the service systems need to continue their operation [by degree] because we designed them.

Note that this economic model gives priority allocation to urgently needed resources: those resources that are needed for the sustained production of life support needs, and the stability and maintenance (i.e., inner loop), of the community's technological systems. This requirement for a sustained loop of resources to maintain the 'operational continuity' of notably prioritized systems is known as **inner loop prioritization**. Resources that are needed for the continuous functioning of an urgent system receive what is known as 'inner loop prioritization'. This prioritization is strategically designed for by the *Strategic Preservation Planning* operational process. And, the inner loop movement of resources is carried out by the *Maintenance and Operation* operational process. Inner loop prioritization simply means that a system requires the continuous allocation of a particular type, quantity and quality of resource to remain functionally stable. The inner loop is the known "operational cost" of the system and it involves strategic planning and resource budgeting. Essentially, the resources needed to maintain the operation of habitat systems, which have been designed, are known and are "budgeted for" so that knowable scarcities are avoided.

Most economic outputs are strategically planned and have an associated, and known, continuous 'operation and maintenance' resource cost, which are partially 'inner loop prioritized'.

A community desiring a higher potential state of existence might apply technological automation at the level of strategic design and preservation planning toward the overcoming of resource scarcity and the reduction or elimination of undesirable tasks by sentient beings.

> *"Anyone who believes in indefinite growth on a physically finite planet is either mad or an economist [for there are real resource limitations]."*
> *- Kenneth E. Boulding & David Attenborough*

1.9 System input-output tables and analytics

> *A.k.a., Resource planning, input-output literature, Input-output economic tables, input-output economic matrices, Scottish input-output table, Soviet input-output table, dynamic resource allocation problem, resource management, enterprise resource planning, logistics, economic planning mathematics, behavioral economics, economic mathematics*

An input-output table is a matrix showing the input and/or output of information, energy, and/or material (or technology, etc.) between systems. The tables track and show sensible environmental elements that pass between systems. Input output tables are essential for decisioning where analytics will be run with the tables as an input, in order to sustain, and/or produce a better, outcome.

In the current, real world, there are limited resources that need to be assigned in real-time (i.e., finite resources that require allocation in real-time). In the market, these problems are concerned with, "giving humans what they want, when they want it".

All dynamic resource allocation situations deal with changing inputs and environments, some of which are (particularly, market-based scenarios) difficult to estimate and predict. In the market dynamic, resource allocation is difficult to predict because there is no unified, sufficiently integrated, working information systems model; thus, in the market, the future load on resources is not statistically dependent on the current load.

In a unified societal system, like community, one change triggers another change, and if the intention is to control the system with accurate decisions, then the decision system must consider the future status of the system.

Price adds abstraction to the calculation that dis-aligns the input-output table from optimal objective human fulfillment through the inclusion of abstraction (Read: money and authority) as reified (real) entities. Price confuses the table when the objective is mutual human fulfillment.

Fundamentally, dynamic environments (environments where change is continuous), require a dynamic control methodology -- require the selection of methods that can effectively compute real-time decisions about the allocation of resources and monitor execution.

> **STATEMENT:** *It is important for us to develop the ability to remain accurately observant of our environment, and we can use technology*

to facilitate this by recording and tracking our observations over time and as a population.

1.10 Resource types

A.k.a., Resource classes, resource categories, categories of resource, resource specifics, resource characteristics, resource descriptions.

Resources can be generally categorized into the following types:

1. **Resource classification based on renewability (stockability)** - the property of a resource to be replenished. This is a resource inquiry, a resource-side view of the system.
   A. **Renewable resources (replenishable)** - a resource that is replenishing itself at the rate it is used.
   B. **Non-renewable resource** - a resource that is not replenishing itself at the rate it is used. Natural resources that cannot be renewed are natural resources that have a very long regeneration time or cannot regenerate at all. Generally, non-renewable natural resources come from the mineral, metal and fossil fuel groups. Examples of non-renewable natural resources are hydrocarbons, metal, minerals, and certain types of aquifer water. Natural resources such as wood, animals, and fish can also be considered non-renewable natural resources when their use exceeds their regenerative capacity. The characteristics of the renewability of a natural resource include: (1) if used, the amount will decrease (unsustainable usage to production); and (2) cannot regenerate quickly in nature (too long a time; ecosystem decline).
      1. Minerals and metals:
         i. Minerals and metals are chemical materials that occur naturally in the planetary environment. Minerals and metals (inorganic chemicals) are considered non-renewable because when they are extracted, their quantity will decrease and will not increase in a short time.
2. **Resource classification based on criticality in a production [service and object deliverables]** - the necessity, which out which there is no alternative, to use this mineral or other resource. Note here that this is a production-deliverable side view. Some resources are critical to productions, and other resources are inter-changeable, with small quality differences (or not). Here, there are the categories of:
   A. **Substitutable resources**.
   B. **Critical non-substitutable resources** (minerals).
3. **Resources classification based on flow (availability)** - the property of a flow to be available.
   A. **Resource flow (dynamic resource, energy source)** - a flow of objects, a process occurring between objects, a 'dynamic concept'. This is a concept and not a storable resources. The harnessing of these flows is intermittent due to natural processes. The natural dynamics/flows are:
      1. Sunlight ('electromagnetic' pulsation movement). Note that sunlight on ground surfaces is considered highly intermittent.
      2. Gravity ('electromagnetic' atomic pull movement).
      3. Atmospheric ('wind' movement). Note that wind near ground surfaces is considered highly intermittent.
      4. Water ('current' movement) Note that some water currents are continuous, whereas others are intermittent.
4. **Resources based on chemical composition:**
   A. **Resource static (static resource)** - a single object in a single unmoving frame of a dynamic (moving) universe.
      1. **Resource stock** - snapshot of stock of resource at one time, where there are a stock of a resource (or, easy on-demand replacement of stock).
      2. **Dynamic stock resource flow transformer** - these are a unique resource stock; they are the machines that produce electricity that powers the habitats of all of society. These systems harvest flows of matter to ultimately, delver electricity to services for human user functions.
5. **Natural resources** - anything that is available naturally for collection on earth (or in space) is a natural resource.
   A. **Biotic resources (a.k.a., organic resources, bio-resources, biological resources, organic matter)** - living and deceased life forms. Life is a natural resources that is continuous and renewable. The processes for the collection biotic resources is harvesting/cultivating. Biotic resources contain carbon. Organic matter is a natural substance with distinctive chemical and physical properties, composition, and atomic structure.
   B. **Abiotic resources (a.k.a., mineral resources, mineralogical resources)** - never living; minerals (e.g., metals, rocks, stones). Minerals

are natural resources that are finite and non-renewable. There are only finite amounts of each mineral. Minerals are considered non-renewable because they take a very long time to form (millions of years). Minerals do not regrow and they are not replaced or renewed over any duration of time relevant to humanity. Minerals cannot be made by living organisms. Minerals occur through non-living physical processes. The processes for the collection mineral resources is mining. Mining mainly includes the exploration, production, and processing of metals and minerals located in the Earth's crust. A mineral is a natural substance with distinctive chemical and physical properties, composition, and atomic structure. The general list of metals and minerals is: base metals, precious metals, rare earths, non-metallic minerals, minerals, cement, diamonds, glass, stone.

1. **Metallic minerals (a.k.a., metal minerals, metals)** -
   i. **Base metals** - are found in abundance on the planet.
   ii. **Precious metals** - because they are not found in abundance on the planet like base metals are.
2. **Non-metallic minerals (a.k.a., non-metal minerals; non-metals)** - are a special group of chemical elements from which no new product can be generated if they are melted. Nonmetallic minerals are, for example, sand, gravel, limestone, clay, and marble. Such materials lack metallic characteristics like good electric and thermic conductivity, luster, rigor, and malleability. Nonmetallic minerals are used in the production of cement, ceramics, glass, lime products, etc. The transformation of nonmetallic minerals into these products is often an energy-intensive process, which can include several steps, such as heating, grinding, mixing, cutting, shaping and honing. The 'non-metallic mineral products' sector of the economy ("industry") was formerly known as the 'stone, clay, glass, and concrete products' industry. Under the North American Industry Classification System (NAICS), this subsector is separated into clay product and refractory, glass and glass products, cement and concrete products, lime and gypsum products, and other non-metallic mineral products.
3. **Hydrocarbons (a.k.a., energy minerals, chemical precursor minerals)** - these are fuel and chemical production resources. Energy minerals are used to produce electricity, fuel for transportation, heating for homes and offices and in the manufacture of plastics. Energy minerals include coal, oil, natural gas and uranium. Hydrocarbons may also be considered a biotic resource because it contains carbon).
   i. Hydrocarbons can be used for:
      1. Power production through combustion.
      2. Manufacturing through multiple chemical processes.
4. Minerals classified according to their usage:
   i. **Energy minerals** including coal, gas, etc., which are used to produce power.
   ii. **Construction minerals** including sand and gravel, brick clay and crushed rock aggregates used to manufacture concrete, bricks and pipes and in building houses and roads. These minerals produce architectural constructions.
   iii. **Metal minerals (metals)** - all minerals that are metals (a broad usage classifying category).
   iv. **Industrial minerals**, otherwise known as non–metallic minerals, used in a range of industrial applications including the manufacture of chemicals, glass, fertilisers and fillers in pharmaceuticals, plastics and paper. Industrial minerals include salt, clays, graphite, limestone, silica sand, phosphate rock, talc and mica. These minerals produce manufactured items.
   v. **Renewable (power production) technology minerals**, are primarily metallic mineral and include rare earth minerals.
   vi. **Agricultural minerals** for fertilization, including nitrogen, phosphorus, and potassium.

6. **Sources of resources** - the originating location.
   A. Minerals are sourced from mining operations.
   B. Biological are sourced from cultivation operations.
7. **Developed resources (a.k.a., human-made resources, synthetic resources, cybernated resources)** - are deliverables (products) that occur when humans use natural things to make something new that provides use [to human and ecological life]. For example, when productions use metals, wood, cement, sand, and electricity to make habitats, machinery, vehicles, bridges, roads, buildings, tools, toys, etc. they become man-made resources.
   A. **Hydrogen** - this is a fuel and chemical production resource. This is an energy carrier,

and must be human made. Hydrogen has to be made, either via gas or electrolysis.
   B. **Computation** - this is statistical machine intelligence.
8. **Habitat resources (societal-made resources)** - all human-made resources are dependent on the availability of contributed natural resources

1.11 Resource information unit accounting

A.k.a., Complete resource survey, resource survey analysis, total resource accounting.

Each resource unit has the following classes of associated data:

1. Class of resource.
2. Location.
3. Allocation.
4. Quality.
5. Purity (integration).
6. Statuses.

1.11.1 Economic resource accounting

Economic accounting requires the identification of resources as they pass through the different phases of materialization.

Resource flow tracing (resource tracking, resource following, resource) involves materials that move through different phases and acquire recursive IDs at each phase:

1. Chemicals are incorporated into materials, which are incorporated into technologies that produce habitat service systems and products (for usage/consumption) as the deliverable(s) for global human need fulfillment.
   A. Chemical ID *(raw)* > Material ID *(1st composition)* > Technology ID *(2nd composition)* > Deliverable ID *(3rd composition).*
      1. Chemical ID > Material ID > Technology ID > Deliverable ID.

The phases of materialization into which resources can be classified, composed, and identified/coded include:

1. **Identity** (ID; a.k.a., identifier, code, class code, etc.) - identifying an object (in the economy) as separate from some other object.
   A. This is a useful way of recognizing and differentiating.
2. **Element ID** (a.k.a., raw chemical element ID, chemical ID).
   A. Chemical element identifier/label.
   B. This a useful chemical unit ID.
3. **Material ID** (a.k.a., useful material ID, material code, resource ID, resource code)
   A. A material is that which is used in production (i.e., in a technical unit) or directly by a user.
4. **Technology ID** (a.k.a., technical unit ID, production unit ID, technical production unit code, service production unit ID, production service unit code).
   A. A technical unit produces something for either another technical unit or the end user.
   B. This is a useful technical unit ID.
5. **Service ID** (a.k.a., habitat service ID, service support ID, support service ID).
   A. Technical units are part of service systems and produce deliverables for those service systems. Those deliverables then enter into service for the user.
   B. This is a useful service unit ID.
6. **Deliverable ID** (a.k.a., good ID, product ID, model-serial-service ID unit code, habitat service object ID).
   A. A deliverable that is used by an end common and/or personal access user in the habitat, using one or more of the habitats services (objective-human use value).
   B. This is a useful product unit ID.

CLARIFICATION: *Resources in each phase are composed into a 'unit of account'. The identification start with resource units, then material units, then technology units, then deliverable units, some of which are final, and others intermediary.*

1.11.2 Resource application accounting

Resources occupy real-world spacial coordinates, volume at a location. It is important to identify what the resource is to be (or, being) used for:

1. What are the physical tasks done by using the resource?
2. What are the needed services done by integrating the resource?
3. Is the resource integrated into a technical [production] unit? Or, is the resource integrated into a user unit? For example, a tennis racket is a "user unit". The machine(s) that produces tennis rackets is a "technical unit".
4. Is the resource a source of power (energy, fuel, etc.) for a machine?

1.12 Capacities

A.k.a., Resource application capacities).

Capacity refers to the amount of some output (deliverable) produced given a set of inputs (resources). Biological and mechanical systems have capacities for operation. A sufficiency of the appropriate inputs will lead, in such a productive system, to a sufficiency of the appropriate outputs.

The notion of capacity encompasses the following two significant terms:

1. **Threshold** - how much of a resource is available to be used in a way that meets (community values and objectives) and does not exceed carrying capacities.
2. **Allocation** - a translation of thresholds into an organization access perspective. How mow much of what is available is available for personnal, common and team access.

Every economic system has capacities, thresholds, and the necessary allocation (of resources) to service continuation, based on resource inputs:

1. **Planetary capacities** - planetary ecosystem service capacities.
2. **Local ecosystem capacities** - capacities of local and regional ecosystems (to absorb waste and/or produce biotics).
3. **Global habitat network capacities** - global productive capacities.
4. **Local habitat network capacities** - regional productive capacities.
5. **The capacities of the local habitat** - productive capacities of a single habitat.
6. **Productive capacities** - what can be produced with what is.
7. **Reserve capacities** (a.k.a., reserve production capacity, inventory, reserve stock) - if new resource inputs stop, how much longer can production occur.

The two master resources have their own production capacities:

1. What mineral production capacity is required to meet the needs of the global population in the global habitat network, given mineral requirements for technical units.
2. What power production capacity is required to meet the needs of the global population in the global habitat network, given mineral requirements for technical units.
3. What manufacturing production capacity is required to meet the needs of the global population in the global habitat network, given mineral requirements for technical units.

1.12.1 All technologies have requirements for minerals

All technical units, as well as their productive outputs have requirements for minerals. The availability of minerals imposes a universal restriction on all outputs across technical units, significantly influencing their productivity. The constraints on minerals impact all outputs across technical units and their productivity. Some of these minerals are vital for construction and operation, being both irreplaceable and essential.

The fundamental constraints on minerals as resources in technical units and their deliverables are:

1. Is the mineral critical to construction and operation?
2. Is the mineral unique and has no replacements?

1.12.1.1 Critical mineral types for technical units in the power support service system

The critical technologies needed for hydrocarbon technologies are:

1. Furnace.
   A. Engine (with or without an electrical turbine).

The critical technologies needed for non-hydrocarbon ("clean/renewable") technologies are:

1. Solar Photovoltaics (PV).
2. Wind.
3. Hydro.
4. Concentrating Solar Power (CSP).
5. Bioenergy.
6. Geothermal.
7. Nuclear.
8. Electricity networks.
9. Electric vehicles (EVs) and battery storage.
10. Hydrogen.

> **CLARIFICATION:** *The relative importance of minerals for a particular clean energy technology may go from low (composition/integration in technology) to high (composition/integration in technology.*

The critical minerals needed for non-hydrocarbon ("clean/renewable") technologies are:

1. Copper.
2. Cobalt.
3. Nickel.
4. Lithium.
5. Rare Earth Elements (REEs).
6. Chromium.
7. Zinc.
8. Platinum Group Metals (PGMs).

9. Aluminum.

1.12.1.2 Metals needed for renewable power generation sources

The following are the common metals needed for each type of power production system (Micheax, 2021):

1. **Hydrocarbons:**
   - Copper
   - Nickel
   - Cobalt
   - Chromium
   - Manganese
2. **Li-ion batteries:**
   - Lithium
   - Nickel
   - Cobal
   - Graphite
   - Copper
   - Aluminum
   - Iron
   - Silver
3. **Wind turbines:**
   - Aluminum
   - Chromium
   - Copper
   - Iron
   - Lead
   - Mangnese
   - Molybdenum
   - Neodmium
   - Nickel
   - Silver
   - Zinc
4. **Solar PV panels:**
   - Silicon metal
   - Aluminum
   - Copper
   - Indium
   - Camium
   - Gallium
   - Germanium
   - Selenium
   - Tellurium
   - Lead
   - Molybdenum
   - Nickel
   - Silver
   - Zinc
5. **Nuclear fuel cycle:**
   - Uranium graphite (99.999% pure)
   - Aluminum
   - Chromium
   - Copper
   - Indium
   - Lead
   - Molybdenum
   - Nickel
   - Silver
   - Titanium
   - Vanadium
   - Zinc

2 Resource availability

The availability of resources must be understood and defined with the following identifiable data:

1. **Total global availability:** The (total) global, regional, and local *availability***.**
   A. Is the resource there (i.e., where is it present currently)?
2. **Total global accessibility:** The (total) global, regional, and local *accessibility*.
   A. If the resource is there, is it accessible, and how is it accessible?
   B. At what level of quality is the resource accessible?
3. **Total global production:** The (total) global, regional, and local production rate (*production*).
   A. What is the rate of production of the resource?
   B. What is the quality of the produced resource?
4. **Total global consumption:** The (total) global, regional, and local consumption/usage rate (*consumption/usage*).
   A. What is the rate of consumption/usage of the resource?
   B. What is the quality of the consumed resource?
5. **Total global planning:** The (total) global, regional, and local rate and quantity of planned/expected usage (*planning*).
   A. What is the expected future rate of usage of the resource, and for what duration of time is that rate stable/dynamic?
   B. What is the expected quantity of resource required?
6. **Total global recycling:** The (total) global, regional, and local fixed recyclable percentage (*recyclability*).
   A. What is the quantity and quality of the resource that is fixed and non-recyclable?
   B. What is the quantity and quality of the resource that is fixed and recyclable.
7. **Total global reserving:** The (total) global, regional, and local stock inventory and reserves (*reserving*).
   A. What is the quantity and quality of the resource in stock.
   B. What is the quantity and quality of the resource in reserves.

The purpose of a resource survey is to acquire sufficient information to plan for the requirements of oneself and of future generations:

1. Total global availability - is the resource there.
2. Total global accessibility - can the resource be acquired?
3. Total global production - can the resource be produced into some usable material?

4. Total global consumption - at what rate is it being consumed?
5. Total global production deficit - does the consumption of the resource exceed the production?
   A. If no, are they equal, or is there an increasing stock?
   B. If yes, how often does demand exceed supply?
6. Total global planning - will there be sufficient for the future of our generation and others?
   A. Total global economic design and re-cycling. Are the resources for material systems being accounted for at the global planning level?
   B. Total global reserve stocking. Are the resources being stocked at the global level where planned?

It is relevant to note here that there are three (or four) typical "view" levels for to resources:

1. The global *view* - what is happening, or could happen, globally.
   A. Identify all resources and potential resources in the global habitat network.
2. The regional-distance *view* - what is happening at a regional level, based on distance-transport-power parameters.
   A. Identify all resources and potential resources in the regional-distance habitat network.
3. The regional-States *view* - what is happening at a regional level based on the geographic positioning of State borders.
   A. Identify all resources and potential resources in the regional-State habitat network.
4. The local *view* - what is happening at the level of an individual habitat (in the global network of habitats).
   B. Identify all resources and potential resources in a local (single) habitat network.

There are several basic terms related to resources availability:

1. **Potential [resource]** - resources (and resource classes) that may be available in the future. This data is placed into a resource readiness level matrix.
2. **Alternative [resource]**- in reference to an alternative resource/material that provides the same or similar qualities as an originally used material.
3. **Developed [resource]** - these are resources (and resource classes) that are currently available for application.
4. **Stock [resource]** - these are physically stored, inventoried resources. For example, the amount of petrol in an engine's petrol tank. A stock is an amount of something that should be able to be easily accessed and used.
5. **Reserve [resource]** - often used interchangeably with stock, but may also be a separate category - an amount stored after [the amount stored in] 'stock' in case of intermittent 'stock' depletion. For example, the amount of petrol stored in a separate petrol tank on the vehicles exterior. Reserve is an amount that if depleted could mean a critical incident issue has emerged.
6. **Deposited [mineral resource]** - these are minerals deposited ("stored") within the crust of the earth.

Resources become available through:

1. **Discovery** - the work that goes into knowing of and locating a resource on the planet.
2. **Acquisition** - the work that goes into gaining access [touchable] to that resource.
3. **Collection** - the storage of a resource that has been acquired.
4. **Usage** - when a resource is integrated into a technological system or directly used by a user.
5. **Re-cycling** - when the resource is fully used, its materials are re-cycled (in relation to their entropy and the power available for re-cycling).
1. **Renewability** - the ability for the resource to be re-created through natural processes and a human time-frame.

2.1 Resource renewability and sustainability

A.k.a., Renewable material resources, sustainable material resources, sustainable mineral resources.

The sustainability of resources (materials) refers to several factors:

1. A sustainable material is a recycled or bio-sourced material that can be renewed over the lifetime of a human being.
2. The sustainability of a product is defined by more than just the materials that make it up. To reduce the environmental impact of a product, everything that goes into its creation must be analyzed [from cradle to grave].
3. Sustainable product accounting must include:
4. Sourcing of materials.
5. Transportation of materials
6. Production of the product.
7. Transportation and distribution of the product.
8. The performance of the product while in use.
9. End-of-life recycling

At what rate, under what conditions, and with what calculated results are resources types being used:

1. **Biotic resource sustainability** (biological regrowth, **RENEWABILITY**) - biotics are naturally occurring biological life-forms (species) that develop under species specific conditions. It is necessary to identify genetics and the environmental conditions under which those genetics are optimized and adapted. Biological resources, given appropriate genetics and conditions are a fully renewable resource. Biological [renewable] resources can be used at sustainable and unsustainable rates.
2. **Mineral resource sustainability** (**RECYCLEABILITY**) - Minerals are naturally occurring materials extracted from the geological crust of the Earth. Minerals are finite and non-renewing resources, except for hydrocarbon minerals, which take beyond human-relative time to regenerate. It is necessary to differentiate metallic minerals from non-metallic ones, because 'renewability' for operational purposes will be defined by the level of entropy (or disorder) that mineral use will generate. At the chemical level, the renewability of a chemical is simply one of expending enough energy to bring back the material from a higher level of entropy to allow for reuse or recycling. Energy output is required to reverse the entropy created by the mineral's use, which is the main metric to evaluate whether that material's use is sustainable or not. From an operational perspective, metallic minerals are used in lower levels of entropy. Hence, they are usually able to be recycled. Conversely, minerals like coal (or other hydrocarbons), the use of which converts the material to such a high level of entropy (dispersion in the form of carbon dioxide) that it is essentially non-renewable. Mineral usage may be considered sustainable when minerals can be retrieved after usage/service in usable form with relatively low energy expenditure and restorable environmental impact. Further, if conducted appropriately, the extraction process of a finite resource from the Earth's crust can be considered sustainable. In other words, it is extracted at a rate that actually meets requirements, and its extraction is not depleting available mineral deposits at a rate that would inhibit the human population of the future in having their requirements for minerals met.

A sustainable approach to mineral resource acquisition and production is one meets the human needs of the present without compromising the needs for the mineral requirements of future generations. Sustainable access of mineral resources seeks to attain a resource cycling plan between acquisition, stocking, usage, and de-/re-cycling.

Certainly, a sustainable mineral production accounts for the following mineral usage factors:

1. Minerals (resources in general) are used efficiently.
2. Minerals (resources in general) are re-cycled, where possible.
3. Minerals (resources in general) have alternatives in case of shortage.

In other words, a sustainable economic plan uses resources efficiently, recycles where energetically and technically feasible, and identifies alternatives in case of unforeseen availability issues.

The following is a simple data structure of sustainability associated concepts of resource access:

1. Sustainable minerals.
2. Sustainable chemicals.
3. Sustainable fuels.
4. Sustainable mineral fuels.
5. Sustainable power.
6. Sustainable mineral-integrated power technologies.
7. Sustainable habitats.
8. Sustainable mineral-integrated habitats services.
9. Sustainable society.
10. Sustainable societal access fulfillment.

2.1.1 Factors of material renewability

A.k.a., Renewable-type resources, material restorability factors, material sustainability factors.

More sustainable (restorative) materials are more likely to be from:

1. **Natural organic materials:** Use natural materials that are from renewable plant organisms (cellulose materials) as proximal to the site as possible (and that renew in a timely manner). For example,
   A. Wood - is a renewable resource that can be used for construction.
   B. Bamboo: is a rapidly renewable resources that can be grown and harvested quickly. It is also lightweight and durable with a high strength-to-weight ratio.
2. **Natural non-rare mineral materials:** Use natural non-rare deposits of clay and natural stone, from the site or elsewhere, proximal to the site or region. Clay can be turned into bricks and rammed into structures.
3. **Recycled materials:** Use materials that would

otherwise end up in the landfill, such as recycled plastics, paper, and textiles.
4. **Alternative plastics:** Several new types of plastics are made from renewable resources or are biodegradable, such as polylactic acid (PLA) and polyhydroxyalkanoates (PHAs).
5. **Electronic waste:** Disassemble as completely as possible all "electronic waste".

2.1.2 Resource recycling

Recycling is the collection and processing of unwanted materials into useful products.

The resource (Read: materials) recycling inquiry gathers the following data in order to determine recyclability:

1. Once the resource has been integrated into a system, in order to remove it and re-use it, what is required?
   A. As tools and other materials?
   B. As power?
   C. As ecological restoration?
2. What amount of the total material can be recovered?
   A. What is the quality of the material that is recovered?
3. What amount of the total material cannot be recovered?
   A. Where does the unrecoverable material go?
4. Identify: Is the product in which the resource is (is to be) integrated a single or multi-use product before going to recycling?
   A. Was the product in which the material is composed to be used just once and then wasted, or will it be used multiple times before its lifetime is complete?
5. Identify: Is it better to design a product that is less durable and more recyclable, or a system that is less recyclable, but more durable?

Mineral recycling specifics include:

1. Many minerals recycled after usage in industrial and manufacturing processes may only be reused as construction fill.
2. Glass may be recycled through melting or crushing. Crushed glass has many uses, including for use as a sand alternative and construction aggregate.
3. Metals are simple to recycle as they can be melted and used to make new products; although some metals may be used in such small amounts in some products that it would be very inefficient to recover them.

2.2 Resource acquisition methods

A.k.a., Processes for the collection of resources.

All physical resources are acquired and collected into a repository.

There are three methods for the acquisition of resources:

1. Extraction by mining minerals (elements/abiotics).
2. Cultivation by growing biotics (life/organisms).
3. Human-made with machines (a.k.a., developed resources; e.g., hydrogen from electrolysis process of material interactions). Here, there is synthetic chemistry and synthetic biology.

The typical processes involved in resource acquisition and raw processing from the earth's crust include:

1. Mining - physical extraction and collection.
2. Transporting - transport from the mine to a production (materialization) center.
3. Primary cutting - to cut the mineral to a desired next transport or next processing stage (may happen at the mine or at a production facility).
4. Primary crushing - to crush the mineral to a desired next transport or next processing stage (may happen at the mine or at a production facility).
5. Stockpiling - concentrating the mineral in a local area.
6. Eletcromagnetic processes:
   A. Microwave heating (pre-treatment) - microwave pre-treatment can facilitate the liberation of minerals from an ore.
7. Mechanical processes:
   A. Cutting, grinding, and milling (e.g., cutting stone for furniture or tiles).
   B. Floatation.
8. Chemical processes applied to the mineral:
   A. Hydrometallurgy:
      1. Leaching.
      2. Solvent extraction.
      3. Electrowinning.
   B. Pyrometallurgy:
      1. Froth floatation.
      2. Thickening.
      3. Steaming.
      4. Smelting.
      5. Electrolysis.

Note that the typical desired result of these processes is a pure element.

2.2.1 Mining

Only a minority of chemical elements, such as silver and gold, are found uncombined as relatively pure native element minerals. Nearly all other naturally occurring elements occur in the Earth as compounds or mixtures. Similarly, air is primarily a mixture of the elements nitrogen, oxygen, and argon, though it does contain compounds including carbon dioxide and water.

Mining element categories by degree of bulk availability:

1. All elements (all ores, including metals and non-metals).
   A. Industrial ores (industrial minerals and metals) - are found in hulk quantities on the earth).
      1. Technology and precious metals and ores - are not found in bulk quantities on the earth).
   B. Fuel mineral ores - are no longer found in bulk quantities.
   C. Chemical precursor synthetic-source mineral ores - are no longer found in large bulk quantities.

It is important to note that in general, the time taken to discover a mineral deposit to the construction of a functioning mine is between 15 to 20 years.

2.2.1.1 Resource convertibility

A.k.a., Resource conversion.

Resource convertibility refers to the ability to mine and produce a resource (i.e., mining resource and habitat mineral materialization is about resource convertibility).

The following need to be done to convert a raw resource into a finished production:

1. Converting targets to real-world mineral/resource discoveries.
2. Converting discoveries (geo-positions) to extracted and collected resources.
3. Converting resources to reserves (stocking).
4. Converting reserves to production (using).

Note: All steps are about sustaining the user demand for habitat services.

In concern to resource conversion, there are two common metrics. The first common metric focuses on the resources reserve base, because of the long times associated with building a resource base.

- Look at reserve base, identify the "cost" of acquiring (re- and/or pre-) the reserve base.

The formula for the industrial resource reserve base is:

- X = Industry reserves at year 2010 for a mineral.
- Y = Industry reserves at Year 2020 for the mineral .
- Z = Production of mineral from 2010 to 2022. All of production came out of the former reserve base.
- *Net additions to the mineral (eg., copper) reserves: Y - X + Z

**Net additions to mineral reserves shows some combination of exploration and raw processing success.*

The second common metric is the efficiency of exploration metric, where:

- Z = net reserve additions. Answer whether reserves have increased or decreased as measured in mass/weight/stock.
- A = cost (financial, trade, electricity, technical units) of making additions. Answer what has been spent over one year getting copper reserves in financial cost.
- A/Z cost per unit of adding reserves.

2.2.1.2 Mineral mining specifics

The following is a brief description of key factors associated with mining:

1. **Water:** Water is an important consideration in minerals planning as it often plays a key role in mineral extraction and processing. Unsafe mining practices may over-extract and pollute local water systems. Water drainage from mineral extraction must be monitored closely as dissolved or suspended minerals can damage fisheries and wildlife habitats. Mineral operations and tailings (finely ground waste) installations must be designed and monitored in order to avoid overflows which could result in contamination and flooding.
2. **Copper:** Copper occurs naturally in a pure state throughout the earth's crust; however, it is primarily mined from chalcopyrite, bornite, and malachite. Copper ore is extracted from the earth, then converted into copper concentrate, which is then roasted, smelted and converted into refined copper.

2.3 Resource readiness matrix

A.k.a., Resource readiness index, resource readiness level, resource development level, resource development index, resource dependency level, resource development phases, etc.

It is possible to develop new resources for new applications, and it is possible to develop alternative resources for existing applications. A resource development matrix depicts the position of new and alternative resources in relation to how complete and ready the resource is to integrated into a technology. Resource readiness levels (RRL) are a type of measurement system used to assess the maturity level of a particular resource. This matrix is similar to the technology readiness level index, but represents the readiness/development level of the resources that go in to various existing and new technologies.

3 Unified habitat heritage network planning of resources

A habitat is viewable as one large technical unit, within which multiple groupings of sub-habitat technical units exist. The habitat is the unit that produces material life, technology, and exploratory service fulfillment. The habitat is a productive service system for humanity; it is a habitat service system.

In the market-State, future projections of global habitation (demand) are usually developed on past behavior and belief without recognizing that community expresses an altogether different materially integrated service environment.

> **QUESTION:** *What quantity of resources (minerals and biotics) and what kind of resources will be needed to source the construction of, and to operate, community-type habitat service systems.*

3.1 The habitat technical unit resource inquiry

> **INSIGHT:** *All resources are valuable and we ought to get the most out of every resource. And, the economy should serve humanity and ecological service regeneration so that the earth supports a healthy human ecology.*

At the habitat level, it is possible to consider the habitat as a single technical production unit; wherein, the resource inquiry becomes:

1. What is the dependency on a given resource?
   A. How much of the total habitation system uses the resource?
   B. How much of the resource is used in critical infrastructure?
2. Identify the resource producing unit (a.k.a., production unit, technical unit, etc.).
   A. What, why, how much, over how much time?
   B. Estimate future production.
   C. Identify alternative production sources?
   D. What, why, how much, over how much time will it take fully develop the alternative resource production unit (e.g., steel production).
3. How much of each given resource is in each habitat unit?
   A. Estimate of mineral content for each habitat unit. How much mineral is in each habitat unit?
      1. Estimate of metal content for each habitat unit. How much metal is in each habitat unit?
   B. Estimate of how much biological materials (dead and/or living matter) there is for each habitat unit. How much biological material is in each habitat unit?

4. What is the turn-over rate on a given resource, and is it sustainable (is depletion occurring)?
5. Are there alternatives to the given resource?
6. What is the time required to develop, construct (and commission) the habitat unit?
7. What is the human work required to develop, construct (and commission) the habitat unit?
8. What is the human work required to continuously operate the habitat unit?
9. How much of each resource does the habitat unit use over the course of its life-span?
   A. How much fuel and/or flow is required for each habitat unit to operate.
10. How much can be recovered from the habitat unit after de-commissioning?

Unified planning (through integrated habitat master planning and statistical economic services) is the optimal way to efficiently allocate resources for globally optimized human need fulfillment. In order to optimize the acquisition and transformation of resources into needed goods and services, the following data must be identified/collected.

Any physical construction is composed of resources and processes. Useful processes done to resources are called tasks. A habitat is, in part, a composition of tasks. It is possible to identify, given transparency, [human need fulfillment] tasks and the resources required to complete/fulfill them:

1. What are the total tasks done and powered by fixing in minerals?
2. Flow in minerals to production systems that do tasks with power.
3. Flow in minerals to deliverable system that do tasks with power.
4. What are the total tasks done and powered by using minerals as fuel?

Determine true scope of useful work done (identify human needs and the scope of requirements for fulfillment):

1. Calculate the quantity and quality of minerals needed.
2. Calculate the quantity of fixable minerals needed.
3. Calculate the quantity of fixed minerals for production systems needed. Fixed in minerals to production systems.
4. Calculate the quantity of fixed minerals for user deliverables needed. Fixed in minerals to human-user object deliverables.
5. Calculate the quantity and quality of electrical power needed.
6. Calculate the quantity of mineral hydrogen (or other) resources needed as fuel.
7. Calculate the quantity and quality of mineral hydrocarbons needed as fuel and chemical precursor.
8. Calculate the composition maintenance resources needed.

The classes of habitat, for which there are some number of each:

1. Population number and architectural density.
2. Life phase (education & contribution, leisure).
3. Primary production type (cultivation, light, heavy, etc.).

Number of service-object (always, by class):

1. Architectural restoration - number of dwellings by class. Number and class of occupancy.
2. Architectural Production - number of InterSystem team buildings. Number and class of materialization technologies.
3. Architectural medicalization - number of medical team buildings. Number and class of all equipment.
4. Transportation - number of vehicles by class. Number and size of transportation paths.
5. Power - number of power stations by class. Number and size of batteries.
6. Water - number of water stations by class. Number and size of reservoirs.

Architecture support for shelter (for example):

1. An understanding of what and when to use architecture.
2. Medical support for rejuvenation:
   A. An understanding of what and when to use recuperation technologies.
3. Cultivation support for nutrition and biotic resources:
   A. An understanding of what and when to cultivate biological life.
4. Power support for technological motion:
   A. An understanding of what and when to use fossil fuel (hydrocarbons).
   B. An understanding of what and when to use nuclear fuel.
   C. An understanding of what and when to use gravity-solar motions (solar flows, water flows, etc.).
   D. An understanding of what and when to use an electric vehicle (EV).
   E. An understanding of what and when to use a hydrogen fuel cell (a.k.a. hydrogen power cell, H2-cell).
      1. Estimates of an electrical systems (EV) and hydrogen systems (H2-cell) to rail transport.

2. Estimates of an electrical systems (EV) and hydrogen systems (H2-cell) to maritime shipping fleet.

3.2 Resource life-cycle analysis visualization

A habitat master plan must visualize a full resource flow-chain cradle-to-grave, encompassing all resources from biotics, abiotics, and energy. It is further possible to map out all minerals going into all metals going into all service-products in the world (i.e., all minerals going into metals that go into products in habitat services systems). A mineral life-cycle analysis must be done on the construction materials used in the construction of the habitat.

Master plan visual resource accounting, simplified:

1. Identify the master plan of a habitat.
2. Within the habitat, design systems to last.
3. Identify the habitat objects and processes lists (note: processes occur to objects).
4. Identify the composition of all the objects over time/phase-of-life.
5. Create a life-cycle flow model as the objects (resources) move into, though, and out of the habitat as part of 'life', 'technology', and 'exploratory' need categories.
6. Identify current production of minerals (and other required materials).
7. Identify current sources of minerals (and other required materials).
8. Identify whether the current masterplan [for the habitat] is feasible given mineral availability.
9. Identify whether duplication of a constructed habitat is possible given mineral availability.

3.3 Resource-based economic calculation

Economic calculation is based on resource availability and [human] economic calculation. This calculation is done differently depending upon the specific societal system configuration:

1. A market configuration:
    A. Profit-over-others [from production].
    B. Owners [of production].
    C. Employees [of production].
    D. Consumers [of production].
2. A State configuration:
    A. Credit-tokens management.
        1. Money (circulation of credit-tokens).
        2. Sinngle use credit-tokens (no circulation).
    B. Work and operational regulation (including, working hours, zoning, competition & consumer protection laws, etc.).
    C. Police/military (regulation of work & population).
3. A community configuration:
    A. Human requirements.
        1. Needs from a societal system with a habitat service system.
    B. Resource requirements.
        1. Physical resources.
        2. Human labor.
    C. Resource availability.
        1. Physical resources.
        2. Human labor

NOTE: *The primary need-resource that all species manage (coordinate) is food. In other words, food is the basis of the economic system of all species.*

There are series principal questions that this calculation requires the integration of:

1. What are the **NEEDS**?
2. What are the **DELIVERABLE REQUIREMENTS**?
3. What are the **OPERATIONAL UNITS** that must be produced (i.e., of what socio-technical systems are the integrated habitat service systems composed)?
4. What are the technical **TOOL UNITS** that must be produced to produce the operational units?
5. What are the total **RESOURCES REQUIREMENTS** for the system?
    A. What are the resource requirements for the tool units?
    B. What are the labor (human work) requirements for the tools units?
    C. What are the resource requirements for the operational units?
    D. What are the labor (human work) requirements for the operational units?
6. What is the total **RESOURCES AVAILABILITY** for the system?

3.3.1 Economic calculation inquiry using technical units composed of resources and labor

The total integration of information for economic calculation includes technical units composed of resources and of labor. In order to calculate for human needs, technical unit service, resource availability requirements, and human work potential:

1. What class of technical unit?
    - E.g., Transportation technical units include trucks, commercial vans, passenger cars, etc.).
2. How far do they all go in one year?
    - E.g., What distance do they all travel in one year).
3. Qualification for comparative economic analysis/

calculation:
   A. If everything was an electric vehicle and they did that amount of work (distance traveled in one year)?
      1. How much electrical power would they need to charge those batteries over that amount of time?
      2. How much extra electric power would have to be added to the existing power grid).
   B. If everything was a hydrogen fuel cell and they did that amount of work (distance travelled in one year)?
      1. How much extra electric power would have to be added to the existing power grid).
   C. If there was a mix between electric and hydrogen fuel cells?
      1. How much extra electric power would have to be added to the existing power grid).
4. What power generation must occur if gas and coal are phased out, and wind, solar, hydro, nuclear and geothermal are substituted?
   A. What is the preferred and predefined energy split between these substituted electrical power producers?
5. What is the mineral content by analysis of technical units?
      1. What is the mineral (particularly, metal) content per technical production and operation unit (IAEA data)?
      2. What is the mineral (particularly, metal) content in the average electric vehicle.
      3. What is the mineral (particularly, metal) content in different battery chemistries?
      4. What is the mineral (particularly, metal) content in the average power producing technical unit?
      5. Etc.
6. Project the results of the surveys onto the numbers needed to produce to requirements?
      1. Sum it all up and the result is a list of numbers by minerals (particularly, metals) of what is needed for EV's, their batteries, hydrogen fuel cells, and the electrical power producing systems, and stationary power storage.
7. When mineral mining is going well (at sufficient production), what is produced by mining?
   A. One generation of operational technical units last how long, before they are phased out and another unit set is required?
8. How many years of production is needed to hit the economically calculated target number of technical production units required for economic fulfillment operations?
   A. The target set is for one generation of technical [operational & production] units.
9. If x number technical units of a specific class are the target, then:
   A. Cars (transportation service technical units) last about 10 years (given 2023 production engineering). After 10 years, the cars are phased out and another unit set will need to be produced (again).
   B. Wind turbines (electricity production technical units) last about 20 years.
   C. Etc.
10. What are the current reserves of minerals (particularly, metals)?
11. What is the rate of depletion or acquisition of mineral reserves?
12. Where is mineral mining most efficient, and least environmentally degrading?

4 Resource accounting for societal re-configuration

A.k.a., Societal system transition resource accounting.

It is possible to assemble a habitat network (non-market, non-State, significantly non-hydrocarbon) systems that could do the same useful work [as that being done in the market-State in the early 21st century] primarily through trade, wages, coercion, and hydrocarbons. In part, the goal of this project is to replace the market-State type societal system with one that represents community (in the form of humane and ecological production). Community habitats are not focused on trade of property, but on human need fulfillment.

With sufficient access to data, it is possible to determine what configuration of energy and mineral mix could produce a community-type habitat network.

Using the same energy and integrated mineral mix as the early 21st century, determine:

1. How many community master planned habitats would fit that same volume.
2. How many current market-State urban, sub-urban, and rural municipalities can be transformed into community-type habitat environments?
3. How many new habitats are needed?
4. What can be recovered from the old environments?
5. What power must be produced?
6. What mineral quantity, type, and quality must be produced?

The three basic concepts this replacement entails are:

1. How dependent on trade is the information and habitat production systems.
2. How is coercion used and in what applications?
3. By what method and social orientation have been and are resources being integrated as fixed construction and used as fuels?
4. If the market-State were to be phased out immediately, what would be required from:
   A. People?
   B. Materials?
   C. Energy/power generation systems?

Necessary data for determining the replacement of the system includes, but may not be limited to:

1. How much of each of the classes of minerals is consumed at a global scale, and State regional scale?
   A. How is the existing market-State configuration dependent on them?
   B. What applications (services) are the hydrocarbons used for?
   C. Quantify each application in context of its replacement.
2. How much of each of the classes of hydrocarbons is consumed at a global scale, and State regional scale?
   A. How is the existing market-State configuration dependent on them?
   B. What applications (services) are the hydrocarbons used for?
   C. Quantify each application in context of its replacement.
3. How much of each of the classes of technical production unit are consumed at a global scale, and State regional scale?
   A. How is the existing market-State configuration dependent on them?
   B. What production systems are there and what are they used for?
4. How much of each of the classes of service unit are consumed at a global scale, and State regional scale?
   A. How is the existing market-State configuration dependent on them?
   B. What service systems are there and what are they used for?

4.1 Resource transition planning

Unified resource planning involves an identification of what is, what is being moved to, and what is needed for transition:

1. How much extra capacity is required to phase out non-humane habitations and start operating integrate restorative habitat productions.
2. How many new habitats will need to be created?
3. What transformations will need to occur to present urban, rural, and suburban zones?
4. Required power grid expansion to charge the needed batteries and make hydrogen.
5. Number of new power stations.

Estimates of phasing out urban, sub-urban, and rural neighbourhoods for a network of community habitats include, but are not limited to:

1. Phase out (reduce) bad architecture, bad aesthetics, bad infrastructural integration, bad life-radius zones, bad pollution zones, bad master planning as that without integrated infrastructural habitation service zones.
2. What would it take to replace the existing political economic system with a community-type one?
3. Phase out (reduce) economic secrecy and political

competition (corruption) for working groups, habitat master plans, and habitat teams.
4. What would it take to replace property with personal access, trade with common access, and coercion with humane behaviors?
5. Phase out (reduce) the perception that good access requires private ownership for common heritage production optimization.
6. What would it take to replace the existing market-State productions with information working groups, habitat teams, and educated users?
7. What would it take to replace competition over scarce resources with optimization of resource configurations for human fulfillment, given what is known and available.

Material requirements to produce a new generation of technical production units:

1. Estimates of total material by class (e.g., element ID, metal) required to produce one generation of technical production units (a.k.a., technology units; e.g., wind turbines)...to phase out fossil hydrocarbon fuels. Total of each element ID in, tonnes.
2. Reported global reserves in tonnes of each material at a set date (e.g., 2019).
3. Number of generations of technology units that can be produced from global reserves of each material. In, number of generations.
4. Global reserves as a proportion of materials required to...phase out fossil hydrocarbon fuels. In percentage of whole proportion (%). Current global reserves for a give material resource will achieve what percent of 100% full generation of the productive technology unit. 100% means enough of the material for one generation.
5. Global material mining and raw materials processing (e.g., metallurgy) production by class (e.g., element ID, metal) and rate (of production) at a set date (2019). In, tonnes of each element ID, per year.
6. How many years of production are required at the rate produced at the set date (e.g., 2019) to meet the material requirements to produce one generation [of the actual volumes needed of the] new technical production units. In, years.

4.1.1 Power production transitioning

The goal is an integrated network of habitat services. Possibly, this transition necessitates a transition from hydrocarbons as fuel producing power sources to direct electricity power production. However, in the early 21st century there is a financial-industrial system of significant abstraction and physical complexity that took more than a century to construct with the use of the highest calorific dense source of energy on the planet (i.e., natural ore hydrocarbons) in abundant quantities. Hence, if the transition is also one of the replacement of hydrocarbons with technical electricity production units, then how is this to occur, given what is current and what is possible in the near future.

4.1.2 Resource calculation and technical production unit calculation arc

The resource and technical production calculation arc involves the following inquiries:

1. What is the true scope in type, composition, number, and size of technical unit required) to fully phase out?
2. What is the optimal proportional mix (of technical unit classes) to phase out and then to operate the new habitat production system?

Electrical power technical units include batteries, hydrogen cells, solar panels, wind turbines, internal combustion engines, etc.

4.1.3 In the early 21st century

Some data about the early 21st century:

1. In 2018, 85.5 of global primary energy consumption was fossil fuel based. And, less than 1%of the vehicle fleet is electric.
2. The gas industry is the buffer between the require power and what power is produced by solar and wind.
3. In 2018 there are an estimated 1.416 billion vehicles that have travelled an estimated 15.87 trillion kilometers. (with approximately 1.5 billion as of 2022).

4.2 Resource efficiency analysis

A.k.a., Resource optimization inquiry.

Efficiencies can be compared between the types of power systems, for example, if an electric powered transportation system is the objective, then:

1. Hydrogen fuel cells have an energy to weight ratio ten times greater than lithium-ion batteries.
2. An electric vehicle system requires battery storage 3.2 times the mass as the equivalent fuel tank (@700bar) mass of a H-cell system. For the same energy storage mass, the hydrogen fuel cell can go 3.2 times as far or will last 3.2 times as long. But, hydrogen is not an energy source; it is an energy carrier (in the sense that the hydrogen must be human made). It is either made with gas or

electrolysis. To make the hydrogen using electricity, a hydrogen H-cell system will require 2.5 times more electricity compared to make the hydrogen compared to charging an electric vehicle battery system.

From this, the analyses result is that:

1. All short-range transport should be electric vehicle systems. All vehicles that stay in a city ~100km. All passenger cars, vans, trucks and buses (1.39 billion vehicles) would travel 14.25km in 365 days. This would require 65.19 TWh of batteries (282.6 million tones of lithium-ion batteries).
2. All long range vehicles should be powered by hydrogen fuel cells. All class 8 HCV trucks, the rail transport network (including freight), and the maritime shipping fleet.
3. In total, 200.1 million tonnes of hydrogen would be needed annually.
   A. 695.2million passenger cars at 5.4 million km.

4.3 Risks to transitioning using resources

Risks to the transition of society from a market-State configuration to a community configuration using resources, include but are not limited to:

1. Ecological service tipping point - the harm the market-State has caused is so significant that ecological services collapse and provide no habitat for humans (this is a highly unlikely scenario).
2. Cannot provide enough mineral materials.
3. Cannot provide enough biological materials.
4. Cannot provide enough labor.
5. Cannot provide enough power.

5 Acquisition of resources

There are three primary ways of acquiring more resources:

1. Extraction (minerals).
   A. Mining - is the extraction of minerals (elements) from the earth's landscapes and oceans.
      1. Solids.
      2. Liquids and gases.
2. Cultivation (biologics).
   A. Holistic restorative cultivation - is the cultivation of a diversity of flourishing life over the landscape of the earth and water for food, fuel, and fiber, and bio-diversity and eco-system services.
      1. Food.
      2. Fuel.
      3. Fiber.
3. Motivation (humans).
   A. Fulfillment and well-being - humans see the relevance and have the self-ability and availability.
      1. Social support.
      2. Residency.
      3. Contribution
4. Creation (computers).
   A. Simulation and collaboration - computation reveals the feasibility and predictability of the current configuration of the specification.
      1. Virtual reality experiences.
      2. Artificial intelligence.

5.1 Mining for minerals

There are three types of minerals to be mined, based on the three phases of matter (liquids and gases are grouped, because they both are flows, which require conduited hook-ups, versus cutting of solids):

1. **Solid mineral mining (cutting):** This represents the conventional form of mining where solid minerals or ores are extracted from the ground via cutting and pulling out material. It includes a wide array of resources such as metals (gold, silver, copper), minerals (coal, salt, gypsum), precious stones (diamonds, rubies), and industrial materials (limestone, granite). Solid mineral mining involves various methods like surface mining, underground mining, and open-pit mining, depending on the type and location of the mineral deposit. These are produced in cut "grain" units.
2. **Liquid and gaseous minerals (conduited hookup):** minerals in liquid or gaseous states are typically not extracted through cut-mining

methods. Instead, they are often obtained through specialized extraction techniques or drilling processes in the case of oil and gas. Hydrocarbon chains are the most sought after liquid and gas minerals, as are elemental gases.

A. **Liquid minerals:** these might refer to liquid hydrocarbons like crude oil, which are extracted through drilling operations in oil fields. It involves drilling wells and using specialized equipment to bring the liquid hydrocarbons to the surface.
B. **Gaseous minerals:** gaseous minerals commonly refer to natural gases such as methane, propane, and butane found in underground reservoirs. Extraction involves drilling and utilizing techniques like hydraulic fracturing (fracking) or gas well drilling to access and collect these gases.

5.1.1 Solid mineral resources

Solid mineral resources are typically cut further and/or reduced in their cut "grain" size to smaller and smaller areas and then particle size. Here, There's an implied correlation between decreasing mineral grain size and the energy required for grinding. The relationship suggests that as the mineral grains become smaller and require finer grinding, the amount of energy needed to achieve this reduction increases, possibly in an exponential manner. The exponential relationship implies that as the mineral grains reach smaller sizes, the energy consumption for further reduction increases significantly. This may be due to the increased effort required to break down the mineral grains into finer particles as they approach a certain size threshold. Consequently, finer grinding to reduce mineral grains to smaller sizes may demand a disproportionately higher amount of energy. Solid materials also use more energy to transport, because they weigh more.

This relationship is critical in mineral processing and mining operations as it influences the efficiency and location (and quality) of mineral product. Understanding the energy-size relationship helps optimize grinding procedures to achieve the desired particle sizes while considering the energy consumption involved in the process.

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TABLES

Table 16. Decision System > Inquiry > Resources*: Renewable classification.*

Resource Classification Table		
Non-Renewable	Renewable	Resource Transformation
Oil and Gas; Coal; Metals & Mining; Industrial Agriculture	Biofuels (hemp fuel); Solar Energy; Wind Energy; Hydro-Current & Tidal Energy; Fission/Fusion Energy (inherently dangerous); Permacultural Agriculture; Geothermal* Energy (*geothermal may not, in fact, be a renewable energy, at least not on massive scale; we need more research)	Chemicals; Organic Decomposers (Fungi & Bacteria); Electromagnetic Radiation; Quantum Information
Non-Replenishable; Possible Resource Substitution Necessary	Periodically and Cyclically Replenishable	Knowledgeably Replenishable (i.e., necessitates knowledge acquisition and communication)

Economic Calculation Inquiry Accounting

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Abstract

This decision system contains an economic resource resolution matrix calculation service with a set formula that solve for the optimally planned configuration of those resources, given a set of categorical human needs and common heritage resources. A society may produce economic planned allocations of resources in order to optimally meet human needs and preferences, socio-technical master plans are resolved and decidedly selected. It is possible to use statistical calculation to compute significant and certain master plans for the optimization of human need by means of common heritage resource configurations. Economic resource-service plans, composed into tables, identify and calculate the inputs and outputs of habitat services. This inquiry uses both linear algebraic graph-matrix calculations (in order to have tables of "matrix products" that can be compared) with statistical services (including sample collection and analysis) of the demand, through to solution development and selection, and thereafter analytics on operations.

Graphical Abstract

Image Not Yet
Associated

1 Calculation accounting and inquiry

Calculation for habitat configurations is about meticulous planning and resource allocation. It is a systematic approach that utilizes calculated insights to take informed decisions, ensuring that the diverse spectrum of human needs is met in the most efficient and sustainable manner possible. This planning process is a critical component of decisioning, guiding the strategic direction of societal development and resource coordination. Economic calculation in the context of the decision system pertains to the process and methodology for planning and allocating resources within a society, distinct from traditional market-based or capitalist systems. It explains the "economic calculation problem," which traditionally argues that without price signals (provided by a market of supply-demand), rational allocation of resources is impossible. This problem posits that in the absence of market mechanisms, centrally planned economies cannot effectively calculate the needs for production and distribution of goods and services.

However, decisioning in community involves an alternative framework for economic calculation that does not rely on price mechanisms or private ownership to dictate the optimal allocation of resources. It can and may, however, use price during transition to facilitate the transition of people, information, and objects into a community configuration, and for leisure items therem (during transition to a vision of society without price or trade). Community is a model based on direct, participatory planning and contributed decisioning processes. This model aims to achieve an equitable distribution of resources, sustainable development, and the fulfillment of all individuals' needs through a cooperative approach (a service-to-other, and thus to self; v.s., service-to-self[-over others]. In community, the emphasis is on leveraging technology, comprehensive data collection, intelligence, education, residency and community input to take informed decisions about resource allocation, production, and distribution.

A societal decision framework involves economic activities driven by the collective global organization and its optimization of human persons and material resources. It suggests that through systematic planning and the integration of advanced decision support systems, a society can efficiently manage its resources in a way that prioritizes human well-being, environmental sustainability, and technological advancement. Community standards and intelligent master-planning decisions can easily overcome the challenges that market competition and profit motives are the only, or best, means to manage economic activities and resource allocation. In community, economic calculation within this framework is envisioned as a collaborative and dynamic information working group process (consisting of global standards decision working groups and local resident master-plan decision working groups; each of which is rooted in the principles of shared access, transparency, and sustainability.

In planning there is a mathematical (number count) and variable (concept/parameter) control space for calculation. The control "space" is defined as the "space" in which the controllable inputs are considered, processed together, and permitted as appropriate, through time. It is important to explicitly consider this "space" and understand how action in control "space" at time t_i impact the state space in $t_i + 1,..,i + n$. The envisioning of a control space makes it possible to encode the future structure of the production flows and interactions of an economy, and once encoded in a knowledge base, production plans can be computed.

Here, the community population desires to know how greatly its so-called “economy” actually economizes humanity's life-grounded resources by calculating their most efficient and productive [toward global human need fulfillment] usage, in the form of plans. Here, there are objects that have, at least:

1. type,
2. version (sub-type),
3. quantity (count),
4. geo-spatial location,
5. material characteristics,
6. functional characteristics,
7. priority.

Object master-plan assemblies (e.g., the habitat, a dwelling) are categorized as resource compositions, and two types of calculations may be performed on their master-plan solutions:

1. **A calculation that plans optimal allocation of resources of objects (create optimal allocation plans)** to services at specific locations given local and global demands. Mathematical optimization techniques such as linear programming, integer programming, and network optimization are used to solve problems related to allocation of resources, vehicle routing, inventory management, and supply chain optimization. This involves concepts from linear algebra (e.g., matrix operations for system analysis) and calculus (e.g., rates of change in production).
    A. Service resource allocation calculation [protocol, algorithm].
2. **An statistical intelligence analysis service for the socio-technical fulfillment of users (understand needs, preferences, and actualities completely)** through protocols that conform production to stated [societal] objectives. Statistics involves collecting, analyzing, interpreting, and presenting data to make informed decisions or draw conclusions about populations or

phenomena. Probability models and statistical analysis are used in forecasting demand, estimating delivery times, predicting inventory levels, and assessing risks associated with logistics operations.

A. Object[ive] production calculation [protocol, algorithm].

Economic calculation is a process that simulates out economic master-plan resource arrangements, identifies the current design specification's "economic" feasibility via a calculated threshold, and identifies optimal resource configurations. The main goal of the master-plan is to determine the best possible solution (habitat socio-technical configuration) in terms of function and form, based on resources and contribution, and create a plan (blueprint) that can be operationalized and function as a whole system [for global human fulfillment].

Economic calculation relies on user, production, and ecological surveys, and mathematical and economic resource models, which involve both linear algebra matrix calculations (for objects) and statistical calculations (for concepts):

1. **Linear-algebra matrix math calculations:** In [socialist] resource-service matrix economic planning, linear algebra is used to represent economic relationships, using input-output models or models of production and resource allocation, and using matrices/tables of data. Linear algebra can describe the flow of resources, goods, and services within an economy and analyze the impact of different production and allocation strategies, configurations, and service solutions sets. Here, resource configurations composed into socio-technical habitat services can be calculated and compared against one another using matrix math. From the matrix calculations come optimal resource-planned solution configurations. Here, it is possible to calculate the total cost of an issues resolution as its total measurable effect in reducing resource access for other needs (and service-objects) due to the new allocation of resources and human effort. What is the resource cost intra- and inter-solution? What are the resource costs between different solutions to the same issue (i.e., "intra-solution")? And, what are the resource costs between solutions to different issues (i.e., "inter-solution").
   A. What must be known is a precise habitat resource specification plan for the solution to calculate, using matrix mathematics (linear algebra) solutions with known and optimized resource allocations. Here, computers run many parallel processes to return/matrix calculated products of optimal technical production unit plans per resource, inclusive of thresholds and planned as specified socio-technical resource, labor, and knowledge configurations. Here, the quantities of what is produced (per the solution) are mathematically calculated for an effective-efficient economic system.
2. **Statistical-sample analytic math calculations:** Statistical methods may be used to analyze historical data, estimate parameters, and make

Diagram of appropriate automation given the accounting of community service elements

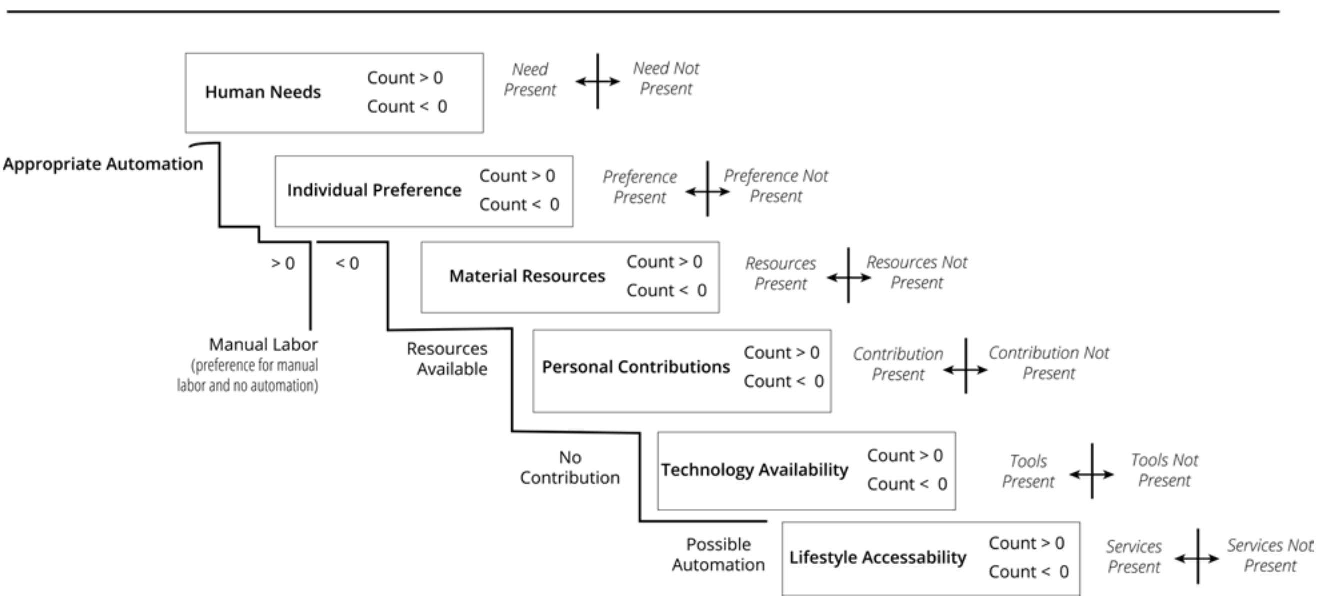

Figure 34. *Accountable habitat service elements for calculation of resource allocation and automation. Diagram shows appropriate automation given an accounting of community services.*

predictions about outcomes in the context of economic planning. For example, time series analysis, regression analysis, and statistical inference can be applied to assess past economic performance and forecast future trends. Significance, certainty, and deviation can be calculated as "statistics". Among other useful statistics gained. From statistical sampling and analysis comes the visualization of practical solution thresholds and parameters.

B. What must be known are data from environmental surveys, and the methods of statistical analysis.

The specific techniques and methods employed in socialist economic calculation can vary depending on the goals of the economic plan, the complexity of the economy, and the available data. Economic calculation inquiry planners may use a combination of mathematical models, linear algebra, statistical analysis, and computation to visualize and take decisions regarding resource allocation, production, and distribution (i.e., decisions about an economy).

An economic computational unit must:

1. Calculate the number needed to fulfill (as a demand survey threshold for final units), before resources are to be dedicated to its solution and productive execution.

Statistical analysis samples socio-technical fulfillment safety and quality/effectiveness. For any issue that requires societal coordination and contribution, the team population is sampled for purpose and objectives, and the user population is sampled for the presence and quality of need/issue, whereupon, statistics is a set of methods:

1. Search functions to sample data.
2. Conceptual data analysis (statistical criteria) on sampled data (e.g., mean, median, standard deviation, etc.).
3. Confidence/certainty analysis to be certain of statements about the data (e.g., p-value).
4. Power calculations to be certain of hierarchy.
5. Preference surveys to account for user data (e.g., user value).

In statistical system, the types and qualities of what is produced are mathematically calculated as a statistical service for the economic decision system.

For both mathematical systems (algebra and statical ones, there is the necessity for data search, data collection, data analysis, and decision threshold stopping rules.

Object linear variable measured description math (a.k.a., algebra) sub-inquiry and it's calculated resolution; and

Concept multi-variable measure description math (a.k.a., statistic) sub-inquiry and it's calculated resolution.

In order to calculate a plan for an economy, it is of significant importance to identify:

1. What a unit of production is (objectively):
   A. Objects.
   B. Processes.
   C. Complex of objects and processes.
2. What a cycle of production of that unit is:
   A. One cycle (e.g., on-demand, one actual production cycle).
   B. Multiple cycles (e.g., assembly-line production re-configurations over time).
   C. Flexible cycles (e.g., current production is customizable to continued adjustments of preference during production cycle).
3. What is the axiomatic unit [representational of the platform] for human-need fulfillment:
   A. A whole habitat (i.e., a complex of objects and processes).
   B. A usable service sector/area in a habitat (Read: habitat services can be sectorized within the perimeter of a local habitat; zoning).
   C. A usable object/good in a habitat (Read: people actually interact with objects that produce for end-users or are used by end-users; access designating to team, personal, or common).

A fundamental understanding of economic calculation requires, at least, an understanding of:

1. Understand systems thinking and methods.
2. Understand the basic elements and structure of input-output tables (IO tables).
3. Understand matrices (a.k.a., tables, spreadsheets, arrays), which are a presentation and calculation tool. A table (or, matrix) consists of the figures in a spreadsheet, arranged in a specified order, and from which charts (or, tables) undergo mathematical operations. Spreadsheets can show the relationships in an economy visually, interactively, and they can have the calculations done upon them.
4. Understand key aspects of linear algebra. Understand the use of linear algebra to create a system of linear equations from the IO table. Linear algebra codifies properties of matrices in the notion of linear maps. Matrix computation is the fundamental operation of economic calculation.
5. Understand how to setup a product system as a

set of linear equations, and express these as linear algebra.
6. Understand balances in IO tables.
7. Understand how to calculate a coefficient matrix (a.k.a., Leontief inverse, technology matrix, resource flow matrix, energy matrix).
8. Understand how to conduct a variable analysis.
9. Understand how to conduct statistical analyses.

Within a community-type societal system, the above "economic" information is calculated in the context of a larger decision systems that resolves complex state solutions to re-configurations of the natural, real-world.

1.1 Production calculation inquiry

A.k.a., Calculated production planning inquiry, central planning, central production planning, centralized economic planning, mathematical planning, etc.

The following taxonomy identifies the interconnectedness of mathematical modeling, simulation, and optimization within the context of production planning, emphasizing how they collectively contribute to informed decisioning and efficient production:

CLARIFICATION: *The choice of math depends on the specific problem or question being addressed and the available data.*

A simplified overview of the calculation planning system:

CLARIFICATION: *Each service below operates within the broader framework of the economic calculation service system, providing specialized expertise and methodologies to address specific aspects of economic decision planning. By integrating the outputs and insights from these services, the decision can formulate comprehensive plans that are informed by optimization models, complexity analyses, statistical forecasts, and simulated scenarios. This integrated approach ensures that the economic decision system is robust, adaptable, and capable of supporting a sustainable network of human habitats, with a focus on optimizing life, technology, and exploratory services to meet the needs of residents.*

1. **Linear optimization planning (e.g., kantorovich):**
   A. **Objective:** To optimize resource allocation and production processes using linear programming and other optimization techniques.
   B. **Functions:** Develop linear optimization models to maximize efficiency and productivity; solve resource allocation problems; optimize supply chain and logistics.
   C. **Applications:** Sustainable resource distribution, infrastructure development planning, and efficiency optimization in service delivery.
2. **Assembly complexity analysis:**
   A. **Objective:** To manage and reduce the assembly complexity of physical infrastructure and service systems.
   B. **Functions:** Quantify assembly complexity using specific metrics; implement modular integration strategies; conduct efficiency analysis to minimize complexity impacts.
   C. **Applications:** Design and reconfiguration of habitat infrastructure; integration of new technology into existing systems; scalability and adaptability of service delivery models.
3. **Statistical services:**
   A. **Objective:** To provide probabilistic analysis and risk assessment capabilities, supporting decision-making under uncertainty.
   B. **Functions:** Forecast demand and supply trends; analyze risk factors and their potential impacts; perform statistical quality control.
   C. **Applications:** Risk management and uncertainty analysis in resource provisioning; demand forecasting for life, technology, and exploration services; statistical analysis for policy development.
4. **Simulation services:**
   A. **Objective:** To simulate various operational scenarios and their outcomes, aiding in strategic planning and decision-making.
   B. **Functions**: Develop and run simulations to test the impacts of different decisions and external factors; use scenario analysis to explore future possibilities.
   C. **Applications:** Strategic planning for service evolution; operational resilience testing; exploration of new technological or service opportunities.

A complete overview of the calculation planning system:

1. **Mathematical modeling and optimization:** Utilizes linear algebra and statistical methods for solving optimization problems to make better decisions in production planning. Here, mathematical formula are used to represent [economic] production systems, facilitating the analysis and optimization of resource allocation and production processes for efficiency and effectiveness. Here, math is used to plan and optimize the design and construction of habitat service-object delivery systems.
   A. **Linear algebra mathematics (determinitive; deterministic planning services -- linear math):** Essential for modeling the structural relationships within the production process,

solving resource distribution of equations in production, and optimizing resource allocation. Required for expressing and solving optimization problems. Used for structural optimization in production. Used for modeling and analyzing the habitat service production system's structure and behavior under uncertainty.

1. Linear formulas express a deterministic relationship between two or more variables. Linear formulas represent exact relationships, assuming no other factors influence the variables. Linear formula describe deterministic relationships.
    i. Linear formula form: are expressed as equations involving linear algebra, inclusive of variables, constants, and arithmetic operations like addition, subtraction, multiplication, division, and matrix equations.
        1. Variables and coefficients can be represented by matrices, leading to matrix equations. Matrix multiplication is then used to resolve complex linear relationships involving multiple variables simultaneously. Matrix equations are still deterministic, just like traditional linear formulas.
        2. Kantorovich's optimization formula: Linear programming and resource allocation directly inform capacity planning and optimization tasks used in production planning and the efficient use of resources. Linear programming is a foundation for decision sciences.
            a. Kantorovich's linear programming formula: Maximize $c^T x$ subject to $Ax \leq b$, $x \geq 0$, where c is the coefficients vector of the objective function, A is the coefficients matrix for constraints, x is the variables vector, and b is the constants vector of constraints.
2. Role in economic calculation: Fundamental for determining the most efficient use of resources across different sectors and activities, employing mathematical modeling to optimize production and distribution plans in line with economic objectives.
3. Role in habitat economy: Optimizes the sustainable use of resources across habitats, ensuring efficient allocation to life, technology, and exploratory support services.
4. Example forms of linear formula are:
    i. Graph form: $y = mx + b$ (slope-intercept form).
    ii. Physical/natural unit form: Distance = Speed x Time.
    iii. Maximization form: maximize or minimize f(x) subject to $g(x) \leq b$, where f(x) is the objective function, g(x) represents constraints, and b is a boundary condition.
    iv. Matrix form: $Ax = b$ (general form of a linear system of equations), where A is a matrix of coefficients, x is a vector of unknowns, and b is a vector representing the right-hand side constants.

B. **Statistical mathematics (correlative; statistical planning services -- statistical math):** Essential for analyzing variability and probablistics, forecasting demand, and assessing risks in production processes. Required for uncertainty and risk modeling; for handling variability, forecasting, and risk assessment. Used for risk and variability analysis. Used for modeling and analyzing the habitat service production system's structure and behavior under uncertainty.

1. Statistical formulas describe the statistical distribution of data or quantify the relationship between variables based on observations or samples. Statistical formulas express likelihoods or trends within data, not exact values. Statistical formula describe data distribution and variable relationships.
    i. Statistical formula form: Can involve statistical measures and functions like means, medians, standard deviations, correlation coefficients, regression models, and probability distributions.
    ii. Can be adapted to work with matrices: Statistical formulas adapted to matrices still deal with probabilities and variability, even when using matrix operations.
        1. Linear regression: Utilizes matrices to estimate coefficients in models relating multiple independent variables to a dependent variable.
        2. Statistical measures like mean, variance, and covariance can be calculated for matrix-valued data, providing summaries of complex multivariate distributions.
2. Example forms of statistical formula are:
    i. Traditional, sampling form: Mean production time = $\Sigma x_i / n$ (calculating the average).
    ii. Matrix form: Calculating descriptive statistics for data stored in matrices.

C. **Assembly complexity formula mathematics (compositive; assembly complexity planning services -- assembly math):** Analyzes assembly complexity and efficiency, including principles of component integration and the assembly index as a measure of complexity. Focuses on the mathematical analysis of assembly complexity and the optimization of assembly processes, including the use of the assembly index to measure and manage complexity. The formula may be used to analyze assembly complexity and efficiency, including principles of component integration. The formula becomes usable once an assembly tree diagram is constructed. Assembly complexity analysis facilitates the efficient design and delivery of services related to life, technology, and exploration services, optimizing technological and socio-technical assemblies. Used for modeling and analyzing the assembly complexity of a habitat service productions.

1. Assembly complexity index formula: Summation (sigma) notation form.
2. Accounting for and coordinating assembly complexity involves complexity metrics, and efficiency analysis, often focused on evaluating and reducing the complexity associated with assembling systems. This involves using metrics to quantify assembly complexity and adopting modular integration strategies that enhance adaptability and scalability. Efficiency analysis ensures that the design and deployment of habitat components minimize resource consumption and environmental impact while maximizing functionality and resident satisfaction.
3.

2. **Simulation and computational modeling mathematics (simulation planning services -- simulation math):** Uses mathematical algorithms to simulate and evaluate (test and prototype) different resource configurations and scenarios (in habitat production), aiding in decisioning by visualizing the impact of various actions on assembly and production efficiency. Here, computational techniques are used to replicate the behavior of [economic] production systems under simulation conditions, aiding in understanding the impacts of decisions and variability without direct real-world experimentation. Simulating the habitat network facilitates demand education, service delivery, technological development, and service production.
   A. **Animated event simulation:** Useful for modeling production and usage as a series of discrete events and understanding the sequential impacts on the process.
3. **Risk analysis and management (risk math):** Involves identifying and managing potential risks in the production process to minimize negative impacts. Required for identifying and managing potential assembly-related risks. Risk analysis identifies and mitigates risks associated with habitat operations and external environmental factors, ensuring adaptive and resilient planning for life, technology, and exploration services.
   A. Statistical methods: Uses statistical methods to identify, assess, and mitigate risks associated with production and assembly processes, ensuring that potential issues are managed proactively.
   B. Linear formula: expected loss = ∑ (probability of risk × impact of risk).

1.1.1 Centralized economic production planning

Centralized economic production planning requires at least the following forms of mathematical techniques in order to effectively and efficiently allocate resources:

1. 1. Optimization techniques:
   A. Linear programming: Essential for allocating discrete resources like machines or workers, particularly in scenarios with limited quantities.
   B. Dynamic programming: Crucial for long-term planning and resource allocation across multiple periods, especially under fluctuating demand or supply.

2. Data analysis & machine learning:

2. Time series analysis: Underpins accurate forecasting of future demand and production requirements, shaping informed planning decisions.
3. Regression analysis: Reveals valuable insights into factors influencing costs, quality, and efficiency, guiding optimization efforts.

3. Modeling:
   A. Queueing theory: Helps optimize buffer sizes and scheduling to reduce bottlenecks and improve resource utilization, ensuring smooth production flow.

1.1 Structural capacity

A.k.a., Carrying capacity.

Most ecosystems (as well as commons) have a [structural] **carrying capacity**, a limit on their use beyond which the commons itself will begin to suffer decline. A forest where "commoners" gather wood will replenish itself so long as the commoners never exceed the forest's carrying capacity. The moment they do, the probability becomes that resource loss will [after a dynamically set, variable amount of time] render the non-existent of any forest in that time-space.

The concept that a given finite environment has a 'carrying capacity' is a verifiably factual understanding; carrying capacity is an empirical concept which relates the needs of a group of organisms to their environment, which may also have a set of needs. If, for instance, a group of people exceed the carrying capacity of a bridge, then they risk not having a structure [safely] under their feet. The bridge, as part of the groups spatial environment, has a weighted 'carrying capacity'; and, humans have a need for a [sufficiently] stable platform under their feet when they traverse a height.

The carrying capacity of a community's socio-economic system is dynamic. It is dynamic, in part, because it exists within a natural environment, and also, because the system depends upon its material design, which is dynamically informed by the community's iterative design. Natural processes may be used to produce surplus (e.g., permaculture) and the designed application of technology might extend carrying capacities (e.g., multilevel flooring).

As a factor in the real world cost of production and a characteristic element of every preservation strategy, the technical economic efficiency inquiry must necessarily include the *carrying capacity* of the known environment as one of its inputs. This includes (1) the carrying capacity of the community's systems as well as (2) the natural environment's carrying capacity. A carrying capacity is the maximum population size an ecosystem or structure can support. Both man-made structures and natural environments have carrying capacities - every dynamic system maintains a carrying capacity.

An inquiry into the carrying capacity of a living system asks, "With the information known, how many organisms can a particular ecosystem [or planet] support strategically [over time] without suffering severe or irreparable damage?" The answer to such a question constitutes the system's carrying capacity [in context]. Since physical structures and ecosystems are finite in their size and resources, each has an upper limit to the population that it can support. In other words, each eco-system has an upper limit to its ability to provide food, resources, maintain itself, resist damage, maintain safety, and provide the assorted ecological services that allow a given population to live and exist somewhere in sometime.

Herein, 'population pressure' is defined as the ratio between population density and the density of available resources (i.e., the resource capacity of an environment). An increase in population pressure is a circumstance that makes it harder for organisms to survive, which may be self-caused, such as high population growth, or environmentally induced, such as through a draught.

Garrett Hardin likens carrying capacity to an "engineer's ... estimate of the carrying capacity of a bridge." (Hardin, 1986) Biologists (and systems engineers in general) often use the term **thresholds** to refer to limits that, when exceeded, constitute critical boundaries within a system. As Soule observes, "Many, if not all, ecological processes have thresholds ..." In the same paper, Soule reminds us that "genetic and demographic processes" also have thresholds. (Soule, 1985)

The carrying capacity of an ecosystem is derived from a formula involving a variety of physical-ecological (environmental) variables. The variable set includes, but is not limited to environmental media (e.g., water, soil, air, energy and physical size) and the periodicity of resource regeneration. Such a calculation involves the tracking of systems change, and the regeneration of resources, over time. Tracking of resources is necessary for a system to remain in a state of dynamic equilibrium (or 'threshold effect') so that resources are available as desired (i.e., for access abundance). If a community uses up trees in their habitat faster than they grow back, then the community has a serious life-support problem emerging, for such an action is unsustainable and reaches beyond the carrying capacity of the habitat. Herein, transparency and resource tracking facilitate the ability to optimize an economic fulfillment system.

The physical-ecological information set comprises all fixed and flexible components of the natural and human-designed environments, including the habitat service system infrastructure. The *fixed* components refer to the capacity of natural systems expressed occasionally as *ecological capacity*, *assimilative capacity,* etc. They cannot be manipulated easily by human action and to the extent these limits can be estimated they should be carefully observed and respected as such. The *flexible* components refer primarily to our designed 'service support' systems (and their characteristics) like water supply, sewerage, electricity, transportation, social amenities, and other services. The capacity limits of these systems are improved through greater knowledge and understanding, and technical production efficiency.

In other words, carrying capacity exists, and a carrying capacity can be synthetically extended through increases in the efficiency and effectiveness of technological integration.

Please note that the carrying capacity calculation requires the continuous surveying, monitoring, and tracking of physical resources (i.e., it requires *Resource Inquiry*). In a 'global access system' all resources are tracked in a transparent manner such that every individual in the community has an awareness of the availability of a resource and acutely understands the implications of its re-allocation (or "consumption").

The structure of a system limits its capacity. There is only so much that can be done to increase capacity, beyond that the structure must be re-designed. Wherein, when function is lost, so is capacity.

There are three distinct levels of optimization:

1. Optimization within the structures (or system management.
2. Optimization of the systems structures (or system design).
3. Optimization of the context structures (or global system design).

Regulating the process of generating fulfilling goods and services is the process of 'systems coordination' as the organized rearranging and replacing of tools and components, which is necessary for all forms of optimization Herein, the integration of a system among a community of individuals for commonly optimized access is known as 'global system design'.

> **NOTE:** *In a sustainable economic design model, the rates of natural regeneration must be accounted for.*

1.2 Computational capacity

> *A.k.a., Computational inquiry resolution*

This inquiry space is designed to calculate the technical feasibility of a solution via an inquiry and a "triggering" threshold. Herein, the economic efficiency inquiry assesses the designed solutions for their placement along a technical optimization and preservation spectrum. The spectrum maintains a formally set, qualified and calculable, triggering threshold. When this threshold is reached, then the issue as it is presently solved for (by inquiry into the current design specification) does not "pass" this inquiry process, and therefore, requires a structural or material redesigned with different resources or fewer real world costs. This inquiry process asks if the proposed solution is technically feasible:

1. The solution doesn't significantly impact the resource requirements of other priority issues.
2. The solution is "structurally sound" given what we know of the system and its material's composition.

For humans, exceeding the carrying capacity of their environment is likely to lead to environmental challenges as well as a wide-variety of social and behavioral problems that fundamentally do not support an evolution toward a higher potential form of life enriching experience. Hence, resources can only be used at a rate that they can be adequately renewed. The sustainable management of a community's resources is integral to the survival of the community, and their equitable allocation is integral to social stability. Resource regeneration must never dip below what is sufficient for each system, particularly the core systems, if the community is to sustain a state of dynamic equilibrium, and maintain a common level of basic fulfillment.

The economic efficiency inquiry is essentially a preservation strategy that is logical founded upon the empirical processes of biological preservation and technical [structural] efficiency, which can only define true human sustainability; leading to a greater potential for access abundance and material freedom in our designs. And, a reminder, that material freedom (i.e., a more thought responsive environment) comes with a different value set.

By calculating the total cost of an issue's resolution as its impact on other economic inputs and outputs (e.g., true cost economics), then this inquiry process presents the community with an economic adaptation mechanism that objectively and cohesively visualizes all possible alternative options for the allocation of resources toward the resolution of an economic issue. And, that information can be processed to select for a solution that indicates the highest community optimization and preservation based on an informed and formalized feasibility threshold. Herein, *optimization* refers to the selection of a solution that has the lowest resource cost/requirements relative to other needed and formally prioritized goods and services.

> **NOTE:** *An infinite-grow paradigm [on a finite planet] is unsustainable.*

1.3 Optimizational capacity

> *A.k.a., Optimization inquiry resolution, pareto efficiency, pareto efficient optimization, optimal distribution.*

A pareto-efficient distribution of goods based on individual needs, preferences, and available resources. Pareto efficiency, named after the economist Vilfredo Pareto, refers to an allocation of resources or goods in a way that no individual can be made better off without making someone else worse off. It essentially suggests that a distribution of goods is "Pareto" efficient if there is no way to reallocate those goods that would improve the well-being of at least one person without reducing the well-being of someone else. A pareto-distribution is optimal if it is impossible to improve anyone's condition by modifying the distribution of goods, without making someone else worse off.

More completely, achieving Pareto efficiency in the allocation of resources to fulfill human needs means that the distribution is such that no individual's fulfillment of needs can be increased without reducing the fulfillment of someone else's needs. In other words, achieving Pareto efficiency in the distribution of common heritage resources to human need would mean that the allocation is at a point where no one's basic needs can be better addressed without sacrificing the ability of others to meet their own basic needs. Pareto efficiency reflects an allocation where resources are distributed in a way that maximizes the fulfillment of human needs without worsening anyone else's situation. It emphasizes an optimal distribution where no one's needs can be improved without negatively impacting someone else's ability to meet their own needs.

Pareto-efficiency is a desirable property of an social economic production system. In the context of individual needs and preferences, and goods distributions, achieving Pareto efficiency means that the allocation of goods among individuals is at an optimal point where no one can be made better off without making someone else worse off. This doesn't imply that everyone is equally well off, but rather that the statistical distribution has reached an optimal state given the needs, preferences, and resources available.

It is possible to imagine Pareto-efficiency optimized situations. Imagine a situation where there are two individuals, A and B, and a certain quantity of goods (like food, clothing, etc.). If the total goods are re-distributed in a way that increases the amount of goods for A without reducing B's goods, or vice versa, that new distribution would be considered Pareto improving. However, if A cannot be made better off without making B worse off, or vice versa, the current distribution is said to be Pareto efficient. Pareto efficiency is a desirable property in economics because it signifies an allocation of resources where no one can be made better off without causing harm to others. It's considered a benchmark for economic optimality, though achieving it in the real world can be challenging due to various complexities, market imperfections, and conflicting intentions among individuals.

1.3.1 Market pareto rule

A.k.a., Market pareto rule.

Pareto efficiency ought not be confused with the "market pareto rule". The market "pareto rule" is especially relevant in business and government. This "pareto" rule that says that these structures (market-State) are likely to form organizations of people in the ratio of 80 to 20 (80:20). The pareto rule is more often seen with larger organizations, with larger populations of people .Eighty percent of the people in the organization will be dedicated to one type of issue (e.g., the survival of the organization), and twenty percent will be dedicated to the actual mission of the organization (e.g., making a product). In the pejorative sense, twenty percent of people are doing the actual work (or 20% of everyone's time is dedicated to actually useful work), and eighty percent of people are working to support the management/owners of the organization (80% of everyone's time is dedicated to non-useful work).

1.4 The economic calculation problem

The economic calculation "problem" is a contextual criticism of economic planning in favor of price and market-based allocation organizations. In the market, economic calculation involves adding up costs in terms of money. By viewing society as an information system with key sub-systems, one of which is a decision system, it becomes possible to see that through the use of project planning and systems engineering actionable lists are made available from which objective measures of progress are determinable. Economic calculation and planning are possible when there is contribution within the context of different habitat configurations of common heritage resources, and a system for useful calculation. In order to calculate an economic plan, a society requires accurate data on resources, knowledge, and expectations. Economic calculation occurs in the market in a similar way to community, but in community, the entities who are accountable for economic planning are cooperating and not competing. The economic calculation problem was given by Von Mises and latter built upon by Hayek:

1. Misesian argument: This focuses on the challenge of economic calculation in socialism, arguing that without market prices, it's impossible to make rational economic decisions regarding resource allocation.
2. Hayekian argument: Emphasizes the dispersion of knowledge and the complexity of economic coordination, arguing that a central planning body cannot possess all the dispersed information necessary for efficient economic planning.

The basic argument is that:

> *Rational economic decision-making (about fulfilling wants, "consumer" preferences) is not possible without the price signals provided by genuinely competitive markets based on private ownership of the means of production, investment on the basis of profit-maximization, and market supply-demand price.*

The economic calculation problem is a criticism of central economic planning and planning without price. The "problem" being referred to is that of "how to distribute resources rationally in an economy" without market prices. The free market solution involves something known as "the price mechanism"; which is itself a claim that "people individually have the ability to decide how a good or service should be distributed based on their willingness to give money for it". Instead of proposing a contextualized problem, the claimed "economic calculation problem" argues that the "price mechanism" is the only possible means to understand how to "efficiently" create and move goods around an economy.

The controversy over socialist-type economic calculation (a.k.a., the economic calculation problem) dates from a split in the Vienna intellectual community in the early 1920s. On the one side was Neurath who had become a strong "socialist" who was adamant that a socialist economy had to be moneyless. (Cockshot, 2018) On the other side of the argument, against a moneyless-type society, were Mises and Hayek. Neurath had argued for a "socialist" economy in which calculation in-kind replaced/obsoleted money. Mises response was to simply state that such calculation was impossible and irrational. Neurath's argument become the "left" or "left wing" case, where societally could be optimally organized according to knowledge, resources (and human effort), and human needs; on the other hand, Mises and Hayak became the "right" or "right wing" case, where society could be optimally organized based on property, trade, and possible regulatory assurance organization (Read: a State or State-like entity).

The economic calculation problem makes the claim that price can be, and is, the ultimate mediator of decisions in the market; which, is a truism for the organization of an economy as a market. Notice the continuous presupposition of the presence of a “market” in the description of the problem itself. The economic calculation problem is a market problem, if it is in fact even a problem. In other words, if the economic calculation is a problem at all, then it is a problem with a specific form of economic organization known as “the market”.

The economic calculation problem put forward by Mises states that without a pricing mechanism there is no way to rationally allocate goods and services [in a market], wherein ‘price’ acts as the data point that communicates to the market [system of consumers and producers] how much to adjust their production levels in order to meet demand. The assumption (or assertion) that market advocates take as though it is an axiomatic principle of logic is that demand and distribution cannot be computed (or calculated) without price.

In other words, the economic calculation problem as it is described can only pertain to a trade economy, it is de-contextualized from other (or different) relationships to the natural world. The economic calculation problem has no reference for the existence of an economy not based on the trade of goods and services in a market. Essentially, the language which created the claimed “problem” can’t be used to understand the actual problem. It is necessary to have integrated an understanding of systems thinking as a tool if one is to critically comprehend why the economic calculation problem is the problem of a particular socio-economic structuring, and does not necessarily apply to other structural organizations. It is the use and the framework of language in the question that imparts a misunderstanding about the essential issue - the economic fulfillment of human need.

The economic calculation problem may in fact be a valid criticism of a “centrally planned market”. There is some degree of competition in every market; hence, there is some artificially enforced degree of opacity to the acquisition of information; hence, there is some noise interfering with a purposeful plan [to distribute resource “rationally”].

Traditional market thought argues that the dynamic variability of human interests make it technically impossible to “calculate demand” without the “price mechanism”. While this may have been somewhat true in the early 20th century when these claims were made, the age of digital computation and information calculation, systems thinking and design engineering, coupled with the functional extension of ourselves through (sensing and tracking) technology, humankind has commonly removed this barrier to the obfuscated realization of complexity in the natural environment.

1. **Price negotiates** decisions in the market. Negotiations occur between, competing and otherwise opposing, forces.
    A. *Profit* is an encoded value (there is *profit value system - the value system of a market-State society*).
2. **Individuals in a community account** for information and calculate (or compute) the most effective and efficient means of freely fulfilling their needs. The accounting and calculation of information in a system necessitates cooperation, a synthesis of forces. Calculation notes the degree of accountable efficiency in a cooperative relationship.
    A. *Use* is an encoded value (there is *use value system - the value system of a community-type society*).

In market-based thought, “price” takes upon itself (Read: assumes) “subjective human whims” and converts them into “objective numerical values” creating a state where all “heterogeneous goods” can be “objectively” compared; thereupon, a vase can be compared [in price] against a bottle of water [in price]. Price is an arbitrarily subjective and utilitarian value placed upon owned[-able] property [with some sprinkling of labor energy and scarcity reflected in price, though they are obscured by noise].

1. What are “subjective human whims”?
2. What is this conversion taking place?
3. What is objective?
4. How are numerical values derived from a subject?
5. What is meant by “heterogeneous goods”?
6. What is actually being compared?

The “signaling function” of the market (i.e., price) is erroneous because it does not separate the noise from the signal; and hence, it cannot facilitate orientation in an intentional direction through a common environment.

Price is subjective; it redirects our individual relationships away from nature, away from that which is. It is not a rational measure for the prices themselves are subject to the very market they claim to rule; price is subject to the systematically generated and reinforced value characteristics of its overall structure, competition being one of its principal value coordinates. The price mechanism is subject to all kinds of distortion; it is a bunch of noise with a façade of advertising and marketing [so that it “slips down more easily”] ... and once swallowed whole it is challenging to get out. Fluctuations in the price of goods and services in the market can kill people. Do we really want to organize a society around the market and around price? The price mechanism itself is the arbiter of decisions in the market.

There are going to be people who can't find a way to make a life for themselves within the market system; it is an inevitability due to the structural design of the market system itself.

The price mechanism has an inherent tendency toward personal maximization at others expense, monopolistic collusion, hierarchical dominance, and the need for waste and scarcity. The price mechanism leads to pockets of poverty [in the self and in others], and it is not an effective or efficient way of ensuring the persistence of a system that maintains individuals access to the resources, goods and services, that they need to survive and thrive. Price removes the idea of intentional design and of intentional orientation in a knowable and common territory.

The price mechanism is an element in the generation of unsustainable cultural and environmental environments in the market. The market is the real tragedy of the commons: the commons exists, the market doesn't. The tragedy is that the belief in the market leads to the destruction (de-structuring) of common natural services [provided in appreciation by the Earth]. Competition between market entities pricing property generates a state of excess consumption and mismanaged (e.g., unsafe) production in what would otherwise be seen as area for the caretaking of what are natural, common services for all life on the planet. Fear consumes life; fear will de-structure and de-cohere the flow of information from a source [of consciousness]. Prices never tell the truth. Prices are full of tricks, and those tricks do harm. Price is a non-rational force. Some societal systems produce value disorders that prop up false demands .

The idea that price is rational to begin with is incorrect. The way that price manifests is not necessarily a rational act. The random irrationality of demand can falsely create high prices. Someone could buy a load of copper tomorrow and it would make the price of copper rise. De Beers, to use a continuing historic example, could market or conceal diamonds (Epstein, 1982) in a way to control or falsely inflate the price of diamonds. Or, they could flood the market with diamonds and drop the price. Price, in the national and international markets, is not connected to use-value, at all.

'Use-value' refers to the value a user get from the functional use of a product or service or system; which due to modern electronic automation technology is now becoming 'production value' - the ability to create goods and the ability to be an "owner" of a particular mode of production. For example, 3D printers are products and producers at the same time. This understanding has led some economists, most notably Jeremy Rifkin (2015) in his book "The zero marginal cost society" to assert with evidence that society in the near future will no longer be composed of producers and consumers, but will instead involve "prosumers" (i.e., consumers who have become their own producers; users that design their own systems -- a prosumer is an individual who both consumes and produces). In essence, as we produce more data about how our services should be produced the market system becomes increasingly obsolete since "prosumers" are capable of producing things at zero-marginal cost. 3D printers are just one example of such a fundamental, socio-economic structural modifying, technology. Note here that the term "prosumer" is a market-based term.

Does price tell us anything about the actual nature of copper or its uses – what scientific instrument can we use to investigate copper to find its intrinsic use value? Instead, the movement of a commodity and the discussion surrounding a commodity is reflective of market behavior, quite possibly, to manipulate the price of the commodity (or securities investment) in the market for financial or some other gain.

Economists use the term "inelastic demand" to refer to things that "you", as a human organism, have to have in order to survive - they are not temporally flexible demands, they are knowable, persistent, and have common durations between when and under what conditions they need to be filled. But what if someone were to own the resources required for the fulfilling of these "inelastic demands" of a given population. If someone owns what are essentially life-ground needs (and maintains a [police/military] group to fight for and defend that ownership), then that person is going to have a tremendous amount of control over other people's lives. Some "economists" then go on and make the claim that a system which has "inelastic demands" and uses the force of police and military to maintain the persistence of human fulfillment is a truly voluntary system, which is highly disingenuous. To the common people, such a system isn't voluntary, if "voluntary" means the synergy of conscious intention, volition and participation without structural coercion or social manipulation.

Without advertising and marketing, without the forceful conditioning of competing market entities, it becomes far easier to look at the landscape ahead of us and calculate what we need. If we create a society that venerates and encourages the cultivation of the cooperatively safe, effective, and efficient use of resources based on [at least] fulfilling evaluations and corrective feedback, then we might begin to arrive at community.

There is no such thing as "perfect" per say. The term "perfect" information is not only meaningless, but it paralyzes consciousness by embedding the idea of a fixed status or standard in one's relationship with the world. Perfection is the lowest standard; it is a standard of zero. Perfection is the lowest standard you could possibly have because it isn't a possible standard, it is not achievable. Perfection represents the negation of emergence. In systems thinking, information is emergent, not perfect. In the mentality of "the market" there may exist the idea of "perfect" information, but in the real world, systems are designed and re-designed, "perfect" information is neither a useful nor an accurate idea.

The claim that there is "no way that anyone can get all the information they need in order to arrive at an economic decision", is a highly confused claim. What does it mean to "arrive at an economic decision"? What information is needed? What does it mean to "get all the information"? And, just who is "anyone"?

The price system is a way of communicating among the market, but in a family environment, there are better ways of communicating. Family members tell each other what they need and what they want, and they coordinate and cooperate from that point forward. Is it unwise to use the price system and open competition to manage a household or manage loved ones. Awareness of access and availability pervades; the family knows what is and is not possible. Learning about reality is foundational. The price system is a mechanism of communication and today we have better mechanisms of communication. We have computational processing technologies that may extend the functioning of our minds to more efficiently organize our economies.

The presupposition in the economic calculation problem is that the market does what it is claimed to do, to translate individual "subjective" values into "objective" information necessary for the "rational" allocation of resources in society. To a community, rational allocation is allocation toward human fulfillment.

Is it possible to facilitate feedback with respect to consumer preference, demand, labor value, and resource (or component) scarcity without the price system, subjective property values, or exchange? Just eliminate exchange and cooperatively create a direct control process and feedback link between the consumer and the means of production itself - a participative, real world habitat system. The consumer becomes both the user and the creator of the "means of production", and the infrastructure becomes nothing more than a tool that enables access by the community to the re-generational design of our habitat fulfillment services.

The same information technology systems that are being used in the market today would be used by the systems in this Community. Companies in the market this very day are using information technological services to calculate the production of their products and services in real-time and on-demand through both vertical [business integration] and horizontal [customer integration of information tracking and acquisition] utilizing live feed information and technical feedback. Society is now at a stage where its technological infrastructure is so superior to the technology possible conceived of when the economic calculation problem was thought up. Information technology is now to the point that individuals can share in real-time what is being consumed, and how and when and where and why, and its environmental effects such that humanity has the information available to re-orient itself when desired toward a direction of higher potential fulfillment.

Through measurement, society can process information into numerical correlation, and with that calculation process, done by complexly designed processing computation systems, a community can arrive at an optimal resource allocation and material decision for a given demand at a given point in time - this is true economic calculation.

The framework of thought that poses the economic calculation problem cannot conceive of a process of commonly formalized inquiry and re-engineered design [with transparent, real-time information feeds and fully automated production tools] to rationally fulfill identifiable, real world human [economic] needs. The problem was conceived of through the lens of a politically-organized social system and a market-structured economic system. The problem here is the conceptual framework of thought used to construct the "problem".

Price is determined within the market, which encircles itself [from externalities*] and produces its own structural values. Price isn't determined with conscience [as con+science] in mind. If a society wants to resolve the economic calculation problem's claimed "problem" of determining value, then it will have remove exchange explicitly [from its socio-economically encoded language]. In place of the "price mechanism" a society might use information systems and technology to "produce" a fulfilling environment for the whole [Earthly] community.

Given community standards in conjunction with the information, communications, and computation systems available in the early 21st century, it is entirely feasible to compute plans for local habitats within a global resource-sharing habitat network using available information technologies and societal engineering models (for a community-type configuration of society):

1. **Societal technological basis/structure:** Proposes using modern information system technology for economic calculation ("cybernetic") planning, allowing for the collection, processing, analyzing, and deciding and utilization of dispersed economic information in real time, effectively addressing Hayek's concern about knowledge dispersion.
    A. The existence of formalized algorithmic thought, as verifiably evidenced by technology, is a component of the solving of the "economic calculation problem"
        1. ... if the idea of a formalized algorithm is understood.
    B. Scientific-technical coordination: Uses a synthesis of calculation in-natura and in-kind, including labor time, mathematical optimization, and linear alegraic input-output, matrix methodology, which addresses completely the Misesian calculation problem. In community, production units provide technological (habitats) and information (databases and intelligence) to users by contributing their labor life-phase time, as a duty-in-service to all.
2. **Societal information basis/structure:** Suggests creating a decentralized physical habitat

constructed through a unified and integrated societal standard involving global and local planning and decisioning mechanisms. Buy understanding any configuration of society as composed of four fundamental conceptual systems, it is possible to use that model to design and intend a direction for society, and oneself therein. Conceptually modeling society within a set of standards that explain its operation and define the fundamental means by which human sustainably meets its needs effectively addresses Mises concern about the impossibility of making rational decisions without price. Here, the rational decision given access to all available information is optimize the fulfillment of human need.

A. The ability to account for human need as verifiably evidenced by what is required for survival and flourishing, is a component of the solving of the "economic calculation problem"
    1. ... if the idea of a real-world human need is understood.
B. The ability to visualize concepts in the form of a model (Read: concept model, vector database graph), as verifiably evidenced by images of concept models and large language models, is a component of the solving of the "economic calculation problem"
    1. ... if the conceived ideas are visualized and rational linguistic intelligence is applied.
C. Project coordination (a.k.a., project management as a discipline) conveys the ability to organize and plan projects involving a global network of projects involving users and contributors, as verifiably evidenced by successful implementations of large-scale projects across various sectors of the global economy. This is a component of solving the "economic calculation problem" if efficient and dynamic project management/coordination practices are integrated, allowing for real-time adjustments and optimizations based on evolving project needs and external conditions.

The interplay between human needs, concept visualization, and project coordination underscores a multi-dimensional approach to addressing the economic calculation problem. Each component contributes uniquely to the overarching goal of achieving an efficient, responsive, and needs-oriented economic system. By understanding real-world human needs, visualizing complex concepts through models, and applying disciplined project management, it becomes possible to navigate the challenges of resource allocation and economic planning in a manner that is both practical and aligned with human well-being. This holistic approach leverages the strengths of human intelligence, technological advancement, and organizational skills to resolve pathways toward solving one of the most persistent challenges in economic theory; which is, how to organize the economy of society toward community?

In the market economy, it is true that there is no "perfect information" because between competing entities there is not trustworthy transparency; no one really knows the depth and breadth of scarcity because of State and business secrets and unrevealing public narratives, because of competition and hierarchy. Hence, no one can actually trust any figures that are published by market entities, nor can anyone say that the market in any way accounts for scarcity in price figures. Scarcity is not quantifiable in any price; because, of the existence of competition and trade advantage in the market. For their very survival, market entities and producers withhold information or narrate over information that would otherwise cause their customers to shop at a competitor.

In a community there must exist:

1. Absolute transparency of all resources.
2. The value of sharing information for common benefit.
3. And then,
    A. A community uses its intelligence and resources to create formalized societal standards and systems involving cybernated algorithms, which account for resource scarcities and and compute resources thresholds. Logical calculation is a particular form of integration.

Every material [resource] is an object with a quantity of mass/matter. That quantity of mass-matter resources has a set of sensory-identifiable qualities, forms (structures), and states. For example, copper and other metals maintain the property of conductivity [of electricity] with different degrees (i.e., qualities) of efficiency. Materials can be compared by their quantity of matter (in-natura) and unit measurements (in-kind) using calculation.

It is possible to calculate a new orientational state based upon information in the total information system, and particular, the demand present in the decision system. A 'calculation space' is a mental (or computational) spatially-oriented and relational process that relies on the application of rules (programmable instructions) for the selection of one abstract object/entity from a given set of abstract/conceptual objects. It can either be reasoning-oriented (i.e., evaluation) or action-oriented (i.e., decision). Calculation accounts for referential information; the market de-references information creating pockets in our hearts and our souls.

The economic calculation problem claims that only a free market can determine an accurate price for economic goods because only a group of decentralized consumers projecting their subjective value into the market through the materialization of "price" is capable of organizing human socio-economic arrangements. The embedded claim is that there is no other way to end up with a "fairly accurate representation of how desirable something is" and "how scarce, rare or abundant it is" without the paradox of a subjectively objective price. The claim within that is that there isn't enough information input possible to determine and calculate production. Yet there is, it simply isn't transparently available at the moment because of the materialized acceptance of the market as the means of human fulfillment.

INSIGHT: *If you don't understand all of the pieces you aren't likely to understand the system.*

The economic calculation problem is almost a Luddite fallacy in clever disguise. The Luddites were 19th-century English textile artisans who protested against newly developed labor-saving machinery (i.e., technological automation) from 1811 to 1817. They did actually lose their jobs and were maybe ahead of their time in saying that everybody would lose their jobs to the exponentiation of efficiency of information technology. The exponential development of information technology will change the labor-productivity landscape forever; it is inevitable.

Fundamentally, the economic calculation "problem" exists in a different kind of thought paradigm than that which acknowledges the value of an access-based, transparently information rich, systematically understood and anticipated environment. The language which created the claimed "problem" can't even be used to understand the actual problem.

Cybernation has come to mean many things to many people. However, herein, it is defined as a formalized control process that feeds information from the results of its actions in an environment back into itself so that it can correct its trajectory [toward our most fulfilling purpose - the highest potential fulfillment of human need and well-being].

NOTE: *Economists refer to the natural ecological services of the Earth as "externalities" (i.e., they are external to their market calculations).*

1.4.1 The economic rationality problem

When Mises speaks about economic rationality, he had in mind the problem of producing the maximum "useful effect" (defined as satisfaction of wants, consumer preferences) on the basis of a set of economic resources. Mises framed the problem in terms of its core: how to create the most efficient form of production in order to minimize resources used to produce a given "useful effect" (Read: "want" satisfaction). Market economists typically do not define their idea of a "rational" economy as it operates in the real-world, based significantly on the relationships between the incomes of different social classes (i.e., political economy production and access). Mises claims is that only trade with money (a market with money), by reducing all costs and benefits to the common denominator of "money" (Read: price of private property), can there be a rational comparison of alternative possibilities, alternative plans/ways of carrying out production. (Cockshot, 2018)

Mises' question to "socialist" economic planners was, "How can the planning system calculate the least-cost method of achieving human objects (i.e., a railway or house)?" In the literature of Mises, he goes through a series of ways in which a planner might calculate the least-cost method, and rejects them all. He starts out rejecting Neurath's proposal of calculation in-kind on the basis that it is impossible to add together quantities of different inputs, unless they are first converted to a common unit of measurement, such as "money". In other words, Mises states that there is no rational/possible way of combining inputs (into a single means of production) unless all of the inputs can be "costed" in terms of a single unit like "money". However, this argument is false. Kantorovich's work using linear programming shows, on the contrary, that in-kind optimization without money is feasible provided that there is a defined plan target (e.g., a 2 or 5 year plan target). Kantorovich's work showed that it is possible, starting out from a description in purely physical terms of the various production techniques available, to use a determinate mathematical procedure to determine which combination of techniques will best meet plan targets. These linear techniques demonstrate that in-natura calculation (using natural units) is possible, show that a non-monetary scalar objective function is possible (as in, the degree to which plan targets are met). (Cockshot, 2014) Kantorovich even got a Nobel Prize in economics for proving this mathematically. Kantorovich's optimization procedures do not depend on monetary calculation; they only require knowledge of technology, knowledge of mathematics, accounting for used services and service objects, and a planned target. (Cockshot, 2018)

Describing his discovery, Kantorovich wrote (Kantorovich, 1960, p. 368):

> *I discovered that a whole range of problems of the most diverse character relating to the scientific organization of production (questions of the optimum distribution of the work of machines and mechanisms, the minimization of scrap, the best utilization of raw materials and local materials, fuel, transportation, and so on) lead to the formulation of a single group of mathematical problems (extremal problems). These problems are not directly comparable to problems considered in mathematical analysis. It is more correct to say that they are formally similar, and even turn out to be formally very simple, but the process of solving them with which one is faced [i.e., by mathematical analysis] is practically completely unusable, since it requires the solution of tens of thousands or even millions of systems of*

> *equations for completion. I have succeeded in finding a comparatively simple general method of solving this group of problems which is applicable to all the problems I have mentioned, and is sufficiently simple and effective for their solution to be made completely achievable under practical conditions.*

Mises presents the labor theory of value, and rejects it in a single sentence:

> *"This suggestion [the labor theory of value] does not take into account the original material factors of production and ignores the different qualities of work accomplished in the various labor-hours worked by the same and by different people."*

The rejection that there are different material factors of production may itself be rejected since it is possible reduce the material factors of production to:

1. **Labor (in-natura units)** - work time (reasoned by Ricardo and Marx).
2. **Resources (in-natura units)** - materials (informed by science, material science).
3. **Habitat services (in-kind units)** - human fulfillment socio-technical service support sub-systems of life, technology, and exploratory (involves in-kind calculation and urban planning working groups).
    A. **Access as a service** (demand units) - access to socio-technical services and objects in existing locations (Read: habitats) by existing users through personal-access, common-access, or, team-access.

Further, the rejection that there will be significant differences in the quality of work among habitats (producers) itself may be rejected when considering the development and application of a unified and optimized community standard for all operations, and the engagement of intrinsic motivation (versus extrinsic reward).

In concern to the different material factors of production, Mises confuses "concrete" labor with "abstract" labor, which is a distinction originally proposed by Marx. "Abstract" labor refers to human labor for market exchange (i.e., exchange value or valuable worktime for market economics) versus "concrete" labor, which refers to human labor for a specifically and directly useful (final user) service/effect or object. All "concrete" labor is reduced to the common social data ("substance value") of labor time and direct human need fulfillment. In Marx's theory, an hour of work counts as value (i.e., is a count of value); insofar as it is a fraction of the total time available to society to do work. It does not matter if the "concrete" labor time is spent fabricating something or monitoring something, from the standpoint of social total human cost, it is human effort. In the market-State, abstract human effort is a (large) portion of society's labor time. Behind the scenes in Mises objection was a hidden bias. All people in society are humans with universal needs, there are classes of people with preferences and qualifications for contribution).

Mises rejects the suggestion that the "unit" of measure be 'utility' (user usefulness) on the grounds that this is not directly measurable. Market economists, the societal category-type Mises fits in, defines utility as a measure of: 1) capitalist profit (profit utility); and 2) the satisfaction received by buying and consuming goods and services in the market (consumer utility, "want-satiation"). Under market conditions, utility is a social construction, not a personal user selection. Utility is a social construction under market conditions because it is based in market exchange and the "wanted private property" (not needed or preferred access) consumption of goods and services in a market, which is an abstract concept. It is not possible to operationalize the market; doing so would be a reification (and yet, the market is all around everyone in early 21st century society; it is in the heads and minds (mental operationalizations) of most everyone. In a community-type society, however, utility can be operationalized based on human needs, material resource characteristics and availability, habitat services (derived from universal human needs), and user [f]actually stated fulfillment. Utility, from a user's perspective, means to meet functional and non-functional expectations, and is often objectively experienced by someone's emotional state of completion, pleasure, need satisfaction/fulfillment, and/or objective well-being.

Mises rejects the market "socialist" approach (socialism as State ownership) to production on the grounds that the market is essentially the pursuit of self-interest. For mises, there cannot exist market-based "socialism" with State ownership (of production) and a market (trade-price) operation; because, a market is essentially the pursuit of self-interest. Because the market is the pursuit of self-interest, Mises claims that the "entrepreneur" (business owner) is absolutely necessary. In other words, Mises claims that risk taking "entrepreneurs" (business owners) are required for efficient operation of an [market] economy.

It is possible to plan how best to use current resources to achieve a given future output. The multi-year plan methods show that it is, and there are well-defined mathematical techniques for economic planning. Mises also rejects the method of trial and error (prototyping).

Mises continually concentrates on the alleged impossibility of apply algorithmic methods (arithmetical techniques) to comparing inputs with outputs in the absence of markets (trade, exchange, money) for the means of production. Effectively, Mises states repetitively that there cannot just exist a market for consumer goods, there must also be a market for producer goods, otherwise the optimal market calculations cannot be complete.

The Austrian School of Economics are significant, because they provide a key part of the libertarian ("free" market and property only) argument against "socialism" and a community-type society. The Austrian School of Economics are the start of a competitive, property-based economic system; and hence, an argument against them can clarify and make more robust the argument for operation of an economic system based upon cooperation. Mises was the first of the Austrian Economists to be involved with arguing against societal economic planning through calculation. Later in historical time, Hayek as an Austrian Economist argued against societal economic calculation planning also.

Von Mises claims:

1. Only money provides a rational basis for comparing costs.
2. Calculation in terms of labor time is impractical because of the millions of equations that would need to be solved.

Hayek:

1. Market is like a telephone system exchanging information optimizes economic production.
2. Only the market can solve the problem of dispersed information [because it operates at the speed of the telephone].

Scale of problem:

1. In the mid 1950s, GOSPLAN (Soviet Union. Established in 1921, Gosplan was the central economic planning agency) could prepare detailed material balances for some 3,000 products, and had some control over a further 30,000. (Dobb, 2008)
    A. By the late 1960s, there were several million distinct products involved in the whole Soviet economy (Economics of feasible socialism, A. Novel). This was more than could be handled in detail by the existing GOSPLAN staff of 3,000-4,000 people thousand people. Suppose each of 1 million products uses say an average of 200 other components in its direct manufacture. It is possible to describe each production process as a list of pairs:
        1. Product code of input, amount of input. Product code of the input, combined with the amount required to produce one unit of output.
            i. With each product code pair taking 2 full words of computer memory.
            ii. For a million products, there would be a requirement for a minimum of 400 million words of memory to do planning or compute labor values - say around 1.5 GigaBytes.
    B. Ideally, it is best to have the 1.5 GB of data in [fast] RAM, but it is also possible to use hard disks.
        1. The best United States technology didn't reach this level until the mid 1970s. By 1975, CDC in America was building 300MB drives, but these were embargoed for the USSR.
    C. In addition, there is a requirement for >1 million words of [fast] RAM.
        1. The best US technology did not reach this level till 1975 (CRAY 1).
        2. Four 1975 models of CDC drives could have held the information to computer 1 million labor values.
    D. During GOSPLAN money was still being used for wage payments, which led to black markets, corruption, and the constant pressure to rationalize and replace planned production by market production, which led to Peristroyka, and eventually, the rapid destruction of the planned system. Although the Soviet system did use some computers, they computers were not sufficient and they had to rely on money for economic calculation, even in the planned sector. Effectively, soviet socialism could be characterized as having:
        1. Money still needed for economic calculation even in the planned sector.
        2. Problem of aggregation in planning required monetary objectives.
        3. Inability to handle disaggregated plans at all levels.
        4. Insufficient computation. To work out the labor content of every good required the solution of millions of equations. 1960s computes were not powerful enough.
        5. Money still needed for wage payments.
2. In a series of papers, Allin Cottrell, Greg Michaelson, and Paul Cockshot have shown that the computational complexity of computing labor values for an entire economy with N distinct products grows as N log(N). The number of iterations required for Gaussian elimination on a matrix of order of 10^{18} arithmetic operations. Assuming the Fujitsu VP 200 supercomputer can perform 200 million arithmetic operations per second, calculating all the labor values using Gaussian elimination for an input-output table of this size would indeed take a substantial amount of time. The calculation provided (50 billion seconds or approximately 16,000 years). Where the fujitsu VP 200 supercomputer is replaced with

an modern xeon chip and an H100 graphics card using the same formulas would complete the same computation in minutes; because it can run tens of billions of operations per second.

A. Computation is the computer execution of a mathematical model, whereas simulation mimics a process or a system. It is possible to execute a mathematical (linear algebra) model that performs sufficient computations to simulate an economy in a reasonable amount of time with (showing dates, and, how many products could be computed for at that date):
   1. 1980s: 600,000 products.
   2. 1989s: Machine with a capacity of 10,000 million instructions per second.
   3. 1990s: 1 million million operations per second.

B. Key developments in productive forces since the 1960s include, but are not limited to:
   1. Internet - allows real-time cybernetic planning and can solve the problem of dispersed information (note: this was Hayeks key objection).
   2. Database technology - allows for the aggregation of information needed for planning.
   3. Computers - can solve the millions of equations in seconds (note: this was von Mises objection).
   4. Electronic payment cards - allows replacement of cash with non-transferable labor credits.
   5. Machine artificial intelligence - allows data collection, analytics, and decision support at the common wealth of nations level.

3. In 2021, Amazon corporation runs logistical calculations and decisions on millions to billions of products with modern CPUs and GPU arrangements. The computation of labour values, assembly indices, and all community [free access] information is available in the early 21st century for a planning a whole economy feasibly in a few minutes using modern supercomputers. These computers are expensive, but not prohibitively so. They are already used for artificial intelligence training, visualization, weather forecasting, astronomy, etc. In this event, a cooperative/ State (planning/statistics) organization buys one of these systems (or access to it). Until recently, supercomputer technology has been within the capability of a only few States (with export controls).

Social "socialist" planning organization knows:

1. The labor contents of the all the different means of production.
2. The labor contents of all the end personal and common user products (and services, habitat services) themselves.
3. The number of labor tokens (State credits) that each consumer of an object-service will fetch from its executed priced-sale in the State ("commissary") market to individuals.
   A. All products sold in the market of the Sate are produced by the State (one office, one factory).
   B. Some products sold in the market of the State are produced by the State and some by localized market entities (who will likely be competing to some degree to sell their commodities; many offices, many factories).
   C. All products sold in the market of the State are produced by the market (many offices, many factories) and the State regulates (only) the trade, sale or distribution, therein.

With these three data points, it is possible to compare the social cost (in tokens/credits) of producing something with the valuation put on it by consumers.

> **NOTE:** *When resources and technologies are fully accounted for, then a full socio-technical non-token accounting (system/program) can begin.*

Mises effectively rejected mathematical economics as a method of economic planning. However, in the 1930s and 1940s, Kantorovich and Leontief came up with mathematical methods to solve the problem of planning in natura. Despite the fact that the methods of doing economic calculation have been in the "socialist" literature (in at least Russian, English, and little German); the Austrian school (and others) have dismissed and ignored any deep and humanely- and ecologically-based integrated analysis of this work.

Hayek puts forward his critique to "socialist" economic planning in his article, "The use of knowledge in society" (1945). Hayek's argument has an irreducible subjective element to it:

> *"Most of the objects of social or human action are not 'objective facts' in the special narrow sense in which the term is used in the Sciences and contrasted to 'opinions', and they cannot at all be defined in physical terms. So far as human actions are concerned, things are what they acting people think they are." (Hayek, 1955, pp. 27) This statement by Hayek introduces subjectivism into his argument. Here, the misperception of reality is to [mis-]take one's own, or other's beliefs for reality. Beliefs are not reality. This encoding of subjectivism, taking beliefs and opinions for reality, leads to all sorts of disasters. Beliefs can easily misalign a population from reality, from real-world fulfillment and ecological limitations.*

Hayek thought that the difference between the subjective nature of society and objective facts introduced a fundamental dichotomy (i.e., paradox) between the study of nature and of society; since, in dealing with natural phenomena it may be reasonable to suppose that the individual scientist can know all the relevant information, while in the social context this condition cannot possibly be met. (Cockshot et al., 1996)

To Hayek, the basic problem of economics is that of creating a rational economic order out of the complexity of the real-world, in which fact about knowledge of the circumstances of which humanity must make use never exists in concentrated or integrated form, but solely as the dispersed bits of incomplete and frequently contradictory knowledge, of which all the separate individuals' possess. Here, the economic problem is essentially a problem about brining coherence to the different subjective views that people have in society. In other words, the problem starts off with the assumption that there are a set of subjective views, and economics is a problem of brining the subjective views into some coherent form for societal production. To Hayek, thus, the economic problem is therefore, "How to secure the best use of resources known to any of the members of society, for ends whose relative importance only individuals know." (Hayek, 1945, p.520) The point at issue between Hayek and the proponents of" socialist" economic planning is not, whether planning is done, or not; rather, it is "whether planning is done centrally by one authority for the whole economic system, or is to be divided among many individuals." (Hayek, 1945, pp.520-521) The latter case is nothing other than market competition, which "means decentralized planning by many separate persons". (Hayek, 1945, p. 521; Cockshot et al., 1996)

The next step in Hayek's argument involves distinguishing two different kinds of knowledge:

1. Scientific knowledge (i.e., understood as knowledge of general laws).
2. Unorganized knowledge (i.e., knowledge of the particular circumstances of time and place).

Hayek's argument, commonly known as the "knowledge problem," contends that a centrally planned economy faces insurmountable challenges in efficiently allocating resources; because, the relevant knowledge about supply, demand, and individual preferences is dispersed among countless individuals and cannot be effectively aggregated and processed by a central "authority" (Read: computational system).

The former, Hayek states, may be susceptible to centralization via a "body of suitable chosen experts", but the latter is incomprehensible (Hayek, 1945, p. 521). And certainly, at a time before the Internet, databases, and GPS, the later may be incomprehensible, but in the early 21st century, it is not. Hayek further states that effective economical management requires that, "new dispositions [be] made every day in the light of circumstances not known the day before". (Hayek, 1945, p. 524) In reality, a large part of this uncertainty is just due to the chaotic character of the market. Hence, Hayek brings in the chaotic character of the market to justify the chaotic character of the market, thus introducing circular reasoning. (Cockshot et al., 1996)

A central theme of Hayek is that the market acts as a "telecommunications" system, which might seem a reasonable analogy to someone present when telecommunication systems were just beginning to emerge as a technology on the planet. Hayek provides an example of what he means:

"Assume that somewhere in the world a new opportunity for the use of some raw material, say tin, has arisen, or that one of the sources of supply of tin has been eliminated. It does not matter for our purpose and it is very significant that it does not matter which of these two causes has made tin more scarce. All that the users of tin need to know is that some of the tin they used to consume is now more profitable employed elsewhere, and that in consequence they must economize tin. There is no need for the great majority of them even to know where the more urgent need has arisen, or in favor of what other uses they out to husband the supply." (Hayek, 1945, p.526)

In reality, the market is not an efficient telecommunications system. A telecommunications system is efficient, like every socio-technical system is efficient, when it is based on cooperation, and not, on competition, on transparency, and not, secrecy, and on restoration, and not, punishment. Scientific information theory, and the formal mathematics therein, prove Hayek's argument wrong. (Shannon et al., 1949) Hayek's notion of information remains, definitionally, pre-scientific (and pre-modern-computation). (Cockshot et al., 1996, p.7) What communication takes place in the Market and under conditions of scarcity and coercion are different than what communication takes place under community conditions; within a community-directed, centrally distributed, planning system. Community is centrally distributed because it develops and applies a unified societal standard in conjunction with a global habitat service system forming a semi-distributed, semi-autonomous network of customized local habitats (i.e., local habitat service systems). Community-type communication openly shares of useful for societal benefit.

In the early 21st century, technology and user interaction, allow for systems (Read: teams of contributors and community users) that have a high-level of informational context (i.e., situational awareness, metadata) about users, their demands, and about real-world resources and ecological limits, about the total economic context. Hayek thought that information about persons and their demands was only sufficiently possible through the trade-/market-based "price" signals, given by the metaphorical "body of the market". Hayek writes that the significant thing about the prices system is "the economy of knowledge with which it operates" (Hayek, 1945, pp.526-527), as if, "price" information carries with it intrinsic information about the state of and changes in the real-world and about what humans need and require. In the early 21st century, real-time communication, information processing and storage enables all of the information necessary to solve the economic problem of yearly and multi-yearly mathematically calculating an economic system via a central planning algorithm, without markets. With the necessarily information it is possible to perform the calculations, to plan the production and distribution of goods and services. Kantorovich came up with an effective means by which socialist planners can calculate the most cost effective way of using tools and resources.

> **NOTE:** *In the market-State, war economies are prototypical high-planned, central economies.*

The notion of the "subject" in the market-State is derived from the idea of an extant:

1. Subjective individuated user ("consumer") who has issues and places demands for socio-technical services.
2. Citizen-subject, who is expected to follow the law, and is a contractual [private-]property owner.
3. A legal fiction is a legal [social] construction, contract, a treaty, a special-legal agreement, a corporation "of articles", a business "plan", a trust "of assets", a State "of property policing" or a State "community configuring".

Economic "subjects" in the market-State are legal abstractions, not real people. In some States, the absurdity even reaches the level of having corporations be defined as citizens, like real individual people. A law may be based on a belief, or it may be a necessary social function for the viable replication of the system, the species (considering, viable replication theory). Hayek's economic "subject" is a reification of the market grouping of "subjective ideas", within every individual. Hayek projects his belief that all efficiently and sustainably accessible can only be priced access, through a market (i.e., trade, and not scientific coordination).

The market-State is essentially concretizes the ownership of resource in the form of legal-State enforceable "private-property and public-/State-property" relations among owning individuals and economic sub-classes. The concept of the separated economic "subjects" who do not share a common heritage (planetary-ecological heritage) or objectively coordinated life reality [common-heritage contribution and habitation resource-platforms], otherwise known as, individual "capital" (Read: market "self-ownership", from which there is self-sale and private-property). Under market conditions, each person becomes a legal object with market-State inputs and outputs. The most notable output for the individual is their "salable" labor in return for some exploited wage (exploited, because profit is extraction from the only other one who counts in the moment, the other human being). In the market-State, the citizen can own property, the citizen can sell property, the citizen can sell their physical body-property (culturally limited), and no person can own the physical body of another as property (i.e., no full slaves); but, in the market, all (except criminalized, sometimes) individuals can sell their own physical body property for work in return for money (a business transaction), or other exchange. (Cockshot et al., 1996)

In the market, where trade is universal, the concept of an economic "subject" refers to all individuals in a population being separated from one another by "priced" access to property. In a community-type society, the concept of an economic "subject" refers to each and every individual with accountable human needs living within this common [heritage] planetary ecology. Human needs become issued demands, engineered productions, and then, usage of habitat services (operated by habitat teams), which are fed-back information flows into the unified societal network-city system's production system, itself. Hayek's essential exclusion of science, as a method for studying reality to more greatly inform societal construction, is untenable. The exclusion of science from the study of society is untenable; because, it presumes that human need fulfillment cannot be informed by a scientific approach. Science has to explain the explain the motions and constructions of society. Without science about human fulfillment, planning for technological and service productions becomes uncertain, and price is likely to become paramount. Fundamentally, Hayek's argument, and the argument of subjectivists in general is that the integrating data for understanding and economic fulfillment only comes from the category of subjective (individual specific) information (i.e., no universal, objectively shared context). Hayek's notion of "economically useful" information is pre-scientific. The subjectivist view is that information is subjective; thus, there is no accounting for the common good (objective), and persuasion (and ownership) becomes the method of account. In reality, knowledge in the minds of many can be combined for the common good. Because Hayek's view is irreducibly subjective, it lacks any kind of planning. (Cockshot et al., 1996)

1.4.2 The computer-power problem

> **INSIGHT:** *There is a distinct difference between [social] power embedded in an authoritarian hierarchy and the [technical] computing power of a computational system. This distinction must necessarily be understood for the "economic calculation problem" to be seen for what it truly is.*

'Computational power' refers to the speed that instructions are carried out by a computer. Computing power would include this, but would normally include other aspects of the system as well (i.e., all operations/ operational processes), such as memory and bandwidth for i/o, and other hardware aspects of the system. In other words, computing power refers to the operation processing capability of a computing system; including, the types of operations the system can process.

Clearly, having more computational power allows a computing system to do more [work]. Yet, computing power is not [authority-driven] socially hierarchical power (as power over strategy); instead, computing power is more akin to strategy added power. If for any given amount of computing power [a given amount of memory and compute cycles] and a particular task, there is an optimal system for doing that task with that amount of compute power.

If rational behavior is the [most] optimal way of meeting and completing a given task and we think of systems as living on a continuum, then as systems get more computational power they can choose actions that are closer and closer to being the/an optimally rational action.

It is important for us, as a society to come to the realization that we are going to have intelligent systems around us, and that we are going to have to choose what type of environment they facilitate in the creation of: an environment that brings out the best in people or an environment where they compete with, control, dictate to, limit, and reduce people (i.e., perform the role of government more efficiently). Hence, it is important for us to create an infrastructure today that will give us confidence that our well-being and fulfillment will remain strategically preserved and continue to reflect our goals as we continue to advance in our technological development and accompanying computing power.

If engineers that built bridges had the same levels of standards that business does for software then no one would drive on them. In other words, software businesses do not generally utilize provably safe mathematical tools in the design of their software.

In the case of a resource-based economy we are building and iterating the system in a transparent manner, piece by piece. During the design or re-design process we as a community design into (or encode, "write into") the system the properties that we would like the system to have, such as, "this system will prioritize needs that are required to support life and ecological stability over wants that are not required for life support". Note that to express such a statement a specification language is required.

Just as some Austrian economists put forward the "economic calculation problem", there are computer scientists who put forward what is known as "the halting problem". The halting problem states that you can never prove anything about an arbitrary computer program. The halting problem is true, in part. If you were to take a random arbitrary program that someone wrote, then proving properties of it may or may not be easy. Similarly, if you take a highly manipulated and obfuscated monetary-financial market, then calculating out resources, demand, production, and sustainability would not be easy (or even feasible). But, the system described herein is designed (or generated) from its very transparent inception to have "correctness", feedback, and safety properties designed-in.

The properties that we want the system to have need to be built into the system transparently and from its inception, or at least, next iteration. This is necessary if we want an economic decisioning system that does not generate de-generate propensities as behavioral characteristics of the system itself. In other words, the software of the economic decisioning system must be generated at the same time the proof for the system is created, such that the system doesn't produce economic operations that make it hard to identify and discern what is actually occurring in the system and whether the system is going to violate safety properties or develop further ambiguous and potentially dangerous behavioral characteristics.

Humans find parallel programming and calculating at the order of magnitude necessary for the operation of a societal-level economy particularly difficult. Hence, we need computing systems to perform these calculations for us. And, they must be designed so that they will safely serve as an economic infrastructure that we can trust, that we can iteratively vet, and that facilitate in the creation of habitat service systems that have the safety and fulfillment properties we want. And, from there, we can create more and more powerful and trusted systems through a process of iterative self-improvement, but controlled by the properties of safe proofing. Fundamentally, we want our decisioning system to reflect our highest direction and values, which in the case of a community are reflective of human well-being and ecological preservation.

We want systems that will facilitate our adaptive evolution into our higher potential selves - systems that help us to become that which we want at our deepest level. So, the challenge is not just the technical challenge of building these systems, but also identifying where we want to go, what is the future of humanity, what is the nature of the human experience, and what is it going to turn into? The human element is an integral part of this.

> **INSIGHT:** *If you can build, maintain, and generate trust with others, you can do anything. And to the extent you don't do that, it doesn't matter what principles you use, you'll have problems.*

1.5 Economic technical unit planning and coordination

The questions central to economics (Read: macroeconomics) are:

1. What is needed as the outputs of an economics system?

2. What is required as the inputs of an economic system?
3. How is/will the economic system produce the outputs from inputs?
4. What configurations of the economic system are possible (or, optimal) to produce the outputs?

The questions central to useful economic products of work are:

1. The direct physical labor inclusive time (in hours/day, days/year, years/life).
2. Materials inclusive in the means of production (Read: production technologies, including power).
3. Materials inclusive in the user's habitat service-objects (Read: user products, including power).
4. Average amount of time to produce a habitat service-object (is a calculated measure).

An economy (macroeconomy) can be divided into several main sectors. In a community-type society, the aggregation of all the sectors is called a habitat service system, and the escorts themselves are called habitat service systems (or, habitat service support systems). At the highest level, a habitat service system can be divided into three main sectors:

1. Life support [habitat] service sector.
2. Technology [habitat] support service sector.
3. Exploratory [habitat] support service sector.

Within any economy, each one of these sectors depends on all the other sectors. If the output of each one of the sectors is added, then it will show the overall output of the economy. Here, it is noticeable that a service (industry, sector, etc.) can be linearly represented as a combination of other services. Services can be categorized, prioritized, aggregated, and disaggregated.

Note here that high-level sectors have sub-sectors. An economy or habitat is divided into sectors (in the market, these are often called industries). Each terminal sector produces one service or product (object) defined previously as a demand (in engineering, these are called requirements). Some demand/requirements are intermediary, that is, in order to produce the final demand/requirement, the sector (itself) has a number of internal demands/requirements [for processes and objects] it must meet.

In terms of access, team access/demand is an intermediary production requirement, in order to meet final user, community and personal access, demands.

Input-output tables consider intermediary outputs and the production of a final output. This is useful to societal material planning because it allows the planning system and its users to observe how resources are distributed and used in the production process of a final user product/service. It allows for viewing and calculating flows of some quantifiable amount, which come into, and go out, of allocation [within service systems].

In this way, a producer can know varieties (categories) and quantities of products (goods), and make the necessary adjustments to improve the production system as a mutually interrelated whole.

In a market economic structure, there is the assumption of competition; whereas, in a habitat/community economic structure, there is the assumption of cooperation. Competition and cooperation represent two differently oriented social [system] value states. In a market-State, input and output may be expressed in monetary units. In a habitat, generally, input and output are expressed in natural (or natural derived) units.

If the production of a sector is consumed internally by the sector itself, it is called a closed model. Here, an economy (or society) is stable (Read: not going to fall apart) when the output is its input.

Each sector is, in part, a production (or, produced) system. With any production system, some of the production is used (consumed) by the production process (or, system) itself. This means that, in general, there is an interrelation within and between sectors (production systems). In other words, production systems have requirements for the production outputs of other productions systems, and maybe even from within their own production system itself. For example, the energy/power sector provides power to an agriculture/cultivation sector to operate its machinery, as well as providing power to some of its own systems. So, an output of power is an input of cultivation to produce an output of cultivation. Similarly, food may be a required input into the cultivation system to make more and/or new food. For instance, cultivated animals require food themselves, and a final item of food might require yeast, which is another food. Another complete example is the architecting sector, which provides buildings to the power sector, as well as providing buildings for producing other buildings and the clothing to be worn by humans (which may be worn within and without buildings). So, the architecting sector provides inputs into the power sector as well as proving inputs into its own sector in order to produce the end outputs needed/demanded by humans. Every sector requires some kind of input in order to produce its output. Through modeling it is possible to visualize and understand how these sectors relate to one another in a dynamic economy. Afterward, once what is is accounted for (e.g., in an input-output table), it is possible to run calculations (computational operations, math) on the data. In computation, logicals (logical data and operations) can be written in full (True or False), or abbreviated (T or F). The results of these calculation should be useful for decisioning in determining the next iteration of the economy.

All of this information about an economy can be conveniently visualized ("captured") inside of a matrix (Read: input-output matrix). In other words, it is possible to use a simple matrix equation (Read: input-output planning) to model, understand, and plan for an economy such as defined herein. Simply, a matrix can encapsulate all input and output information for a given economy and all of its different sectors (as long as units/objects and amounts/quantities can be accounted for). In real world economics, only that which can be measured (in either natural or natural derived units) in the real world can be accounted. For instance, volume, electricity, distance and weight can be accounted for in a real world economic system. In non-real world economics, abstractions also become accounted for; pure conceptions are reified. Money is an example of a non-real world economic unit [of account]. There is no such measurable object or process as money in the real world; there is only peoples' belief in money. Money, as an economic categorization, can even become a sector of an economic system itself (e.g., the financial sector).

Matrix equations can be applied to economics problems (Read: mathematical economics). Matrices applied to [object-ive] economics are quantitative matrices, primarily. Versus, qualitative (statistical) matrices, such as, a probability-impact risk matrix. Leontief input-output analysis is a series of equations in which quantities (of materials) can be counted ("valued") within matrices. A basic input-output matrix consists of columns and rows. Generally, the columns correspond to the inputs of each sector, and the rows correspond to the outputs. The Leontief input-output matrix analysis uses physical quantities as inputs and outputs.

The Leontief method for matrix calculation that does not have to include price (i.e., it is a non-price required method for doing economic calculation planning (i.e., it does economic planning using matrix calculation) using either physical quantity units and/or abstraction units. The Leontief model does not explicitly incorporate prices; instead, it provides insights into the production relationships and resource requirements among different sectors. The focus is on understanding the flows of inputs and outputs between sectors rather than explicitly observing prices. In the Leontief model, the units used to measure the inputs and outputs in each sector are physical quantities (i.e., the physical quantity value form). However, it is possible to replace the physical units with abstract point-type units that either circulate (i.e., money), or do not. The choice of units depends on the specific context and purpose of the economic system. Points can circulate, or they cannot, and there doesn't need to be a point count circulation between users at all. Instead of accounting for private property points, it is possible to account for actual human need and preference (use value form), to account for materials (physical unit form), and account for ecological systems (ecological unit form). If labor comes in the form of exchange, then laborers will acquire points (e.g., money, tokens, etc.) for their working hours and/or training hours. If labor comes in the form of contribution (national community service), then laborers are not paid in any points (e.g., money, tokens, etc.); instead, everyone's working hours are considered equal, and thus, is removed from the access "rights" equation because it is equal for all. Hours are still calculated and tracked, but there is no exchange of points for labor (in this case, contribution, volunteering).

Another kind of matrix required for a complex economic model (really a sub-matrix of the sander input-output matrix) is a production matrix (a column matrix), which accounts for how much (how many assembled units) each sector is producing. This matrix typically appears to the right of the Leontief standard input-output matrix. The two matrices can be multiplied together to create another column matrix to show the amount used (or, consumed). In some sense, it is the amount the economy uses (consumes), itself. There is a certain percentage of the economy that will be used/ consumed by itself in order to supply final user demand. The products produced to be consumed for sustained and continued production are called intermediary products (or goods), and whatever is left over is the output to humans of the economy. Intermediary means the production of services to produce the final

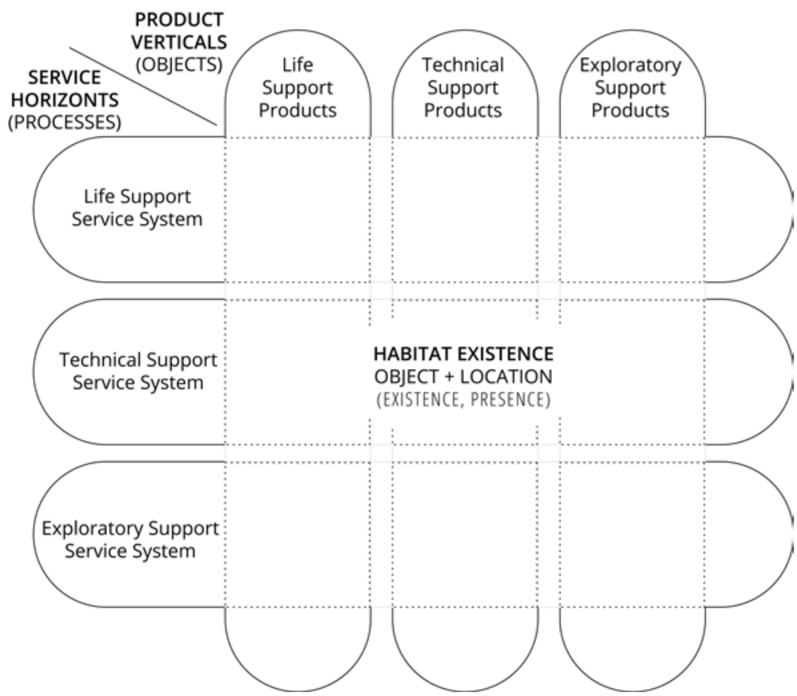

Figure 35. *A simplified view of a matrix/table for habitat service (life, technology, and exploratory) inputs and outputs. Life support outputs are absorbed by other life support outputs, technical support services, and exploratory support services. Each service system is a service with associated resources allocated to products in that service.*

demanded service.

Hence, in this sense, an economic model is a model of production process interrelationships. Different types of society are likely to have different productions and different arrangements of interrelationships for those productions. The sectors chosen [to exist] as part of the economy form its economic input-output network. For humans, it is possible and desirable to select sectors based upon aggregated human need. Thus, each sector becomes an output to fulfill human need and a potential input to another sector to meet human need.

Note here that the production of outputs by sectors for themselves, and for other sectors prior to the production of the final human demanded output, are called intermediary outputs. Intermediary outputs are the outputs of a sector that are required for supporting its own sector, or any other sector, in the fulfillment of final human need. Here, it is reasonable to consider the danger a sector [of the economy] might pose if it is decoupled from human need or the real world.

1.5.1 Habitat sectorized service systems and common economics

A.k.a., The input-output approach for cities, habitat service system planning and operations with input-output modeling.

One important result of a study of interdependent economic systems is the ability to have a better understanding of the system components (e.g., economic sectors), and their interconnectedness with other societal system components. A measure of the interconnectedness of an economic sector(s) is essential to unified societal [economic] planning. Here, resources become interconnected into habitat service production platforms in order to output services and objects demanded for usage by humans for their fulfillment.

A habitat service economy may be formed through the accounting of *resources* and of *access* (as well as *systems* and *participation*):

1. The intermediary habitat service production platforms are composed of resources, and are accessed by InterSystem teams.
2. The final services and objects are composed of resources, and are accessed by community groups (common access) and individuals (personal access).

An economy acts as a service platform; it produces objects (and services). An economy makes things and provides services. In an economic system that is habitat based, a habitat service system provides services to humanity, some of which provide objects to humanity. Herein, the highest orders of service are often called "economic sectors". In a habitat service system, the highest-level economic sectors are: Life Support, Technology Support, and Exploratory support.

At an economic decision level of a habitat, the concept of a "sector" refers to a top-level habitat service support sub-system, a core habitat service platform for humanity. At the material level, where city systems exist (Read: the materialized habitat service system) the term "sectors" is often used to refer to divisible portions of the whole city, and to differentiate various functional locations from the whole city platform.

If an economy is divided into sectors, it is possible to study the inter-sectoral resource flows and transactions between the sectors. In order to create a output from one of the sectors, outputs from the other sectors may (or, may not) be required.

It is possible to plan the operation of a habitat, as it is equally possible to plan the operation of any industrial plant or sector using process evaluation, economic analysis, and linear programming to decidedly optimize material configurations. Fundamentally, the method of optimization applied by various industries, governments, and cities in the early 20th and early 21st century could be applied to the global economy as a whole (i.e., applied to the global habitat service system). Therein, the habitat service subsystems are the processing sectors of the economy. Physical input–output models can be used to aid in the synthesis (design) or operations of cities.

In a habitat service system, each habitat subsystem could be considered an input-output system. Accordingly, it is possible to analyze and plan the pattern of materials and energy flows amongst service systems, and between service systems and the final user. The proposed input-output model can be applied as an accounting and planning tool both to a single city (local habitat service system and to the global city network (global habitat service system). Input–output models can be used to represent supply chain networks in entire economic systems (i.e., in the global habitat service system also known as the cities network or community network of cities). At the city level, an input-output model is necessary to coordinate and control internal and external logistics flows. At both levels, input-output models are used to analyze and plan logistics flows and materialization processes.

A large majority of I–O matrices in the market are measured in terms of monetary units. However, in community, the data are provided in their “natural” (or physical) units.

Integrated city systems allows service systems co-located in the same city to benefit from localized energy, waste, and materials flows that can reduce resource usage and environmental damage. By adopting the input–output framework, the economy is translated into a physical flow of materials and energy for production, consumption, recycling, and waste disposal. The role of habitat symbiosis in integrated cities (and city networks) can be addressed through identifying the objectives (values) and demands of the users.

A habitat economic planning model deals with a supply chain composed of a network of materialization and informatics processes. This network can be fully described if all the interrelated processes as well as input and output flows are identified.

Requirements for a global habitat service system input-output model include, but are not limited to:

1. All habitat service systems are accounted for and modeled as process inputs.
   A. Transport is accounted for as any other habitat service system and is modeled as a primary input that includes distance covered.
   B. Human contribution amount is accounted for.
2. All processes are time referenced.
3. All resources are accounted for and modeled as primary inputs
4. All materialization processes are geo-referenced.
5. All materials are geo-referenced.
6. All land use is accounted and geo-referenced.
7. All land use change is accounted and geo-referenced.

A complete input-output system for a network of integrated city systems will required:

1. A human view of the inputs-outputs.
2. A service view of the inputs-outputs.
3. A resource view of the inputs-outputs.
4. A city view of the inputs-outputs. This view is for the cities network.

1.5.2 Real-world, socio-technical planning

Real world planning requires not one, but many separate natural units as part of its material balancing procedure. Material balances use natural unit, such as meter, meter squared, gram, etc., to plan products. Some forms of planning homogenize the diversity of natural units to a single unit, like money, labor time, or energy credits. The experience of the method of material balances verifies that there is no single natural unit of economic (a resource flow quantity) planning.

For any socio-technically planned economy, there are two primary types of economic requirements/effects that need to be balanced in units and amounts:

1. **1st order materially balanced effect of production** - more requirement of product x; hence, more product y (e.g., steal) is needed to produce product x, because product x output has changed to require more product y (steal) in its design, or there is more demand for product x, and hence, more requirement for product y (steel). Here, capacity refers to product demand being be balanced with (i.e., account for some amount of) the supply or availability of product y (steal).
   A. What demand does the solution meet?
   B. What is the resource composition of the final solution?
2. **2nd order materially balanced effect of production (effects on intermediary goods)** - more coal, electricity, etc., is needed to produce the additional steal. Here, all inputs that go into the steal supply must be balanced with (i.e., account for some amount of) the demand for steal.
   A. What does the solution depend upon?
   B. What are the dependencies' resource composition?

A method or methods may be applied to solve for problems given these two requirements/effects.

Natural units must be accounted for in a real-world, human oriented economic decision system. Once natural units are present in the information set, then the input-output method may be applied to a signaled demand and all possible potential output options may be calculated.

1.5.3 Complexity

Algorithms can be measured in terms of their complexity. The complexity of an algorithm is measured in how the number of instructions used to compute it grows as the size of the problem grows (i.e., as the size of the input data grows). In other words, how long will the problem take to compute as a function of the growth in the size of the input data to the problem.

Complexity defines how long it takes the algorithm complete its task a function of the problem size. There are various complexity classes that grow increasingly harder. Classes include, but are not limited to (O = order):

1. Constant time algorithm - gives the same answer irrespective of the amount of data it is working on.
2. Linear algorithm (linear O N) - will take an amount of time proportional to the amount of data.
3. Log linear class (log linear On log N) - an algorithm takes an amount of time that is proportional to bot the number of data items there is and the logarithm of the number of items (e.g., best methods of sorting).
4. Polynomial algorithms (Polynomial ON2, ON3, etc.) - the time taken is a fixed power of the amount of data (e.g., it might grow as the square or the cube of the number of items).
5. Exponential algorithms (exponential OeN) - the running time grows as eN. Generally, because of their exponential runtime, exponential algorithms are unusable for anything but the smallest economic data sizes.

Indexing and sorting are log n types of problems. The complexity of looking up an item from a number is of order n, or On, with n number of items in it. Problems with log n steps are highly efficient problems for computers to calculate. This is significant, because just the sorting of already available data can turn an intractable (impossible) problem and tune it in to a tractable (possible) problem.

Economic planning requires more than the sorting of lists; it requires matrices of input-output tables. Input output tables can be measured (and computed) in natural units (or, in abstraction units, such as, money, urgency, or priority). Given an [economic] input-output table, it is possible to compute how much of each intermediary product is required to produce a given amount of each of the final [economic sector demand] products to be use (Read: the final output) . Further, it is possible to compute the required contribution ("labor") content of each final output. It is also possible to compute the priority and urgency of content of each final output. And therein, with coordinated scheduling and open source contribution, it is possible to share mutual access to common heritage resources.

1.5.4 Dynamic control and coordination

These dynamic coordination systems have to optimize what is occurring right now, but also navigate the possible current alternatives occurrences and future probable predictable trajectories. The simulation and future planning of a societal economic system must compute and coordinate between multiple contingent options, dynamically, with the purpose of identifying which option is closer to reality, and then that direction/vision may be steered toward. By doing the calculation it is possible to identify options that may not have been obvious or possible in the first place. It is possible to not only consider production in terms of virtual scenarios, but it is possible to visualize society in terms of simulation and standardization. Being able to understand occurrences in a virtual space and then being able to commit to something actual provides additional room for safe maneuvering as a society. A society that optimizes for human flourishing may not know that there are even more optimal ways of flourishing until the calculations and integrations are complete; an adaptive society necessarily has a discovery (exploratory) process going on. Maybe even the things known as flourishing are not fully knowable ahead of time; that is, there is a continuous discovery process (inquiry process) that the society is going through, itself. A society must have some sort of way of generating new possibilities, continuously. In a community-type society, the exploration habitat service system houses several of subsystems primarily dedicated to discovery and possibility generation. A community-based decision system is designed to integrate both the present and the possible futures into one another to navigate a dynamic, real world environment where individuals with an intention of mutual fulfillment interconnect, optimally. It is a serious and complex endeavour to create an open society that can navigate its own possibility space. There is no exchange (trade) between economic agents in a community-type society, like among cooperative species in nature.

In a community-type society, all inputs and outputs for all production processes are known (i.e., are directly knowable). In a market-type economy, globally, inputs and outputs have to be inferred, because competition leads to concealment and a lack of attention to contribution, and thus, lack of data for those who are cooperating. Whereas economic calculation may only be an inferred result, economic under conditions of directly known data makes calculation a precise and possible tool for planning an economy.

2 Product coding (assembly identification)

A.k.a., Object lookup code, object name, object code, product coding for enterprise resource planing, product codes, GTIN, UPC, EAN, ISBN, SKU, product lookup codes (PLU).

A product code is a code (set of numbers and or numbers and letters) in a system that uniquely identifies the product. Product coding is necessary for coherent economic calculation (and economic understanding in general). Product coding is necessary for categorical understanding of products, as well as, the coordination of production, usage, and materials cycling. When coding for products, there is a hierarchical taxonomy that can be populated into a database.

CLARIFICATION: *Habitats are master-planned products too, cyclically.*

Appropriate and accurate categorization is essential for planning a habitat service system, because it enables the mapping (categorized allocation) of products to the three habitat service support systems (life, technology, and exploratory), which therein, allows for appropriate prioritization of products and activities. Accurate categorization also ensures accurate tracking of resources, products, and their usages. Herein, imprecise categorization leads to imprecise models, and then, higher uncertainty that production will meet fulfillment requirements. Being able to categorize objects as similar or different, as well as identify differences, is an essential tool for the planning of an economic system. Herein, product coding is the process of assigning codes to products at different scales. In society, because technology and social development are dynamic, classification accuracy must be continuously assessed, and updated where necessary.

Product codes provide necessary information about products at four principal levels:

1. Categorization of a product type out of all possible product categorization types (e.g., global identification number).
2. Categorization of production run of product (product sub-type; e.g., model number).
3. Identification of each uniquely produced unit [of a product] (e.g., serial number).
4. Identification of location of a unit (e.g., coordinates, location name, etc.).
5. Identification of quantity of units at a location (e.g., count).
6. As well as other product metadata associations (e.g., usage, phase of lifecycle, composition of raw materials, composition of intermediary materials).

In community, the following basic product codes are used for the production and coordination of products:

1. **Global identification number** - an identifier that identifies a specific product or product category.
2. **Model number** - an identifier that identifies the sub-type of a specific product or product category.
3. **Serial number** - an identifier that identifies a unique, individual unit of a product.
4. **Stock keeping units (SKUs)** - an identifier that identifies a specific type or sub-type of product, as well as the quantity of the product, in a specific physical location.

Common coding identifiers for products in the market include the following:

NOTE: *National statistics offices of many States collect, compile, and release "official" statistics. National economic statistics offices, often use unique codes that have been assigned to products and services.*

1. **Global Trade Identifier Number (GTIN)** - is a universal identifier for every possible product, it also generally identifies the manufacturer of the product. A GTIN is typically a 12-14 digit identifier (e.g., generally in the form of a barcode) visible on a product. In other words, it is an identifier that identifies a specific product and the manufacturer of that product. The number (or code) is unique to a product-type and it is universal to its categorization. Simply, a code carries identification information about a product. Internationally, a GTIN is called a different name (for example, UPC code in the US, EAN code in Europe). In the market-State, the code standard to be used depends on where the business is located. Note the usage of the word "trade" in the title of this product coding category.
   A. **Universal Product Codes (UPC) and European Article Number (EAN)** - are product tracking-manufacturing codes that are standardized for use (even in the market, and hence, universal to all market-State operating organizations). In the market, the UPS/EAN is a true universal product identifier. The UPC/EAN code is affixed to a product wherever it is acquired by a user (sold), remaining a constant throughout the product's shelf life. Note here that the EAN (European article number) serves the same purpose as the UPC and has thirteen digits. UPCs are 12 digits, numeric only. There is also Japanese Article Number for all products sold in Japan.
      1. In the market, UPCs must be purchased from business. These "authorities" ensure that

two sets of numbers are not issued to more than one company for a product. Many UPC providers sell them online.

2. The "authority" for creating and maintaining UPC standards for the market is GS1 [gs1.org] (formerly the Uniform Product Code Council).

B. **International Standard Book Number (ISBN)** is a universal tracking-manufacturing code for all text-based materials (e.g., books, magazines, ebooks, and other published objects). The code carries information about the book registrant, title, edition, format, etc. In general, every book version and edition gets its unique ISBN. There are ISBNs with 10 and 13 digits. Those numbers that were registered before the end of December 2006 have 10 digits, while those that are released since 1 January 2007 till now contain 13 digits in length.

2. **Stock keeping units (SKUs)** - are used to account for the amount of a product (specific type of object) in inventory and units of the product that have been acquired by users (e.g, sold). SKUs are alphanumeric code. SKU numbers can be assigned to physical products, as well as intangible products, such as services (i.e., market billable activities), units of repair time, or market warranties. Simplistically, they are product (service) inventory codes. SKUs are used in warehouses and fulfillment centers. In the market, SKUs are unique to different companies. In community, SKUs are universal like the universal product code UPC, but each is tagged with a particular geographic position). Since an SKU is unique to the company, the same product would have different SKUs if sold by different companies, but they would have the same UPC. SKUs are generally on the packaging a product comes in, rather than on the product themselves. SKUs are essential doing calculations on inventory, because it supplies inventory data. For example, a simple example SKU for an 18 quantity stock of red sandals might be: Sand-Red-18. Additionally, it is possible to assign different SKUs to the same product in order to track product batches by quality level, expiry dates (food industry), location (when managing multiple sites), or merchant information (if doing fulfillment as a service). Note that in the market, the term SKU is often used inconsistently, sometimes to mean UPC, the manufacturer part number, as well as the company's part number); these are all improper usages of the conception of an SKU.

A. **Amazon Standard Identification Numbers (ASINs)** - are assigned by Amazon Corporation to products it sells and used to manage and organize all products throughout Amazon. ASINs are 10-digit alphanumeric Amazon-specific SKU codes. On Amazon corporation's website, it is possible to find the ASIN of a product in the product's URL. ASINs are distinct from manufacturer model numbers and from SKU numbers used by other sellers in Amazon's supply chain.

B. **Fulfillment Network Stock Keeping Unit (FNSKU)** - is an Amazon Corporation generated identifier to identify the product that has been sent by the seller to their fulfillment centers. In other words, every unique item that is eligible for fulfillment by amazon (FBA) AND enters an Amazon warehouses should be assigned an FNSKU.

3. **Model numbers (a.k.a., manufacturer model numbers, and sometimes, product numbers, product codes)** - a model number is a code used to identify a group of items made in a production run, such as a particular type of blender, vacuum cleaner, a silicon processor, etc. Simply, serial numbers are issued to individual units within a production run. These may be numeric or alphanumeric. A model number identifies the product sub-type. Note that it is possible to use model numbers as part of the SKUs, but one additional option would be to set them up as [metadata] attributes so that users can use filters. Knowing a model number is essential when garnering services for a product's repair since replacement parts often correspond with a model number.

4. **Serial numbers (SNs)** - is a manufacturers assignment of a unique number to every single individual production of a product type. The serial number will only be for one single object. Serial numbers are unique to each unit. It is a sequential number that is assigned to a single item of a product. In the market, serial numbers are used to track ownership and warranty information of that item. In community, serial numbers are used to track the location, usage, and time elements of a product. Serial numbers are generally numeric only, but may be alphanumeric.

3 Optimal resource allocation calculation planning and analysis

A.k.a., Computational economics, optimal economic allocation plan, optimal allocation calculation, optimal planning, Kantorovich method, mathematical programming, etc.

An optimal economic calculation system uses computer computations to optimize for the fulfillment of all user needs,

1. for interim (means of production) and final goods and services,
2. without money (i.e., without trade/markets),
3. using Leontief-type methods, Kantorovich-type methods, and various statistical analyses,
4. which together informs a plan for economic service production of a city network,
5. within which are three primary service sectors (life, technology, and exploratory).

Without reliance on markets or currency, the a decisioning structure coordinates the production and distribution of goods and services based on societal requirements, rather than market demand. The Leontief input-output model and the Kantorovich method, along with statistical analyses, play pivotal roles in this planning process:

1. **Linear input-output method** (e.g., the Leontief input-output model) - is an economic tool that quantifies interdependencies among different [habitat] sectors in an economy. It provides a systematic representation of interdependencies among different sectors within an economy. By quantifying the relationships between inputs and outputs of various sectors, this model can be utilized to understand the flow of goods and services required among different sectors, including the three primary service sectors: life, technology, and exploratory. It uses matrices to represent input-output relationships between sectors, showing how changes in demand for goods and services in one sector affect other sectors. The mathematical structure involves a system of linear equations that can be solved using matrix algebra to determine the flow of goods and services between sectors.
2. **Linear input-output optimization method** (e.g., Kantorovich method) - is an economic tool used in optimization problems, particularly in linear programming and resource allocation. It enables the efficient allocation of resources to meet production goals and fulfill user needs. The Kantorovich method deals with maximizing or minimizing an objective function, subject to certain constraints, often in the context of resource allocation. The mathematical structure of the optimization model includes techniques such as linear programming, convex analysis, and algorithms to find the optimal allocation of resources as a "plan". This method facilitates in determining the most effective use of resources among the three service sectors (life, technology, and exploratory) to satisfy the diverse demands of the city network's inhabitants.
3. **Sampled statistical analysis method** (a.k.a., pareto efficiency, etc.) - is an economic tool used in analyzing and providing intelligence for decisioning. Statistical analyses encompass a range of methodologies, including data analysis of historical usage patterns, population demand assessments, technological advancements, etc. These analyses are crucial for forecasting demand, identifying resource requirements, and optimizing the allocation of resources across the city's service sectors. Of all the economic statistical analyses, the Pareto efficiency analysis may be one of the most important.
   A. Pareto efficiency relies on statistically comparing different allocations of resources and service/objects, and determining if a change can make at least one person better off without making anyone else worse off. In the market-State, pareto efficiency is a concept more associated with welfare economics and is evaluated based on individual preferences and utility rather than using mathematical equations. However, there are several ways statistical analysis affects decisioning and relates to assessing Pareto efficiency, including but not limited to:
      1. Common-wealth access distribution analysis (access to resources): Statistical analysis can be used to examine commonwealth access distributions within a society or economy. Measures such as the Gini coefficient, Lorenz curve, or income percentiles can provide insights into the degree of inequality within a population. A distribution closer to Pareto efficiency would suggest a more equitable allocation of resources.
      2. Common-wealth functional service analysis (well-being from access to resources): Economists might use statistical methods to estimate personal-, common-, and team-utility from different allocations of resources. This involves assessing needs, preferences,

satisfaction, or well-being through surveys or economic models. Statistical analysis could help compare different distributions and their impact on overall wellness.

3. Efficiency indicators in production: Statistical analysis can be applied to evaluate production efficiency in habitat sectors. Measures like Total Factor Productivity (TFP) or efficiency scores derived from Data Envelopment Analysis (DEA) can indirectly relate to Pareto efficiency by assessing how efficiently resources are used in production processes.

Simplistically speaking, the [socialist] economic calculation method includes, but is not limited to:

1. **Resource allocation data based on leontief model:** Utilize the leontief input-output model to analyze the interdependencies and resource requirements among the life, technology, and exploratory sectors. Determine the input needs of each sector and establish their interlinkages.
2. **Optimization data with kantorovich method:** Employ the kantorovich method to optimize resource allocation, considering constraints, preferences, and production capacities within each sector. This includes balancing resource utilization across sectors to meet the city network's needs efficiently.
3. **Statistical analysis for demand forecasting and distributive justice:** Conduct comprehensive statistical analyses to forecast user needs, considering historical consumption patterns, residency changes, resource changes, environmental changes, technological advancements, contribution changes, and evolving societal preferences.
4. **Iterative planning and adjustment:** Continuously refine the economic plan based on feedback from user needs assessments, technological advancements, and changing requirements.
5. **Quality control and evaluation:** Implement mechanisms for quality control and performance evaluation to ensure the economic plan's effectiveness in meeting user needs and fostering societal well-being.

In economics, an input–output model (I-O or IO model) is a quantitative economic model that represents the interdependencies between different [macro] economic entities and their activities. The input–output (I–O) model views the economic system as a set of interconnected subsystems, which produce outputs (goods) and use resources in the process of production. Input-output models describe and analyse the logistics flows (a.k.a., streams) of spatial and environmental effects associated with production and other economic processes, including demand. Therein, the output from one economic entity becomes the input of another. In fact, economic and operational analysis, planning, and performance can be evaluated through IO tables. IO models are an essential material accounting approach and tool. Input-output analysis is a form of analysis based on the interdependencies between economic entities. Further, input–output (IO) models can be used to study the environmental, social and economics impacts of human activities in an interconnected world. (Rodrigues, 2016) Organizational structures can be represented as a system with interdependent components where the outputs of some components become inputs of another. The input-output model is a essential tool in economic decisioning.

The input-output method is defined in terms of flows [of materials and information]. Essentially, within an input-output table everything is a flow per time (e.g., year) of resource composition (e.g., product Y) into the production process of service (e.g., sector X). Such expressions are sometimes known as flow formalism. Cybernetics introduces the idea of using machines to run the calculations, and machine learning and neural networks are being proposed in the early 21st century as computational frameworks. Under cybernetic planning there are continuous fast calculations and iterations, where different levels of immediate planning and future predictions occur to control operations. Further, demand, usage, and contribution are the three axiomatic points of interaction that an economic (material) system has with its individual community of users.

Fundamentally, input-output (IO) models are tools for economic and operational accounting and planning. (Polenske, 2001). Input-output tables can be used to analyze and plan the structure and flow of an economy. Historically, the input-output modeling approach has been applied to analyze the economic structures of nations and region, in terms of flows between sectors and commercial entities by representing the economy as a system of matrices and linear equations. (Leontief, 1941) Such modeling allows for analyzing and planning the interdependences among all interdependent economic entities. By analysing the interdependencies among entities, it is further possible to evaluate the effect of technological and economic change on an economy, and in the case of community, a habitat.

The widespread use of this method can also be seen by the scale of the scientific literature on the topic. For example, searching for “input–output analysis” in Google Scholar in early 2020 yields over 101,000 documents (this result includes scientific articles, conference papers, books, chapters, and online gray literature). There have also been several individuals awarded nobel prizes for their work in this discipline, including Wassily W. Leontief, Leonid V. Kantorovich, Tjalling Charles Koopmans, and John Richard Nicholas Stone.

Logistics flows can be analyzed from at least the following two perspectives. Firstly, logistics flows can be analyzed from a spatial perspective where entities and processes are described referring to their location. Secondly, logistics flows can be analyzed from an operational perspective that describes all the processes (as a set) in a given geographic area. (Albino et al., 2007:35)

Industry uses the term "supply chain" to refer to a network of production processes, which transform inputs into outputs, and are located in a given area. A "supply chain" may be considered an input-output system wherein a set of tightly interconnected production processes convert materials into final products, which are then delivered to users who demanded them. In other words, a "supply chain" is a network of production processes, including transportation and energy, which transform inputs into outputs, and are located in a given area. (Albino et al., 2002) Note that in the market-State, the term, "supply chain", is an industrial manufacturing term that can have vertical and/or horizontal integration. However, in a community-type society, the supply chain is considered to be fully integrated and there is no competition or sales price between entities involved in the supply chain (as there is in commercial industry).

Input-output activities are essential in order to represent the relationships between production processes and to investigate the effects of possible development scenarios on the economic and environmental performance of the supply chains.

It is relevant to note here that in the market-State there are at least three supply chains for end products:

1. One supply chain that feeds commercial entities: the commercial market, including workplaces, stores, and direct to sale manufacturers and manufacturing for other commercial entities.
2. One supply chain that feeds residential individuals and families: Household supply chain that feeds individuals and families; including retail outlets, stores, restaurants, etc.
3. One supply chain that feeds each government.

Note that there is significantly complexity under market-State conditions in calculating, planning, and otherwise agreeing on inputs, processes, and outputs for society. Here, in general, each individual entity in the supply chain does its own calculation and planning for that which is relevant to its own existence and profit. In a unified societal system, planning is more feasible and significantly likely.

At a basic level, the conceptual framework of an input-output system requires at least four types of data input:

1. Processes: The services, which are processes that transform inputs into demanded outputs (a.k.a., sectors).
2. Inputs: The resource inputs required of each service to be transformed into demanded outputs (a.k.a., resource inputs).
3. Demanded outputs: The known demands of each service (a.k.a., final outputs).
4. By-product outputs: The known non-demands of each service that are a by-product of their processing resources into final outputs (a.k.a., wastes/emissions).

Take note that the usage of natural resources and the generation of wastes and emissions are negative externalities that are not included in the conventional accounting process for economic systems. In the market-State, these flows/streams emanate directly from, or terminate directly to, the natural environment rather than economic sectors within the system. Accounting for such flows plays an critical role in measuring the sustainability of a production process and identifying opportunities for improvement. (Tan et al., 2018:2) In community, these streams/flows are included and are not considered external to the model.

Input-outputs can be geographically referenced with GIS technology and temporally referenced with a schedule. The IO approach can be integrated with GIS technology that spatially references all the inputs and outputs accounted in the model. Spatial complexity, can be modelled through the integration of an I-O approach with a Geographic Information System (GIS), which enables the geographical reference of input-output data, then allowing the organization and processing of information both geographically and logically. (Malczewski, 2004) Inputs and outputs must be spatially (Read: geographically) referenced.

Albino et al., (2007) provide an input-output model of a local supply chain supported by GIS technology. Therein, transportation is modeled as a primary input for logistical services required by each production process to convey its output to its final destination. Therein, the transportation system includes all the tracks covered by transportation means to deliver products.

Scalability and general systems applicability are two useful features of input–output analysis. While the original idea of input–output analysis was for analyzing and planning economic systems, it has been extended to other applications, such as ecosystem food chain analysis, human organizational system analysis, and industrial plant analysis and planning. As a fundamental means of understanding systems dynamics, input–output analysis has proven its versatility not only through its application to the field of economics, but also through its application to various fields of sciences. (Tan, 2018:7)

3.1 Computational economics in historical context

A.k.a., Early work on the economic calculation problem.

Input-output tables and calculations are common in the sciences, and although input-output techniques have been perfected for many decades, in the early 21st century, they are not being used toward any sort of cooperative, global economic plan.

In the 1930s Wassily Leontief formalized an analytical technique to quantify the impact that changes on demand for products had on an economic system. This model was not originally from Leontief, there is earlier evidence of it from Quesnay's "Tableau Économique". In the early 21st century, Wassily Leontief is the primary persona associated with the development of the general model of economic balance, and the use of the input-output analysis in economic planning. Input-output tables are a charting tool that allow for analysing the relation that exists between the inputs and the outputs that a certain economic sector needs for its production. These outputs may become the final product for human demand, or they may become the inputs to another economic sector, wherein they are used by that sector to produce its own outputs. This way different sectors can be connected to the final human demand of a certain solution (or, product). Leontief demonstrated how to combine facts about the world and formula for inter-sector input-output analysis. He realized, the production process is a "circular flow" of requirements

According to Wassily Leontief, "input-output analysis is a practical extension of the classical theory of general interdependence which views the whole economy of a region, a country and even of the entire world as a single system and sets out to describe and to interpret its operation in terms of directly observable basic structural relationships." (Leontief, 1987:860; Heinz, et al., 2020)

The first systematic presentation of computational economics was that of input-output planning as described by Leontif in 1941. Leontif used a matrix representation for the economy, using an input-output table. The input-output model forms a standard matrix representation of the data (i.e., a matrix representation of the economy). Input-output planning is the core of computational economics. Leontief was an economist who wrote a paper in 1941 where he described a way to analyze an economy through a series of equations. Wassily Leontief won a Nobel prize in economics in 1973 for his work on input-output planning and analysis. Through the work of Leontief and others it is known that the production process is a "circular flow" of requirements and resource compositions. It is correct to say that input-output models may be used to model the entire economic production system of a society, which is essential in the construction of a habitat service system for the global population.

Here, there is the problem of quantity for which a structure of the levels of operation of processes of production is needed in order to guarantee the reproduction of the means of production used up in the course of production and the satisfaction of some 'final demand', that is, the needs and preferences of the different access types. Here, there are resources, that may have mutually decided allocations.

Early national socialist economic planners ignored input-output planning as too consumer oriented (in place of reproductive material balance planning), because it accounted for user need, which robbed the human planners of their discretionary power to manipulate the figures. Paradoxically, the pursuit of consistency and equilibrium enabled by input-output tables was not what practicing socialist planners wanted; instead, their top priority was to maximize their discretionary power. Indeed, fear of the abolition of the administrative system of intermediate goods and supplies is at the core of the opposition to input-output tables. Hence, many of the early economic planning systems used material tables (and not, complete input-output tables). Where input-output tables were used, they were highly linear, which is problematic in two respects:

1. There is an assumption that labor (work) requirements will scale linearly with production demands. This assumption is false as more advanced technologies allows for ephemeralization (Read: doing more work with less effort and/or resource input).
2. There is the assumption that raw materials are used to make a product, and after the product's use, it is disposed of, and not, reused or recycled. This assumption is false because some products can be reused and most materials can be recycled.

The moment the demand for intermediate goods is derived from final demand, in an activity model, the reason for the entire administrative and bureaucratic supply system, to even exist, comes into question. Hence, traditional planners used a regulated variable, but it was a variable that is pathological. The planners regulated their own levels of discretion, and did not actually regulate the economy. In other words, they continued a regulated bureaucracy. The method(s) selected by and for the planners were to aid in bureaucratic power regulation, not actual economic coordination for human life fulfillment. This is why the methodology (method selection) is so important to the success of human fulfillment, and why it must be transparently conveyed in a standard available to everyone in society.

The use of material balance planning primarily by early socialist economic players led to planning targets that had little to no relationship to actual user demand (as in, human need). In places where socialist planning did occur, crazy surpluses were produced (e.g., too many shoes, which were then wasted on fields, hoarding became pervasive, and a black market developed as a secondary life-cycle for products). The market often ends up with products that are useful, but bad in some significant way at being useful.

The core of the Soviet-type planning method:

$P_tQ_t = Y_t + TP_t - S_t - T_t$

- Wherein,
  - P is the retail price level.
  - Q is the quantity of goods and services produced.
  - Y is output.
  - TP represents transfer payments (often viewed as redistributed taxes from previous periods).
  - S are savings.
  - T are taxes.

Notice how, in the Soviet system, price is still present. According to the "market theory of value", price is the sole source of value in a commodity. According to the Marxism "labor theory of value", labor is the sole source of value in a commodity. In other words, the real[-world] expenditure that a society undertakes is the expenditure of its people's time. The flow of this labor-time "value" generated by an economy (of people doing labor and consumption) can be thrown off by the inflation of deflation of the unit of value, money (if there is money used in the society).

The "labor theory of value" is capable of being expressed conceptually and mathematically:

Price (of a commodity) = payments of constant (Capital, Labor, and Profits)

1. 'Capital' is machinery and raw materials.
2. 'Labor' is living humans doing work.
3. 'Profits' is more money.

The Soviet-type planning method only eliminates profit, not price. The Soviet-type planning method uses material balance planning primarily to balance price, in order that planner maintain control. In the Soviet-type planning method, bureaucrats and employed planners in the government (Read: labor-State) decide how to balance the economic equation by adjusting the price level on both sides, which impacts priced demand directly. In a Soviet planned economy, price levels can be adjusted directly; they are immediately controllable by those with the authority. Alternatively, in the early 21st century, the financial commodity planning method uses a centralized bank to decide growth ("interest") rates, which impacts the demand for money, which impacts price indirectly. Under financial commodity planning conditions, the authority takes decisions that impact financial institutions, which impact a competitive environment, which impact price, which impact demand. One system uses authority and competition to impact demand, and the other system simply uses authority to do so. To authority, power is the ultimate commodity.

It is not correct to regard material balances and input-out planning as a specific to any type of society (community, capitalist, communist, etc.). All complex socio-technical economies use material balances and input-output planning to some degree. The differences in societies economies typically come in how, and to what end, they are applied.

Since the earlier socialist planners, humanity now has the following additional capabilities that make economic calculation feasible for the global population:

1. Internet allows real-time cybernetic planning. Distributed computation and network block chains can solve the problems of dispersed computation.
2. A unified information systems standard allows for socio-technical agreement (i.e., understanding).
3. Computers can solve the necessary and complex equations in feasible amounts of time.
4. Integrated habitat service systems contributed to by open source methods, to a common, mutually fulfilling standard. This is a habitat service matrix of tables of contribution, priority, urgency, technology, and production service sectors).
5. In a contribution-based system, there are users, some of whom, are also contributors.
   A. Users.
   B. Contributors.

Under these conditions, priorities in the context of demands and requirements therefrom, become clearly visible (or at least, the data becomes available for its computation if a societal arrangement is there is there to compute it). Mutual user access and contribution access in combination with a technology matrix allow for the dissolution of a price between an owner, a laborer, and a consumer, or some combination thereof. Direct population surveys of needs (workgroups, "assessment"), and demands (whole population).

In this system, the society gets back in productions the same amount of production (via contribution) it performs. Products are calculated via direct feedback from demand, which is usage, to planning.

3.2 The linear economic calculation techniques

Linear economic calculation is a simple stepped technique:

1. Know about what is.
   A. Know about the input-output model and know about input-output matrix mathematics.
      1. Construct the input-output chart/matrix/table.
      2. Populate the table with accurate data.
      3. Use matrix calculation equations to derive [more] useful data.
2. Know about what is demanded (needed).
   A. Know about how to calculate the optimal configuration of resources into an integrated assembly of habitat service sectors that optimally meet human requirements.

B. Populate a plan with accurate data.

3.2.1 Linear mathematical planning

The calculated linear planning and decisioning of an economic (habitat service) system [network] can be determined using multiple different potential planning methods, categorized into two axiomatic categories:

1. **The "points" methods (the "priced" method)** - the neutral idea of having a point system that prices a go/no go decision at a threshold price points, upon which the solution master plan is a go/no go. That go/no go decision takes the neutral form of a token and a decision. That is, the token is a unit of trade account:
   A. Exchangeable for object/service (privatization; ownership trade price). Here, there is a trade of a token for access to an object or service.
   B. Exchangeable for doing work (capitalization; labor salary price). Here, there is a trade of a token for labor producing as part of a means of production.
   C. Not exchangeable point system of units of relevant value and object account, as in, the Kantorovich method where there are units of relative administrative value ("points").
      1. The Kontorovich method relies on linear programming techniques (linear programming input-output analysis), providing planners with a computational tool to determine the most efficient resource allocation and production plans, while accounting for the interdependencies between different sectors, considering the input points [thresholds] required and the output points [thresholds] produced by each sector of the economy.
      2. Leontif method (basic coefficient input-output analysis): Basic input-output analysis (a.k.a., Leontief method) does not explicitly consider prices or optimization of resource allocation, however, it can include price in place of physical quality. Therein, it would focuses on understanding the structure and relationships between sectors in terms of points/prices abstracted from resource flows at a material quantity level. The Leontief model starts with a matrix of input-output coefficients, often referred to as the Leontief matrix. Each element of the matrix represents the amount of inputs required by a sector to produce a unit of output. These coefficients capture the technical relationships between sectors and the resource dependencies within the economy.
2. **The non-points method** - does not use any form or points or price; uses objects as quantities and fulfillment as qualities.
   1. Leontif method: Unlike the Kantorovich method, basic input-output analysis (a.k.a., Leontief method) does not explicitly consider prices or optimization of resource allocation. Instead, it focuses on understanding the structure and relationships between sectors in terms of resource flows at a material quantity level. The Leontief model starts with a matrix of input-output coefficients, often referred to as the Leontief matrix. Each element of the matrix represents the amount of inputs required by a sector to produce a unit of output. These coefficients capture the technical relationships between sectors and the resource dependencies within the economy.
   2. Nemchinov (1962).

Price assignment and point assignment refer to different methods of assessing and assigning values or weights to economic variables. Here's an explanation of each:

1. Price assignment: Price assignment involves the determination of prices for goods, services, or resources in an economy. Prices serve as signals that reflect the relative scarcity, demand, and supply of different goods and resources. In a market-based economy, prices are typically determined through the interaction of supply and demand, and other variables. They emerge as a result of market "forces" and reflect the willingness of consumers to pay, and producers to produce and sell. Prices convey information about the value and scarcity of goods and guide resource allocation decisions in the market. Price assignment enables economic calculation by providing a common unit of measurement (monetary exchange value) that facilitates comparisons and trade-offs between different goods, services, and resources. It allows for the evaluation of costs, revenues, profits, and the efficiency of resource allocation.
2. Point assignment: Point assignment refers to the practice of assigning numerical values or weights to specific attributes or characteristics of goods, services, or resources. It involves quantifying non-monetary factors or dimensions that are relevant to economic analysis but may not have direct market prices. For example, in environmental economics, point assignment may be used to assess the ecological impact of economic activities

by assigning values or scores to factors such as pollution levels, biodiversity loss, or carbon emissions. These assigned values or points help in measuring the overall environmental performance or sustainability of different alternatives. Point assignment allows for the incorporation of non-monetary considerations, externalities, or social factors into economic calculations. It helps decision-makers weigh and compare different dimensions of economic choices beyond solely relying on market prices.

To determine how plans are constructed it is useful to ask the following questions:

1. Are the plans commensurate to human fulfillment as an assembled unit of production in the form of a habitat?
   A. An internal inquiry point system to determine optimized production based on categorical inquiry threshold decisions for aligned execution of a solution. Note, there is no need for a commensurate unit between inquiry processes (e.g., between ecological inquiry and preference inquiry); because, each inquiry terminates in a "go"/"no go" decision for a specified solution.
2. Are plans commensurate to private property acquisition and a stabilized trading environment?
   A. If yes, then, a commensurating unit(s) can be used. That commensurating unit can be based on a token trade account (for priced purchases, as a base unit for private property in the market).

Summarily, price assignment primarily focuses on determining market prices for goods and resources, whereas point assignment involves assigning numerical values or weights to non-monetary factors or attributes that are relevant for economic analysis but do not have direct market prices. Both methods contribute to economic calculation by providing a framework for assessing and comparing different aspects of economic choices.

Economic calculation involves the assessment of various factors, which may include both homogeneous and heterogeneous variables, depending on the specific context and the nature of the analysis. There are techniques to analyze homogeneous and heterogeneous variables as economic phenomena, and use results to inform decisioning, and evaluate outcomes. The specific variables considered depend on the particular economic context and the objectives of the analysis.

Some examples of variables considered in economic calculations include:

1. Physical quantities: These are homogeneous variables that represent the physical quantities of goods or resources involved in production, consumption, or trade.
2. Prices and points are often used as a measure of value and play a crucial role in economic calculations, facilitating comparisons and assessments of actions and conditions.
3. Costs and revenues: Economic calculations involve analyzing and quantifying costs incurred in production, such as labor, fixed and marginal material costs, and overhead expenses, as well as revenues generated from sales or other economic activities.
4. Human needs: Heterogeneous variable capturing human needs for life, technology and exploratory services.
5. User preferences: Heterogeneous variables capturing user preferences.
6. Productivity and efficiency measures: Economic calculations assess productivity measures, such as output per unit of input or labor, and efficiency indicators to evaluate the performance of production processes, firms, or industries.
7. Risk and uncertainty: Economic calculations often incorporate variables related to risk and uncertainty, such as probabilities of events, expected returns, and volatility, to assess the potential gains and losses associated with different options.

3.2.2 The Kantorovich method of economic planning

This section presents input-output planning from the perspective of the individual who popularized the knowledge. Kantorovich, a Soviet economist and Nobelist, composed an explanation of how to systematically solve linear algebra mathematical techniques (a.k.a., linear programming or linear optimisation; matrix equations), which solve for objective economic calculation problems. Linear programming involves optimizing (maximizing or minimizing) a linear objective function subject to a set of linear constraints. Kantorovich showed that it is possible to design an optimized [habitat] production plan without any reference to money. The Kantorovich model focuses on optimal resource allocation across different sectors to minimize costs or achieve specific targets. In the same way as Leontief's method, Kantorovich's approach for an optimized production plan, itself, does not inherently involve money. Instead, the plan focuses on allocating resources efficiently to achieve desired objectives and targets within the given constraints. As Cockshott (2018) points out, the significance of Kantorovich's work was that it showed that is possible to use a mathematical procedure to determine which combination of production techniques will best meet planned targets when the initial conditions include a description, in purely physical terms, of the various production techniques available (called, sectors, sub-sectors, or technologies). The Kantorovich method applies an objective evaluation technique to data by organizing it into input-output tables, which can then have operations performed on them to provide more useful data. Kantorovich systematically shows that in-kind calculation is possible, and that there can be a non-monetary scalar objective function: the degree to which plan targets are met. The result of the method is a decision process shown diagrammatically that reveals the optimal [technological planning] decision.

> **NOTE:** *Cockshott (2018:12-13) identifies three areas where Kantorovich's method can be improved.*

At a basic level, Kantorovich's method to solve economic planning problems requires:

1. A linear algebraic algorithm/program.
2. An input output matrix for an economy.
3. A set of initial resources and production sectors.
4. A set of demands and constraints.
5. Final demand vector: The model also considers the final demand vector, which represents the total amount of goods and services demanded by different sectors and by final consumers (households, government, etc.). This vector reflects the desired level of output for each sector.
6. A vector of plan objectives – what Kantorovich called a planray.

The Kantorovich method and the Haromony Planning require, at least (Cockshott, 2019):

1. A flow matrix or flow I/O table.
2. A corresponding technology (i.e., capital, sector, stock, etc.) matrix, specifying the amount of technology "Y" needed to produce an annual flow of product "P" of output quantity "x".
3. A corresponding resource matrix specifying how much resource each type of technology requires in each of its uses.
4. A target vector of net outputs for the current period.

The Kantorovich method uses the methods of:

1. Matrix algebra: To calculate the total input requirements for a given level of output, the Leontief matrix is multiplied by the final demand vector using matrix algebra techniques. The resulting vector represents the total inputs needed by each sector to satisfy the desired level of output.
2. Multiplier effects: The Leontief model allows for the analysis of multiplier effects. By considering the total input requirements, the model can assess how changes in the level of final demand or production in one sector impact other sectors through the ripple effect of interdependencies. This analysis helps understand the broader implications of changes in economic activity. The Leontief input-output model, through its use of input-output matrices, provides a framework to analyze the interconnectedness between different sectors in an economy. It tracks how changes in one sector's output or demand for goods and services affect other sectors. This interconnectedness leads to the concept of multipliers. There are two primary types of multipliers in the Leontief model:
   A. Production multipliers: These multipliers show how an initial change in final demand for a particular sector's output leads to changes in production levels across various sectors of the economy. For instance, an increase in user demand for automobiles will not only impact the automotive production (sector) but also affect sectors supplying mining (raw materials, such as steel or rubber), thus causing a chain reaction of increased demand throughout the economy.
   B. Income or employment multipliers (points): These multipliers illustrate how changes in production levels affect factors like value, income, and employment/contribution within an economy. An increase in production (value(in a specific sector may lead to increased income, increased employment, and/or increased desire for contribution by workers for working in that sector.

The Kantorovich model focuses on optimal resource allocation across different sectors to minimize losses and maximize benefits, to achieve specific targets:

1. Objective function:

   Consider a cost matrix C representing the costs of allocating resources from one sector to another:

   - Input-Output matrix A:

$$A = \begin{bmatrix} a_{AA} & a_{AM} & a_{AS} \\ a_{MA} & a_{MM} & a_{MS} \\ a_{SA} & a_{SM} & a_{SS} \end{bmatrix}$$

   - Where,
     - a_{ij} represents the amount of input required from sector j to produce one unit of output in sector i.

2. Constraints:

There are constraints related to resource availability, production capacities, and possibly demand requirements.

3. Optimization:

   The objective is to minimize the total cost, represented as:

   $Z = \sum_{i,j} c_{ij}x_{ij}$

   Subject to constraints such as $x_{ij} \geq 0$ (non-negativity constraint) and other specific constraints.

To derive a set of useful numbers (i.e., objectively determined valuations), the following inputs are used:

1. The algorithm.
2. The technology available.
3. The objectives of the plan (demands).
4. The constraints on the plan (constraints)
5. The available stock of material resources.

> **INSIGHT:** *Demand is ultimately an issue of population. If there is no population, there is no demand.*

Given this information, it is possible to then apply either Kantorovich or the harmony method to construct a plan. If you want a multi-year plan you need target vectors of net output for each succeeding year of the plan period. If you want a multi-day plan, then you need target vectors of net output for each succeeding day.

The Kantorivich method incorporate points ("prices") as part of the calculation process. In the context of Kantorivich's writing, the method is designed to complete economic calculations (i.e., address the economic calculation problem) in centrally planned economies, where, the State controls:

1. the factory (habitat),
2. the office (working groups),
3. the price (access).

While the Kantorovich method includes points ("prices"), it should be understood that these points are not market-determined, but are set as part of the planning process based on decision inquiry thresholds. The specific process of determining these points can vary depending on the particular parallel decision inquiry. Common approaches to setting prices within the context of the Kantorovich method include:

1. **Administered prices/points (for the "go"/"no go" solution)** - prices are administratively determined by the planning authorities via pre-decided protocols. The authorities consider factors such as equity, environmental impact, human need fulfillment, social priorities, and policy objectives when setting prices for different goods and resources. These prices are often based on directives, calculations, or negotiations among the relevant stakeholders.
2. **Shadow prices** - are "prices" that are not directly observable or administratively set but are derived as part of the optimization process. The Kantorovich method allows for the calculation of these "shadow prices" based on the optimization models and the underlying economic structure. "Shadow prices" represent the opportunity cost or marginal value of resources in the production process and can guide resource allocation decisions.
3. **Iteratively adjusted prices** - are when prices may be determined through an iterative process. The planners start with initial price estimates, administratively determined, and then iteratively adjust them based on the outcomes of the optimization models. This process involves evaluating the results, assessing resource allocation efficiency, and modifying prices accordingly to improve overall economic performance.
4. **Input-output analysis coefficient prices (input-output coefficient analysis)** - a method that examines the interdependencies between sectors in an economy. It quantifies the flow of inputs and outputs among different sectors and can be used to derive relative prices based on the resource requirements and production linkages.
5. **Prices can be set based on input-output coefficients** - reflecting the relative scarcity and importance of different resources. Input-output coefficient analysis examines the interdependencies between different sectors of an economy by quantifying the flows of inputs and outputs. It uses a matrix of input-output coefficients to represent the resource requirements of each sector.
6. **Cost-based pricing** - involves setting prices based on production costs, including factors such as labor, materials, transportation, office work, and "overhead" expenses. The costs incurred in the production process are calculated, and prices are then determined by adding a margin or markup to cover expenses and provide a desired level of profitability.
7. **Comparative analysis** - involves assessing prices in similar or comparable economies or sectors. Planners may examine pricing practices and structures in other economies to inform the setting of prices within their own planning system. This approach takes into account the context and characteristics of the specific economy under

consideration.

The Kantorovich method provides a framework for incorporating these points ("prices") into the optimization models, allowing planners to make resource allocation decisions that align with the desired economic objectives, encoded into the "price". The economic objectives are encoded into the price. In most "socialist" economic proposals, the price is significantly composed of working hours.

In the context of an economy implementing the Kantorovich method or similar mathematical optimization approaches, it is possible to envision a system that operates without traditional forms of currency, trade, or market exchange. Instead of using conventional prices, an alternative concept, such as "points" (a.k.a., "price", "commensurate units of measurement") can be employed to facilitate resource allocation and decisioning. The use of "points" or a similar term serves as a quantitative representation of value within the optimization models (it can even be localized to a team or sub-system, such as each decision system inquiry). These points can be assigned to different resources, services, products or activities, reflecting their relative importance, scarcity, or contribution to the overall goals of the economy and/or society. The mathematical models, typically based on linear algebra and optimization techniques, calculate the optimal allocation of these points, taking into account production capacities, resource constraints, and desired outcomes. The mathematical models, guided by the objectives and constraints defined by the planning decision working group, determine the optimal distribution of resources, production plans, and activities based on the assigned points. By using science- and user-informed points, instead of traditional market prices, the emphasis is placed on achieving efficiency, minimizing costs, and maximizing the overall well-being of all individuals in society.

3.2.3 Material flow analysis (MFA) econonmic planning:

Material Flow Analysis (MFA) tracks the physical flows of materials and resources within an economy. Material flow analysis is a systemic survey and assessment of the flows and stocks of materials within a system defined in space and time (as 3D objects, each with their own geometric-informational model). Material flow analysis quantifies the inputs and outputs of materials in different sectors and provides insights into resource efficiency and sustainability. MFA does not involve price-based calculations or optimization. It emphasizes understanding the physical resource flows and identifying areas for resource conservation and waste reduction.

3.2.4 Modified Leontief models for economic planning

There are many modified forms of the Leontif model. Cumberland (1966) amended the Leontief input-output model to include pollutants and other such externalities (Read: Cumberland I/O model). Rows and columns were added to the original model to highlight the benefits and dis-benefits associated with any economic activity on a sectoral basis. Isard and Daly developed similar approaches along the Cumberland lines to the extension of environmental issues into the input-output framework. Both models are comprehensive in their approach. Each model shows the interactions both within and between the economic and environmental systems. Robert Ayres and Allen Kneese (1969) commented on a slightly varied approach to the problem of externalities. They introduced a concept known as a materials-balance approach which broached the topic of the fact that there is an imbalance between the resources that are drawn from nature, and the return of such resources back to nature.

3.2.5 Energy input-output analysis for economic planning

The energy input-output analysis calculation method does not use price in its mathematical calculation; instead, it uses energy (as "work" capacity). Energy input-output analysis is an approach that quantifies the energy flows within an economy. It tracks the energy (power) inputs and outputs associated with different sectors and economic activities. The analysis typically involves constructing an energy input-output matrix that represents the energy requirements of each sector. This matrix can be derived from data on energy consumption, energy intensities, and energy conversion factors. Energy input-output analysis focuses on energy flows and their interdependencies, disregarding prices. It aims to understand energy efficiency, identify energy-intensive sectors, and explore opportunities for energy conservation.

3.2.6 Adapted Haber (2015) heuristic action rating method for fundamental system functionality calculation economic planning

In a computational economic system, it is possible to rate actions using the fundamental functional components (characteristics) of the system (fundamental system functionality), which include, but may not be limited to:

> *Note that the ratings are primarily designed to fall in a range between -100 and 100, which is to enable mutual compatibility, and make use of the practical features of root functions (they exhibit a steady increase with a fast ascent at the beginning and a subsequent decrease in intensity*

1. **Urgency calculation** (time-frame calculation) - Urgency means, how close to being complete within a given time frame is the request. The closer the request comes to requiring completion, and also, not being complete, the more urgent the request.

   Haber (2015:18) provides an equation that may be adapted to this composition of an urgency request matrix. The following equation may calculate request urgency is adapted from Haber (2015:18):

   $\sqrt{}$ $((T + O_R) \bmod D_R) \times 100/(\sqrt{D}) \cdot C_R$

   - Wherein,
     - T is the current tick.
     - O_R the calculated deadline offset of the requesting agent R (in ticks).
     - D_R is the system's deadline period (in ticks).
     - C_R is a 1 or 0 memory location. C is a Boolean indicating whether the requester has already had the demand fulfilled during the current deadline period. If the demand is fulfilled, C is set zero and thus the whole rating becomes zero, too. If the requester has not had the demand fulfilled, C is set to one and the rating is used as calculated. The function's first factor is responsible for determining a request's urgency as the value under the root increases linearly with approach of the deadline.

2. **Priority calculation** (significance calculation) - Within the decision system, a recognition inquiry process calculates the priority of a request, issue, or demand based on human need conceptualized as a prioritized (and prioritizable) habitat service structure. In a habitat, there are three sectors: life, exploration, and technology.
   A. Wherein,
      1. The life sector is prioritized over all sectors.
      2. And, some of the exploration sector supports the life sector.
      3. And, some of the life sector supports the exploration sector.
      4. And, the life and the exploration sectors require the support of a technology sector.
      5. And, all sectors require the contribution of humans.

3. **Distance calculation** (resource-service-requester distance) - Distance could mean, number of hops or links or length (e.g., cities, regions, sub-sectors, transport networks, etc.) and/or type qualities of method of moving over the distance. Distance could mean the distance a resource has to travel to complete a requirement, or distance could mean a service-object has to travel to interface with and then complete a user demand.

   Haber (2015:18) calculates a requesters distance with the function:

   $\sqrt{(W/L)} \cdot (100/\text{sqr root } D)$

   - Wherein,
     - W is a given request's waitCounter in ticks.
     - L is the number of links or hops between the current agent (e.g., resource current location) and the requester.
     - $\sqrt{(w/L)}$ is a factor that takes into account the amount of time a certain request has been unfulfilled in relation to the distance to the

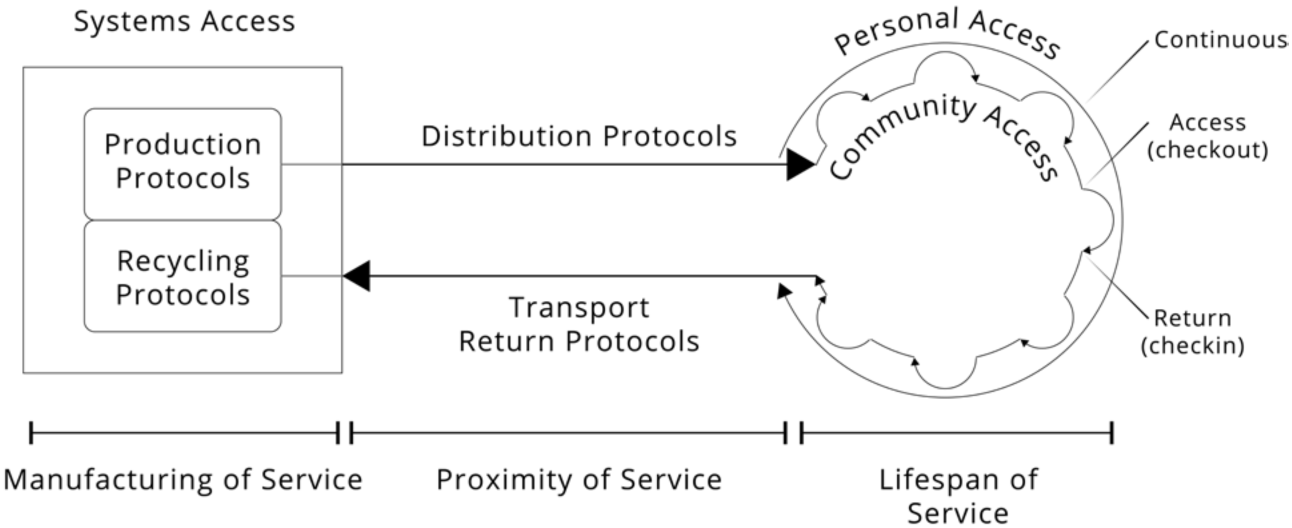

Figure 36. *Model showing visual relationship between access designations and service design.*

requester.
- (100/sqr root D) is a factor equal to the one in the previous formula, stretching the root function to account for the system's deadline period D (in ticks).

4. **Overall resource request** - total resources requested.

   Haber (2020:19) calculates the overall resources requested with a ratio function:

$$\frac{R(x)}{R} \cdot 100$$

- Wherein,
  - R(x) is the request for given resource or product x.
  - R is the current total resource request registered by the agent.

5. **Resource availability** - Actions may be rated with regard to a resource in an agent's inventory, and with regard to a resource that is not in the agent's inventory, but may be currently occupied by a service or object (source) in its sector [of occupation].

   Haber (2020:19) calculates the overall resource availability via a two step process:

   A. Step one determines the regeneration rating for the sources available to the agent. This regeneration rating is determined though the calculation:

$$\frac{R_S(x,D) - E_S(x,D)}{Q_S(x) + E_S(x,D) - R_S(x,D)} \cdot 100$$

- Wherein,
  - $R_s(x, D)$ is the number of regenerated resources of type x in all reachable sources S within the last D ticks.
  - $E_s(x,D)$ is the number of resources of type x extracted from sources S.
  - Qs(x) is the current available quantity of resources of type x in sources S. This rating is positive if during the last D ticks more resources of type x were regenerated than were extracted. If the opposite is true, the rating is negative.

   B. Step two of the rating process now combines this local availability rating with the distance measurement (Haber, 2015:18). If the availability rating in item 5A (above) returned a positive result, it is adopted as the final resource availability's rating, otherwise it is adjusted by subtracting A:

$$A - \quad (-\sqrt{(W/L)} \cdot R(100/\sqrt{D}) \quad + \quad 100$$

- Wherein,
  - A is the (negative) availability rating from equation 5A, and the entire second part is a translated, inverted and double-scaled version of the root function used before.
  - The result is that the formula calculates the difference between resource availability and requester distance, which will still turn out positive if the request's waitCounter is large enough to overpower the resource scarcity warning discount calculated in equation 5A.

6. **Requester utility (or, receiver utility)** - A rating that assesses for actions concerning the assembly of products.

   Haber (2020:18) calculates the receiver utility by way of another conditional function. If the receiver of the assembled product is the assembling agent itself, the score is determined by:

$$\text{argmax} \quad \left(\frac{\text{size}(A)}{\text{size}(W_A)} \cdot 100 \right)$$

argmax ((size (A) / size (W_A)) • 100)

- Wherein,
  - Size(A) is the size of the assembled product
  - Size(W_A) is the size of any demand (for a sector's production) containing the assembled part.
  - Determining the argmax of this function effectively returns the best ratio of demand fulfillment that can be achieved with the assembled part.
  - If the receiver of the assembled product is not the assembling agent itself, the distance function of equation 3 is used since in that case the receiver's demand list cannot be accessed.

The economic tables that could be used in this method include, but are not limited to:

1. Technologies list
2. Product list
3. Demands list
4. Resources list
5. Contributions

6. Priority list and urgency list

3.2.7 The harmony method

The harmony algorithm (the harmony function) is of Order NlogN complexity for single year plans. It retains the same complexity of NlogN for multi-year (i.e., multi-cycle plans). The harmony function is a "social utility" function designed to mimic the principle that there is positive, but diminishing utility, as more of a good is produced. It is a function whose value rises as plan fulfillment approaches, but which "rewards" overfulfillment of the plan less than it "punishes" underfulfillment of the plan. Note here that plan targets may be final user and/or intermediary sector demand targets. In a plot of the harmony function, the plan target of N (x axis) hits 0 on the y axis when it hits its target and less than 0 if there is a shortfall. And, it might increase more slowly if the plan is being overfulfilled. In other words, it is worse for society if there is a shortage of something than big surplus of that thing (i.e., than the gain you get for having a big surplus).

Kantorovich approach specifies exact proportionality (square nxn matrix) between all outputs. This may not always be achievable. It may, sometimes, be possible to overfulfill the plan more for some products than

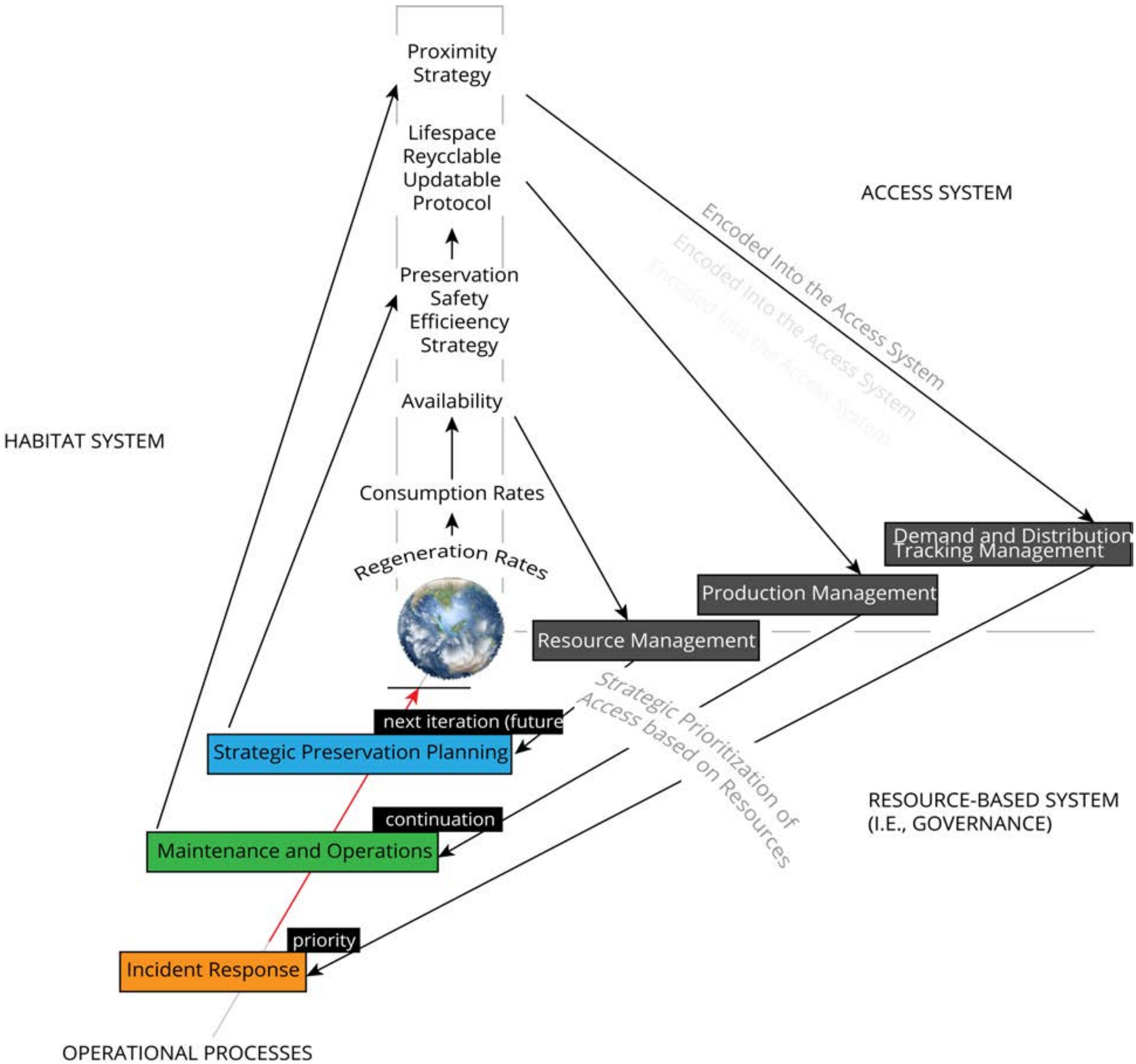

Figure 37. *Accountable dimensions for decisioning within a community-type society. A community-type society resolves decisions by accounting for organization of the system composed of a set of processes that sub-divisible by resource, access, and participation in a real world habitat service system.*

others. And, that may be worth doing. Also, because the harmony function has a continuous first derivative, it allows the use of Newtons method to approximate functions. This allows planning to bring all sectors into approximate alignment with the plan target.

3.2.8 The agent-based modeling method for economic planning

Although the field of Agent-Based Modeling (ABM) was defined by the work of Wooldridge and Jennings (1995), the exact meaning of the term agent is still somewhat controversial. For this project, an intelligent agent can be described as a discrete autonomous entity with its own goals and behaviors and the capability to interact, and adapt and modify its behaviors. In other words, conscious individuals are self-integrating, and goal-directed entities capable of interacting with one another and an environment. Agent-Based Models represent real-world systems using a conscious individual approach, wherein multiples of conscious individuals create a network of effects between the individuals.

In the real-world, the individuals (agents, subjects, etc.), are dependent on the environment for their persistence and fulfillment, which includes an environment of other consciously integrating individuals and common objects (resources).

Hence, economic automation is, in part, a resource allocation problem (a.k.a., object allocation problem). Multi-Agent Resource Allocation is the process of distributing a number of items amongst a number of agents. The objective of a resource allocation procedure is either to find an allocation that is feasible (e.g. to find any allocation of tasks to production units such that all tasks will get completed in time); or to find an allocation that is optimal.' Resources are, generally, indivisible items that may or may not be shared by agents (for example network access as opposed to production tasks), but in some cases may also represent divisible items such as electricity, which can be distributed in fractions. (Chevaleyre et al., 2006)

3.2.9 The Samonthrakis method of economic planning

Samothrakis (2020) details an automated planning system under the tradition of Marx, Leontief, Kantarovich, Beers, and Cockshott as a viable and desirable alternative to current market conditions. In the paper, Samothrakis shows the triviality of planning for up to 50K of industrial goods and 5K final goods in commodity hardware. Samonthrakis shows how it is possible to remove products from market circulation and provision them directly to the population through calculation, cooperation, and globally coordinated planning. Direct economic calculation of products and services is generally called "planning in natura" (Cockshott, 2008), and has direct links to the idea of "universal basic services". One of the primary goals of economic calculation and planning is to remove uncertainty within production and provide a population with access guarantees. More simply, the ultimate goal of an input-output matrix is to plan for demand at the end of a time period. Herein, planning goals are formed using data collected from production units (e.g., factories) and individuals. The goal of the plan is to deliver a set of [real-world] products and services ("goods"). It is important to note here that Samonthrakis' economic calculation plan is only designed to supplement the failures of market and is not designed to abolish it. However, combining it with the rest of the material in this societal standard it is possible to abolish the market entirely.

Samothrakis (2020) introduces the idea of Open Loop In Natura Economic Planning, which adapts the standard input-output with the following:

1. Given that the goal is to provide necessities to sustain humans, set all "external" demand to zero, and introduce a set of profiles combined with the number of citizens attached to each profile.
2. The input-output matrix describes the interactions between:
   A. Consumption profiles,
   B. a set of industrial goods, and
   C. a set of final goods.
3. Profiles are columns that describe the allocation of final goods to each citizen that has been assigned this specific profile.

The real world execution of the open loop in natura economic plan entails two steps:

1. The planner provides information to the production units on their daily targets and requests information on the previous day history, including IO-coefficients (IO-coeffs) in functional form and externalities.
2. The planner requests information on previous days demand and future demand from each individual (or discovers it).

Samothrakis (2020) calls the method/technique open loop in-kind economic planning (OLIN-EP), which builds upon the traditional input-output economic planning framework. Whereas the traditional economic planning timeframe ("tick") was a year, the OLIN-EP timeframe ("tick") is one day (i.e., the plan is re-calculated based on observations and predictions each day/night). Additionally, OLIN-EP does not operate based on abstract notions of aggregate demand; instead, individuals (or close groups) are expected to communicate their demands and projected demands on a timely (e.g., daily basis). Additionally, the productive unites are expected to recalcuate their input-output coefficients (called IO-coeffs - the values of the matrix) and provide them for plan updates on a daily basis in the form of a function. The OLIN-EP operates on a MDP (Puterman, 2014) with the following characteristics (Samothrakis, 2020):

1. Actions $\mathbf{x} \in A$ capture what the production output of each industry should be. Note that due to notation conflicts with input-output literature we use x for individual actions, rather than the most customary *a*.
2. States $s \in S$ capture sufficient statistics of what we want to operate on, as transmitted every morning by production units and citizens. In our case, s is simply a goods inventory.
3. The transition function T(*s* 0 |*s*, *a*) is formally unknown to us, but it is captured partially by the input-output matrix, partially by the semantics we give to the behavior of different outputs of the matrix, and it operates on the inventory and externalities.
4. The reward function denotes how happy the planner is in a specific state and is generally encoded as R(*s*, *a*). We define later on a specific reward function that captures how well the plan targets are met and what damage the plan causes to the world.
5. There is a discount factor γ, which attenuates closer versus further rewards.

Samonthrakis (2020) addresses calculation with following equation:

1. $(I - F(\mathbf{x}))\mathbf{x}=d$
2. This equation allows for the stacking of production units and the utilization of different IO-coeffs values as production scales upward. Additionally, it allows for the planning agent to identify for individuals how important it is to hit certain targets in their profile.
3. Therefore, Samonthrakis identifies the F(x) matrix as:

$$F(\mathbf{x}) = \begin{bmatrix} f_{00}(\mathbf{x}_0) & f_{01}(\mathbf{x}_0) & \cdot & \cdot & \cdot & f_{0n}(\mathbf{x}_0) \\ f_{10}(\mathbf{x}_1) & f_{11}(\mathbf{x}_1) & \cdot & \cdot & \cdot & f_{1n}(\mathbf{x}_1) \\ \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & & \cdot & & \cdot \\ \cdot & \cdot & & & \cdot & \cdot \\ f_{00}(\mathbf{x}_0) & f_{01}(\mathbf{x}_0) & \cdot & \cdot & \cdot & f_{0n}(\mathbf{x}_0) \end{bmatrix}$$

4. To solve this matrix equation, the gradient can be used directly. The mean squared error MSE((I − F(x))x,d) has a gradient that is:

   $\nabla MSE((I - F(\mathbf{x}))\mathbf{x}, d) = 1/n\ ((I - F(\mathbf{x}))\mathbf{x} - d)\ (I - F(\mathbf{x}) - F'(\mathbf{x})\mathbf{x})$.

5. Thus, it is possible to solve the equation using:
   A. A nonlinear least squares algorithm.
   B. A non-linear optimization algorithm.
   C. An end-to-end neural network (note: most useful for highly complex IO-coeffs, while optimizing production at the same time).
   D. A linear solver, such as the power series expansion method (Lahiri, 1976), which is the method selected by Samonthrakis (2020):
      1. $(I - A)^{-1} = \sum^{\infty}_{i=0} A^i = I + A + A^2 + \ldots$
      2. Then, it is possible to define a recursive form of calculating for x:
         $\mathbf{x}_{(i+1)} = F(\mathbf{x}_{(i)})\mathbf{x}_{(i)} + d,\ \mathbf{x}_{(0)} = d$
      3. This method will find the global maximum as long as convexity is maintained.

Samonthrakis (2020) defines the demand for a final good as a profile set to zero:

1. $d'_i(a_{ij} = 0)$
2. With, i coming from final goods C, while j comes from profile consumption P.
3. Herein, when a good is removed from a profile, then a surplus is generated. That surplus, divided by how much that profile was expected to get, defines the "humanity of the plan" (Simonthrakis, 2020).
4. Formally, the humanity equation HU_p is:

   $HU_{p = \min/(i \in C, j \in P)} \{ d'_i(a_{i,j} = 0) / (a_{ij}d_j) \}$

5. Every profile places externalities on the economy (e.g., carbon output from productions). These externalities are modeled at each point in time as:

   $\rho(e(\mathbf{x}_t)\mathbf{x}_t)$

6. The total externalities for a plan are the sum of all externalities in time:

   E_p

7. Wherein, p is a function that weights the importance of each externality for each good.
8. Hence,

   $\mathcal{E}^t_{p} = {}^t\Sigma_0\, \rho(e(\mathbf{x}_t)\mathbf{x}_t)$

3.2.10 Input-output models and time

It is relevant to note here that traditional input-output models have no notation of time (i.e., all production takes place within the same temporal unit). In static equilibrium analysis, a time element has nothing to do. Therein, all economic variables refer to the same point in time. The lack of a temporal unit is significantly problematic for real-world planning (where there is a dynamic and not static environment), but remains suitable for high-level strategic planning (e.g., most States publish input-output tables using monetary prices without a time dimension). However, all real-world production and usage has a time dimension. In the case of production, this is expressed in various forms like gestation times (Read: animal gestation times and the time between when a project starts and when production starts), production times, resource depletion times, usage before re-cycling or maintenance times, etc.

Multiple input-output models that include a time element have been developed, for which Aulin-Ahmavaara (2000) provides an overview. However, these time accountable input-output models (for the most part) are not designed with state-based functional planning in mind. Hence, Samonthrakis (2020) introduces a transition function *T(s 0 |s, a)* and a notion of state *s*.

3.2.11 The input-output model

A.k.a., The input-output method, the Leontif method, the input-output table method, the input-output graph method.

The source of modern mechanisms for planning (in this context) is what is termed the input-output model, which is detailed by Leontief (1986). The Leontief model is a model for the economics of a whole country or region. In the model there are *n* industries (economic sectors) producing *n* different products (service-objects) such that the input equals the output or, in other words, consumption equals production.

The input-output matrix focuses on the interdependencies between different sectors within an economy using input-output analysis. It uses matrices to represent the relationships between sectors. Consider a simplified example with three economic (x) sectors: Agriculture (A), Manufacturing (M), and Services (S).

- Output vector X:

$$X = \begin{bmatrix} x_A \\ x_M \\ x_S \end{bmatrix}$$

- Input-Output matrix A:

$$A = \begin{bmatrix} a_{AA} & a_{AM} & a_{AS} \\ a_{MA} & a_{MM} & a_{MS} \\ a_{SA} & a_{SM} & a_{SS} \end{bmatrix}$$

- Where,
  - a_{ij} represents the amount of input required from sector j to produce one unit of output in sector i.

The Leontief model presents a mathematical relationship, in particular the model's fundamental equation is:

$$X = AX + Y$$

- where,
  - X is the output vector.
  - A is the input-output matrix.
  - Y is the final demand vector representing external demand.

The solution to X is obtained using the equation:

$X = (I-A)^{-1}Y$, where I is the identity matrix.

Input-output modeling is an economic calculation technique. In its simplest form, input-output modeling can be graphed on a table to show the relationship between a set of needs and resources (axiomatic inputs) for a set of things to be produced (axiomatic outputs for services and objects). The type of input-output table shown below is often called a technology matrix, and labeled something like, "Technology Matrix M":

Service-Object		A	B	C	...
Need	A	M_{11}	M_{12}	M_{13}	...
	B	M_{21}	M_{22}	M_{23}	...
	C	M_{31}	M_{32}	M_{33}	...
	...	...	...	...	$M_{...}$

- where,

Humans	Humans have *needs (input)* for *service-objects (output)*.
Items A, B, ... are interrelated	In a habitat service system these may be called economic sectors. These are the service sectors that transform resources into needed service-objects.
A	A need-product, for example, electricity.
B	A need-product, for example, water.
C	A need-product, for example, plant cultivation.
$M_{...}$	Coefficient of relationship between input and output.
Needs	Require identification of (i.e., of the need) and resources. Humans have "needs" as an input category.
Service-objects	Require design and resource compositions. Humans have "service-objects" as an output category.

Herein, Leontief distinguishes two models, which are really one model (the open model) with the closed model being a sub-element thereof:

1. **Open model** (a.k.a., open Leontief model, open input-output model)**:** some production consumed internally by industries, rest consumed by external bodies.
   A. Problem: Find *production level* if external demand is given.
2. **Closed model** (a.k.a., closed Leontief model, closed input-output model)**:** entire production consumed by sectors (industries).

A. Problem: Find *value* (e.g., price, prioritization, urgency, sustainability, etc.) of each product.

It is important here to distinguish between (at least) lists and tables, though both, are in fact, matrices. A table is just a n•m or n•n, whereas a column matrix is a n•1 matrix.

This is a **list** (n•1 - row or column; this example has rows, each with a unique label):

$$\begin{array}{cl} \begin{bmatrix} \# \\ \# \\ \# \end{bmatrix} & \begin{array}{l} \text{Label 1} \\ \text{Label 2} \\ \text{Label 3} \end{array} \end{array}$$

This is a **table** (n•m or n•n; rows and columns with unique labels; A1, B2, A2, ...):

$$\begin{array}{cc} & \begin{array}{cccc} \text{B1} & \text{B2} & \text{B3} & \dots \end{array} \\ \begin{array}{c} \text{A1} \\ \text{A2} \\ \text{A3} \\ \dots \end{array} & \begin{bmatrix} \# & \# & \# & \dots \\ \# & \# & \# & \dots \\ \# & \# & \# & \dots \\ \dots & \dots & \dots & \dots \end{bmatrix} \end{array}$$

- Wherein,
  - B1 = #1 input; A1 = #1 output
  - B2 = #2 input; A2 = #2 output
  - B3 = #3 input; A3 = #3 output

And, **table array (**or just, **array)** is the combination of two or more tables, which has data and values linked and related to one another. An array is a "matrix-like" structure with more than two dimensions.

The input-output model is a technique to study the production structure of an economy considering the mutual interdependence of various sectors using graphic operations and logical algebraic techniques. Thus, the input-output model is:

1. A visual and mathematical tool.
2. A planning and forecasting tool for production (material cycling), given inputs and outputs.
3. A method of analyzing how one economic sector output is used as an input to another economic sector. Here, input implies object (or material) which is demanded (required) by an economic [production] sector for the purpose of production. Here, outputs are products and services to users, some of whom are also producers, as in, contributors). Note that in a market economic type system, there is one additional layer where the products and services do not go directly to the users, but are sold in a market, and then, used by users.

Input-output tables have several functions, including but not limited to:

1. A quantity accounting tool (quantities and their [al]location.
2. A statistical possibility calculation tool (an analysis tool).
3. A scheduling tool (a time planning tool).
4. A visual understanding tool.
5. An input-output analysis model supposes that an economy consists of sectors (e.g., habitat service systems, industries, etc.), and some of the output of each sector is distributed among the various sectors. Input-output tables shows the technical interdependence between service systems in a given environment.

An input-output model (a.k.a., Leontief model) is an economic (resource-requirement-production-demand) model that relates:

1. The production of services and objects using resources.
2. To how they (services and objects) are produced.
3. To user demand/requirement.

Leontief's input-output analysis (Read: the economic input-output calculation method) describes and explains the level of output of each sector of a given economy in terms of its relationships to the corresponding levels of activities in all the other sectors.

Leontief uses a simple two way model that assumes agriculture and manufacturing as two sectors that are interdependent on each other for inputs, as well as a final demand and labour (service) costs. Leontief then expresses this model using value terms (by multiplying prices of factors and services). Subsequently, he then adds an extra row and column for pollution abatement costs. The final demand of the “pollution” is not, according to Leontief, a demand in itself, but a “tolerance limit” to what level of pollution can be borne by the final consumer.

Input-output models use quantitative matrices are concerned with technological problems (technical decisioning), whereas qualitative matrices are concerned more with social decisioning. A quantitative matrix is part of an empirical investigation [into how to best arrange and optimize an economy]. Both quantitative and qualitative methods can be combined together within a unified decision system. Wherein, demand analysis is usually done with qualitative matrices, and input-output matrices plan how to best produce for a given (set) demand of something.

3.2.11.1 *Calculating access with the Leontief input-output model*

Access can be calculated with just a habitat array (technical array) using the "Leontief" input-output method:

$$p = d + (Z \cdot p)$$

access	=	demands	+	(	habitat service array	•	access	)

1. Wherein,
    A. Access is the total production for a user population of a habitat service system (i.e., their current and planned/potential usage of a coordinated service system operated by contributors using compositions of resources).
    B. p = total production (total output access).
    C. d = demands (total needs).
    D. Z = habitat array; a matrix composed of multiple habitat service matrices:
        1. Objectives matrix.
        2. Requirements matrix.
        3. Contribution matrix.
        4. Schedule matrix.
        5. Procedures matrix.
        6. User access matrix.
        7. Resource matrix.
        8. Technology matrix.

A decision chart for an economic system may be calculated as a complete economic (social array) access calculation:

access (A) = demand (d) + priority (r) + urgency (u) + (habitat matrix Z • access)

A = d + r + u + (Z • A)

3.2.12 Input-output tables

A.k.a., Input-output matrix, transaction tables.

Input-output tables allow for the building of statistical models for planning an economy. In terms of building a statistical model of a planned economy, it is possible to start from the structure of an input-output model.

The goal of an input-output matrix may be to plan for demand at the end of a time period. The problem of planning has been formally defined in Lahiri (1976). Per unit of time *t*, a set of demands *d* for certain goods (e.g., products, services) are to be satisfied for individual *i*. The planner's goal is to satisfy the demands of each individual. In machine learning terminology, the planning expression akin to a Markov Decision Process (MDP), with an agent (the planner) receiving information (the state) on the plan and a set of rewards related as to how closely the demand is met.

An I-O table shows the interrelationship between the total products and total inputs among different economic sectors.

A single input-output table records the amount of some unit of balanced account that moves through different habitat service systems (economic sectors), and forms of access, in an economy (where resources are transformed by into useful environments and objects, and then once again become resources). Effectively, this technique can be used to do a life-cycle assessment on all the services and objects produced, or probable to be produced, by an economy.

Individual columns in the IO matrix (Read: input-output planning matrix tool) represent how much of some thing (Read: material or product) it takes to produce a single unit of output. The columns in the coefficient matrix conceptually ask the question, How many units of each input (good) are required to produce a single output (good) of the type portrayed in this column? The dot product (a.k.a., scalar product; linear algebraic operation of the sum of the products of corresponding entries) of each row, along with the technical coefficients, represents usage ("consumption") of a specific good/product.

3.2.13 Input-output planning

A.k.a., Input-output table analysis and planning, the input-output planning method, the input-output table method, economic production plan.

When planning using input-output tables, the planners first identify the final demand, and then determine the target of total input required to meet that demand (i.e., the order is reversed to material balance planning). Here, the production is determined by what the user needs (i.e., by the output target), instead of need being residual to what is produced (as in material balance planning). Of significant note, second order instances of changes in production to intermediary products require the input-output method.

A unified societal planning system has the information available (or, procedures to discover the information) to determine the total economic activity of material products and services and optimize user fulfillment.

Input-output tables can be composed in terms of physical natural units, as well as monetary, merit, priority, or labor-time, etc. The selected units concern the particulars of the situation being planned for.

In input-output planning, the plan itself is composed of tables, and an algorithm is selected and run that solves for the optimal flow (out of all potential flows) of resources (materials, etc.) to meet user demand, given that which is available. A unified society is likely to have a unified plan.

In a community-type society, demand is set by the users. In the market-State, demand is set the policymakers, capitalists, administrators, and bureaucrats. In a habitat service system, versus a market-economic system, there is more cooperation between that which is known as demand (i.e., needs, and preferences for service) and supply (i.e., contribution to that which is available under habitat service priority decisioning conditions). Under community-type societal conditions, humans supply demands as: 1) articulated in the form of issues, collected by surveys and issue interfaces, and 2) in the form of contribution to the development and operation of the habitat service system as a part of the InterSystem Team; essentially, forming a reciprocal open source society (versus, a market-State society, for example). It is under the conditions of community that price becomes unnecessary. It is under the conditions of community that authority becomes unnecessary.

Once a priority matrix for habitat operations is published by a decision system, then the computational economic model can simply read the priority values from that matrix. And, combine those priority values with natural[ly observable] units (or their derivatives). An alternative to a human habitat priority matrix and the usage of natural units is, to use "price".

3.2.14 Input-output analysis software

Paul Cockshot has released an open source linear programming software package (Kantorovich, 2020: [drive.google.com]) based on the lp-solve package [sourceforge.net] that uses the Kantrovich method to print (Read: output) objective valuations and the achievable gross output given the available resources. lpsolve is an open source mixed integer linear programming software solver (which is effectively Kantorovich's method). Lp-solve when applied to economic planning has a complexity of Order n3. In other words, in order to calculate a plan as the result of computing the data it will take O n3 (Read: order n3).

LINDO Systems Corporation produces a software package called “LINGO”. LINGO is an optimization models software tool for linear, non-linear, and integer programming. As Cockshot shows, it is possible to use spreadsheets for input-output analysis; however, LINGO has the advantage of using an equation-based interface and also features a suite of solvers for optimization models.

Cockshot has also put together a plancode for a 5-year input-output Harmony-type method plan that uses java and is order nLogn. The java plancode is available via Cockshot's Github repository for the plancode [github.com/wc22m/5yearplan]. (Cockshot, 2019)

3.2.15 Input-output analysis (mathematical economics)

A.k.a., Input-output calculation economics, resource economics, energy economics, resource allocation mathematics etc.

There are two basic "Leontief" input-output models for conducting economic mathematical analysis. In the closed model, all production by sectors is consumed by those sectors. In the open model, there is some form of outside demand for which the production system must account.

1. In **the closed model** there is no external demand, but there is a production vector and a sector matrix:
   A. An *sector resource* **nxn (n•n) Matrix*** **Z** (elementary row operation matrix) of technical coefficients. These technical coefficeints are useful for planning.
   B. A *production* **vector P** of production level (i.e., how much to produce for each product).

   **An nxn (n•n) matrix/table refers to a square matrix/table. The first useful form of habitat sectorization is life. Life is, of course, also composed of technology, which is sectored*

   The closed model can be described by the matrix equation:

   $$p = Zp$$

2. The **open "Leontief" input-output analysis method** is a homogenous system of equations that form a model, which comprises of:
   A. A *demand* **vector D** (or d).
   B. An *sector resource* **nxn (n•n) Matrix Z** (elementary row operation matrix) of technical coefficients. These technical coefficeints are useful for planning.
   C. A *production* **vector P** (or p) of production level (i.e., how much to produce for each product).

   The open model can be described by the matrix equation:

   $$p = Zp + d$$

3.2.16 Closed input-output analysis model

Consider an economy made up of *n* (some number of) economic production sectors (S) labeled:

$$S_1 , S_2 , \dots , S_n$$

In a certain time period, each sector produces an output of some product (service-object) which is completely utilized by itself or other sectors in a predetermined manner which remains constant during that time period. When simplifying, it is supposed that units are chosen so that each sector produces exactly one unit of its product in the given time period.

Let z_{ij} be the fraction of the total output of sector S_j used by sector S_i. Then each z_{ij} is a non-negative number:

$$z_{ij} + z_{2j} + \dots + z_{nj} = 1$$

The *exchange* or *input-output matrix* is an n•n matrix:

$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ z_{n1} & z_{n2} & \cdots & z_{nn} \end{bmatrix}$$

$Z = [z_{ij}]$

For each sector S_j, let $p_j \geq 0$ denote the quantity of one unit of it output (i.e., the production vector is P):

$$\boxed{P} = \begin{pmatrix} p_1 \\ \vdots \\ p_n \end{pmatrix}$$

Sector S_i has an input of P_i and an output of:

$\sum^{n}_{j=1} z_{ij}p_j$

n	
$\sum$	$z_{ij}p_j$
j=1	

For an economy to be workable, its sectors should not output more than is input:

$\sum^{n}_{j-1} z_{ij}p_j \leq p_i$

n			
$\sum$	$z_{ij}p_j$	$\leq$	p_i
j=1			

Suppose that P is a production vector that results in an equilibrium:

$p = \sum_i p_i \geq \sum_i \sum_j \mathbf{z}_{ij}p_j = \sum_j \sum_i z_{ij}p_j = \sum_j p_j \sum_i z_{ij} = \sum_j p_j \bullet 1$

If,

$\sum_i p_i = \sum_i \sum_j z_{ij}p_j$

Then,

$p_i = \sum_j z_{ij}p_j$

Thus, production P is an equilibrium vector if and only if ZP = P.

Note on matrix denotation: The notation form of these equations is seen written in the literature in three ways:

1. **All Caps**

P = ZP + D   P = ZP

- A capital variable is a complete matrix (not a list matrix).
- A lower case variable is a vector.

2. **Caps and Lower case**

p = Zp + d   p = Zp

3. **Caps and lower cases with lines indicating vectors**

$\overline{p} = Z\overline{p} + \bar{d}$ $\overline{p} = Z\overline{p}$

- A capital variable is a complete matrix (not a list matrix).
- A lower case variable with a straight line over is a vector. A vector is usually denoted by a lower case letter with a bar over it.
    - If the production variable was X, then the production vector variable would be $\bar{x}$, and if it were demand D, then it would be $\bar{d}$: $\overline{p} = Z\overline{p} + \bar{d}$
    - In some cases, matrices are designated as a capital case variable with a line over it $\bar{Z}$: $\overline{p} = \bar{Z}\overline{p} + \bar{d}$

Notes on matrices operations:

1. Placing a -1 exponent after the symbol for a vector or matrix represents the inverse.
2. Placing a letter "t" exponent or apostrophe (') after the symbol fro a vector or matrix represents the transpose (exchanging rows and columns).
3. A unique matrix, a square matrix with ones on the diagonal and zeros elsewhere, is known as the identity matrix and is a multidimensional "1".
4. An upside-down A (∀) means that the preceding statement applies "for all".
5. A comma (,) may be used delimit indices in the element of a matrix, as in $z_{i,j}$.
6. { } means "is in the set". The symbol ∊ indicates set membership and means "is an element of" so that the statement x∊A means that x is an element of the set A.

3.2.17 Open input-output analysis model

Consider an economy made up of *n* (some number of) economic production sectors (S; S_1, S_2, ... , S_n) and some external source of demand for some of the output of each sector. Interpret z_{ij} as the unit value of the output of sector S_i needed to produce one unit's value of output of sector S_j. Then each z_{ij} is non-negative:

$\sum_i z_{ij} \leq 1$

$$\sum_i z_{ij} \leq 1$$

Let p_j be the number of units to be produced by sector S_j.

The production vector is $\overline{p}$ (P or p):

$$\overline{p} = \begin{pmatrix} p_1 \\ \vdots \\ p_n \end{pmatrix}$$

Then, the vector P - ZP = (I - Z)P has components which give the excess production of each sector. And, the user (or, external demand)for output of sector i has a unit value of d_i.

The demand vector is $\bar{d}$ (d or D):

$$\overline{d} = \begin{pmatrix} d_1 \\ \vdots \\ d_n \end{pmatrix}$$

One of the most useful aspects of model is the ability to identify what production is required given some demand. Given a demand vector D, is there a production vector P that meets that demand; that is, (I - A)P = D

3.2.18 The input-output analysis model in greater detail

The relation of dependence of different economic sectors and the product flux (a.k.a., material, resource, etc., flow) between them is expressed by a matrix. The input-output model is highly useful, because of its matrix-based operational flexibility and its absence of complexity to calculate, that make it easy to re-calculate the effects of changes therein. Together, this combination of data categories (i.e., the logic behind it) can be written in matrix equation (X = AX + Y). In an economic system the following listable (placed into rows) equation is satisfied (i.e., the matrix equation for this information is satisfied):

sector: P = matrix Z + D

production of something real: total output = internal consumption (nxn matrix) + external demand

total output = internal demand + final demand

Alternatively,

P = Z + D

Production level (P) = intermediate resource efforts (Z) + final demand (D)

Note that in the literature, there are a variety of different letters, capitalizations, and marks that are used to represent the axiomatic economic concepts, including the accompanying matrices, of production, demand, resource, technology processes, priority, material flow, etc.

1. The **demand vector** is a column of demands:

$$D = \begin{bmatrix} 4 \\ 12 \\ 16 \end{bmatrix} \begin{matrix} \textbf{Item 1}\ (S_1) \\ \textbf{Item 2}\ (S_2) \\ \textbf{Item 3}\ (S_3) \end{matrix}$$

The demand vector list (d):

$$D = \begin{pmatrix} d_1 \\ \vdots \\ d_n \end{pmatrix}$$

- Wherein,
  - D - demands list, is simply a column listing the three demands by users for items 1, 2, and 3. An item could be a service or product.

2. The **nxn sector matrix (technology matrix)** is composed of *n* economic sectors (S; "industries") denoted by:

S1, S2, ..., Sn

The flow (i.e., transfer, transformation, exchange) of products (i.e., resources) can be described by an input-output graph. A table is a type of graph known as a matrix. A base input-output table will always be a square matrix (a.k.a., nxn or n•n). An example matrix composed of [economic] sectors, and their single/standard unit interrelationships, Matrix Z (wherein, Z means the amounts of all the intermediary flows):

S = Sector
Z = Flows

⇩ INPUTS
(consuming sectors; j)

⇩ OUTPUTS *(using sectors; i)*	**S_1**	**S_2**	**S_3**	...	**S_n**
S_1	Z_{11} - 0.1 # unit	Z_{12} - 0.3 # unit	Z_{13} - 0.4 # unit	...	Z_{1n} - n # unit
S_2	Z_{21} - 0.3 # unit	Z_{22} - 0.1 # unit	Z_{23} - 0.2 # unit	...	Z_{2n} - n # unit
S_3	Z_{31} - 0.2 # unit	Z_{32} - 0.1 # unit	Z_{33} - 0.3 # unit	...	Z_{3n} - n # unit
...	...	...	...	...	...
S_n	Z_{n1} - n # unit	Z_{n2} - n # unit	Z_{n3} - n # unit	...	Z_{nn} - n # unit

The internal production and consumption (intermediary requirements and resources) matrix Z (n•n):

$$Z = \begin{pmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & & \vdots \\ z_{n1} & \cdots & z_{nn} \end{pmatrix}$$

Matrix Z:

$$Z = \begin{bmatrix} Z11 & Z12 & Z13 \\ Z21 & Z22 & Z23 \\ Z31 & Z32 & Z33 \end{bmatrix}$$

- Wherein,
  - Matrix Z - is the name of the sector flow matrix or table (table Z).
  - Z_{ij} - denotes the number of units produced by industry S_i necessary to produce one unit by industry S_j.
  - The numbers (0.1, 0.3, etc.) under each Z cell is the example number of units required to be produced (or, produced) by industry S_i necessary to produce one unit by industry S_j.
    - # = the value itself; the amount to be (future) or being (present) produced.
    - unit = the label of the unit shared by the values. Units can be natural units or abstract units like price.

3. The **production vector** is a column of total production outputs.

The following is a simple three sector economy consisting of three sectored demands: food (x_1), clothing (x_2), and shelter (x_3):

$$P = \begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix}$$

The total production output vector (p):

$$\boxed{P} = \begin{bmatrix} p_1 \\ \ldots \\ p_n \end{bmatrix}$$

4. The **matrix equation** becomes available because all data herein is essentially organized by matrices, the above system of linear equations is equivalent to the matrix equation (i.e., in matrix notation or matrix form):

X = AX + B

Note that the equation is often written in the literature using any number of different letters, for example:
Ax + D = x; AX + B = X; AX + Y = X, Ax + f = X; or Ax + Y = x; etc.

In this context, the equation is represented as:

P = ZP + D

$$Zp = \begin{bmatrix} Z_{11} & Z_{12} & Z_{13} \\ Z_{21} & Z_{22} & Z_{23} \\ Z_{31} & Z_{32} & Z_{33} \end{bmatrix} \begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix}$$

- Wherein,
  - P = production matrix (output vector, column matrix; total output of each sector).
    - P = n • 1 vector of sector outputs.
    - P = p_1, p_2, p_3
  - D = demand matrix (final demand vector, column matrix; total demand output for each sector).
    - D = n • 1 vector of final demands.
  - Z = input-output matrix (square matrix).
    - Z = n • n matrix of technical coefficients.
    - Z = Z_{11}, Z_{12}, Z_{13}...Z_{33}
    - In the literature, [Z] is typically called the Leontief technical coefficient matrix.

Together, the data may then be turned into a series of rows, with each row having a label associated with its production of a real-world service or object (that requires real-world resources and contribution), and is expected to be used by a user who is requesting the service or object:

Production of a real service or object	Total Output	=	Internal consumption	+	External demand
Life (S_1)	p_1	=	$p_1 + p_2 + p_3$...	+	d_1
Technology (S_2)	p_2	=	$p_1 + p_2 + p_3$...	+	d_2
Exploration (S_3)	p_3	=	$p_1 + p_2 + p_3$...	+	d_3

- Wherein,
  - p_1,p_2, p_3 are the total output of S_1, S_2, S_3.

For example, this information can be represented in several ways:

	Input			Final demand
Output	P_1 Steel	P_2 Auto	P_3 Oil	
$P_{1\ (steel)}$	Z_{11}	Z_{12}	Z_{13}	d_1
$P_{2\ (Auto)}$	Z_{21}	Z_{22}	Z_{23}	d_2
P_3 (Oil)	Z_{31}	Z_{32}	Z_{33}	d_3
Primary inputs	L_1	L_2	L_3	

The following is a more complete version of the rows, without the S designations, and with a more complete intermediary (internal amounts) matrix:

Total Production / Final Supply (p)	=	Internal amounts of production and consumption (intermediate uses, Zp)	+	Amounts of production going to final user (final uses, d)
p_1	=	$Z_{11} + Z_{12} + Z_{13} + ... + Z_{1n}$	+	d_1
p_2	=	$Z_{21} + Z_{22} + Z_{23} + ... + Z_{2n}$	+	d_2
p_3	=	$Z_{31} + Z_{32} + Z_{33} + ... + Z_{3n}$	+	d_3
...	=	...	+	...
p_n	=	$Z_{n1} + Z_{n2} + Z_{n3} + ... + Z_{nn}$	+	d_n

- Wherein,
  - p_1 is the total production of sector 1.
    - $p_1 = Z_{11} + Z_{12} + Z_{13} ... Z_{1n} + d_1$
    - In other words, some of the production of sector 1 will go to sector 1: Z_{11}. Some of the production of sector 1 will go to sector 2: Z_{12}. Some of the production of sector 1 will go to sector 3: Z_{13}. This pattern continues until the full number of sectors is reached: X_{1n}. Plus the output that goes to actual user/people demand d (or, Y, D, etc.) for sector 1: d_1
- p_2 is the total production of sector 2.
  - $p_2 = Z_{21} + Z_{22} + Z_{23} ... Z_{2n} + d_2$
  - In other words, some of the production of sector 2 will go to sector 1: Z_{21}. Some of the production of sector 2 will go to sector 2: Z_{22}. Some of the production of sector 2 will go to sector 3: Z_{23}. This pattern continues until the full number of sectors is reached: X_{2n}. Plus the output that goes to actual user/people demand d (or, Y, D, etc.) for sector 2: d_2

The fully expressed coefficient transaction matrix for the equation X:

1. $Z_{11}p_1 + Z_{12}p_2 + Z_{13}p_3 + ... Z_{1n}p_n + d_1 = p_1$
2. $Z_{21}p_1 + Z_{22}p_2 + Z_{23}\,p_3 + ... Z_{2n}p_n + d_2 = p_2$
3. ...
4. $Z_{n1}p_1 + Z_{n2}p_2 + Z_{n3}p_3 + ... Z_{nn}p_n + d_n = p_n$

In actual table/matrix form:

Intermediate uses	+	Final uses	=	Final supply
$Z_{11}p_1 + Z_{12}p_2 + Z_{13}p_3 + ... Z_{1n}p_n$	+	$+ d_1$	=	X_1
$Z_{21}p_1 + Z_{22}p_2 + Z_{23}p_3 + ... Z_{2n}p_n$	+	$+ d_2$	=	X_2
...	+	...	=	...
$Z_{n1}p_1 + Z_{n2}p_2 + Z_{n3}p_3 +... Z_{nn}p_n$	+	$+ d_n$	=	X_n

- Wherein,
  - Z_{ij} = Flow (or, transfer) from sector *i* to sector *j*
    - input of sector i to sector j (intermediate usage)
    - Where, both *i* and *j* are $_1$ through $_n$ (i.e., i,j = $_{1...n}$ OR i,j = 1,2, ..., n
    - Z_{ij} - input of sector i to j, normalized with respect to the total output of sector j.
  - d_i = Final demand for [the products of] sector i.
  - p_i = Total output of sector i.
  - p_j - Total output of sector j.

Then, transaction (transformation or flow) coefficients of the IO matrix (Read: IO coefficients) can be defined:

- Z_{ij} = flow (transaction) coefficients.
- Z_{ij} = Input from sector *i* required to produce one standard unit of the product of sector *j.*

It is then possible to assume the following logical ["balance"] equations:

$$Z_{ij} = Z_{ij}p_j$$

$$Z_{ij} = Z_{ij} \cdot p_j$$

- Wherein,
  - $Z_{ij}p_j$ = the output of sector i (e.g., technology) can either be used as an intermediate input to sector j (e.g., life) or consumed as a final product (e.g., technology).
  - Z_{ij} = the total output of sector i is used either as intermediate demands (i.e., Z_{ij}) or as final demand (d_i)

The transaction coefficients form the expression:

$Z_{ij} = P_{ij} / P_j$

$$Z_{ij} = \frac{P_{ij}}{P_j}$$

- Wherein,
  - Z_{ij} = [Quantity of] Input from sector i required to produce one standard unit of the product of sector j.
  - Z_{ij} / p_j = Out of the total production of sector *i*, some quantity goes to sector *j*.

3.2.19 A simplified hunter-gatherer economic example

A simplified hunter-gatherer economy can be used as an example of mathematical economics. In this simplified example, the whole economy consists of three sectors (of demand/service:

1. Food 4 units demanded/needed
2. Clothing 12 units demanded/needed
3. Shelter 16 units demanded/needed

Each of these three sectored services/demands have to be "made" (or, worked toward) by the population. In order to make any 1 unit of any of the sectors, inputs from the other two sectors are required; hence:

1. **To make 1 unit of food requires:** 0.1 food; 0.3 clothing, and 0.2 shelter.
2. **To make 1 unit of clothing requires:** 0.3 food, 0.1 clothing, and 0.1 shelter.
3. **To make 1 unit of shelter requires:** 0.4 food, 0.2 clothing, and 0.3 shelter.

From this collection of data, it is possible to determine how much in-between (intermediary) stuff should be produced to satisfy the three final demands of food, clothing, and shelter. Two simple matrices can be constructed from the available model and its populated data, a requirements matrix and a demands matrix:

1. **Intermediary requirements matrix** (a.k.a., sector flow matrix, production matrix, technology matrix, ratio matrix, input-output coefficients) - "matrix A" tells the planner (=) how much food, clothing and shelter need to be produced, and it is the matrix notation for the three above requirements:

$$Z = \begin{array}{c} \begin{array}{ccc} \textbf{Food} & \textbf{Clothing} & \textbf{Shelter} \end{array} \\ \begin{bmatrix} 0.1 & 0.3 & 0.4 \\ 0.3 & 0.1 & 0.2 \\ 0.2 & 0.1 & 0.3 \end{bmatrix} \end{array} \begin{array}{l} \\ \textbf{Food} \\ \textbf{Clothing} \\ \textbf{Shelter} \end{array}$$

2. **Demands list** (d) - is a column listing the three demands by users for food, clothing, and shelter, in total:

$$d = \begin{bmatrix} 4 \\ 12 \\ 16 \end{bmatrix} \begin{array}{l} \textbf{Food} \\ \textbf{Clothing} \\ \textbf{Shelter} \end{array}$$

3. **Total outputs list** (X) - is a column listing the total production of each of the three outputs.

$$p = \begin{bmatrix} 4 \\ 12 \\ 16 \end{bmatrix} \begin{array}{l} \textbf{Food} \\ \textbf{Clothing} \\ \textbf{Shelter} \end{array}$$

3.2.20 Economic matrix operation to solve for the total demand

Matrix operations may be performed using this combination of data categories. To solve for the total demand, the following formula may be applied:

$d = p\,(I_3 + Z)$

demand = total output times (IdentityMatrix plus matrix Z)

- Wherein,
  - d = final demand.
  - Z = intermediary requirements matrix (proportion values or ratios).
  - p = total output to be produced.

3.2.21 Economic matrix operation to solve for the total output

To solve for the total output, the following formula may be applied (i.e., the same formula above may be alternatively written as):

$p = (I_3 - Z)^{-1}\, d$

total production output = (IdentityMatrix minus matrix Z) inverted, times demand

- Wherein,
  - p is how much in-between stuff should be produced to satisfy the three final demands of food, clothing, and shelter.
  - $(I_3 - Z)$ is computed first.

The economic [Leontif] intput-output analytical operation uses the following formula and the earlier requirements and demands matrix:

1. IdentityMatrix is a matrix with 1s down the diagonal

and 0s everywhere else:
I_3

$$I_3 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} - Z =$$

2. The requirements matrix (for food, clothing, and shelter) is subtracted from the identity matrix (I_3 - Z is called the Leontief matrix):
$I_3 - Z$

$$I_3 - Z = \begin{bmatrix} 0.9 & -0.3 & -0.4 \\ -0.3 & 0.9 & -0.2 \\ -0.2 & -0.1 & 0.7 \end{bmatrix}^{-1} =$$

3. The resulting matrix is inverted:
$(I_3 - Z)^{-1}$

$$(I_3 - Z)^{-1} = \begin{bmatrix} 1.5641 & 0.647 & 1.0769 \\ 0.641 & 1.41 & 0.769 \\ 0.538 & 0.38 & 1.864 \end{bmatrix} \bullet d =$$

4. The resulting matrix is multiplied by the demand matrix:
$(I_3 - Z)^{-1} \bullet d$

$$(I_3 - Z)^{-1} \bullet d = \begin{bmatrix} 31.1795 \\ 31.7949 \\ 36.3077 \end{bmatrix} = p$$

This system of matrices can be solved by the use of the inverse of Z, if Z is regular (i.e., $|Z| \neq 0$). Thus,

$$p = Z^{-1} \bullet d$$

The demand vector 'd' represents how much demand there is, hence, in long-form matrix notation:

$$p_i = Z_{i1}p_1 + Z_{i2}p_2 + \ldots + Z_{in}p_n + d_i$$

In short form matrix notation:

$$p = Zp + d \rightarrow (I - Z)p = d$$

And, in table notation as linear equations (i.e., each row in the table is a linear equation):

- *[Re]Sources = Intermediate Uses + Final Demand*
- For, three and 'n' more products: #1, #2, #3, #n

Sources	=
$X_1 - S_1 + M_1$	=
$X_2 - S_2 + M_2$	=
$X_3 - S_3 + M_3$	=
$X_n - S_n + M_n$	=

Intermediate uses	+	Final Uses
$Z_{11}X_1 + Z_{21}X_2 + Z_{31}X_3 + \ldots + Z_{1n}X_n$	+	$U_1 + I_1 + Ex_1$
$Z_{21}X_1 + Z_{22}X_2 + Z_{32}X_3 + \ldots + a_{2n}X_n$	+	$U_2 + I_2 + Ex_2$
$Z_{31}X_1 + Z_{23}X_2 + Z_{33}X_3 + \ldots + a_{3n}X_n$	+	$U_3 + I_3 + Ex_3$
$Z_{n1}X_1 + Z_{n2}X_2 + Z_{n3}X_3 + \ldots + a_{nn}X_n$	+	$U_n + I_n + Ex_n$

The letter variables used in the above input-output equations refer to:

- p_i - output of the i^{th} service system (planned target).
- S - change in resource stock.
- M - planned tasks/teams.
- Z_{ij} - requirement for input p_i per unit of output in the j^{th} service system. Technical co-efficients (Z_{ij}) are how much of input p_i is needed to produce one unit of output in the j^{th} service system. Technical co-efficients (Z_{ij}) are typically derived from the previous cycle's planning experience.
- U - User usage.
- I - Storage placement.
- Ex - Planned transport.

3.2.22 Economic matrix operation to solve for the allocation of a sector's output to a specific access type

To solve for the allocation of a sector's output to various access/allocation types (intermediate and final) translates to the following mathematical formulation:

$$p_i = \sum_{j=1}^{n} Z_{ij} + d_i$$

		n			
p_i	=	$\sum$	Z_{ij}	+	d_i
		j=1			

Substituting equation ($Z_{ij} = Z_{ij}p_j$) into ($p_i = \sum_{j=1}^{n} Z_{ij} + d_i$) creates the equation:

$$p_i = \sum_{j=1}^{n} Z_{ij}p_j + d_i$$

		n			
p_i	=	$\sum$	$Z_{ij}p_j$	+	d_i
		j=1			

Alternatively, input-output analysis can be used to solve for different questions and arrangements of relationship. For instance, the matrix equation (AX + Y = X or Zp + d = p) could be written as a relationship between the production and the input-output to that of demand (or, given production x, it is possible to find demand capacity):

$p - Zp = d$

$d = p - Zp$

- Wherein,
  - $(p - Zp)$ = net production in the economy (i.e., the amount that is produced in total, both to meet demand and to keep production going).
  - p = production vector.
  - d = demand vector.
  - Z = technology matrix Z (flow ratio, coefficient).

It is then possible to follow the following procedure and to set net output equal to demand (i.e., given demand d, it is possible to find the production level X (i.e., it is possible to solve for production X):

1. $p - Zp = d$
2. $Ip - Zp = d$
3. $(I - Z)p = d$
4. $(I - Z)p = d$
5. $(I - Z)^{-1} (I - Z)p = (I - Z)^{-1} \cdot d$
   - Multiply by the inverse (...on both sides of the equation)
   - While multiplication with numbers is communitive, that is not the case with matrix multiplication (hence, both sides of the equation must be multiplied)
6. $p = (I - Z)^{-1} \cdot d$
   - Identity multiplied by x (Ix) is equal = $(I - Z)^{-1} \cdot d$

x has now become isolated on the left side of the equation:

$p = (I - Z)^{-1} \cdot d$

- Wherein,
  - I = the n • n identity matrix (I_3) with the same [matrix] size as Z
  - p - vector of p_i (total output of sector *i*)
  - Z matrix of Z_{ij} (direct input coefficient (= p_{ij}/p_i)
  - p_{ij} - transfer from sector *i* to sector *j (i.e.,* input of sector *i* to sector *j*)
  - d = vector of d_i (the final demand for p_i)

The inverse term of the equation can now be defined:

$L = (I - Z)^{-1}$

- Wherein,
  - L = L is define as the inverse term.

The inverse term equation [$L = (I - Z)^{-1}$] can be substituted into the Leontif inverse multiplied by demand equation [$p = (I - Z)^{-1} \cdot d$] to simplify the whole equation:

$p = Ld$

- Wherein,
  - The A Matrix and L Matrix are calculated.

3.2.23 Economic matrix operation for resource requirement calculation

To solve for how many resources (the exact amount) are [needed] in each sector, the following system of simultaneous equations is presented:

$Zp = d$

- wherein,
  - Z = input-output matrix,
  - p = production matrix, and
  - d = demand matrix.

The system can be reconfigured to solve for p as an unknown (i.e., if the production matrix is unknown) by the use of the inverse of A:

$p = Z^{-1} \cdot d$

In linear algebra, there are explicit formula for the solution of a system of linear equations with as many equations as unknowns, which are valid whenever the system has a unique solution. And, the human users of the habitat service system require a uniquely selectable solution.

3.2.24 Economic matrix operation for energy sector calculation

The equation for [energy] sector *i*:

$E_i = \sum^{n}_{k=1} E_{ik} + E_{iy}$

- Wherein,
  - E_i = total output of [energy] sector *i*
  - E_{ik} = intersectoral transaction from [energy] sector *i* to another sector k (any other sector)
  - E_{iy} = sale of something (energy, natural units, etc.) of type *i* to final demand

3.2.25 Economic matrix operation for resources

If the matrix equation is AX + Y = X (or, applied prior, Zp + d = p). The equation may also be applied to resources:

$R_H Rp + Rd = Rp$

- Wherein,
  - Rd - the users specific demand for resources.
  - R_H - total resources used in habitat operations.
  - Rp - total resources used.

3.2.26 Human contribution calculation

Human contribution is calculated via the following equation:

ϒ=ZY + /

- contribution (ϒ) = technology matrix (Z), times contribution (ϒ), plus the direct contribution input vector (/)
  - Wherein,
    - ϒ (Lambda) - contribution is a vector of labor contents.
    - Z is the technology input output matrix.
    - / is a vector of direct contribution inputs

Note: Using an iterative method of solving, the complexity of this calculation can be on the order of nLogn.

3.2.27 Material balance planning

A.k.a., Material balance analysis and planning, the material balance planning method, material balance equation.

Material balance accounting is a form of economic accounting based on balancing inputs with outputs in terms of natural units (expressed in physical quantities, as opposed to "money"). In other words, material balancing is a method of economic planning where material supplies are accounted for in natural units (as opposed to using monetary accounting) and used to balance the supply of available inputs with targeted outputs. Material balances apply measures of a natural unit, like meter, m^2, m^3, etc. In other words, material balances use natural units, such as meter, meter squared, gram, etc., to plan products. Material balance planning consists of a central planning chart specifying a list of inputs required to produce one unit of output, whereupon a balancing of outputs and inputs occurs, so that there is a balance between supply and demand.

A balance is a method of accounting for something (e.g., product or material). The material balance method simply accounts for:

1. Where things (objects) come from.
2. Where things (objects) go to.
3. The total number of things (objects).
4. The changes to the total number (or amount).

When market-based planning using material balances, planners first set the target of total output x, while the final demand y is determined as residual. The term "balance" in material balance planning is trying to "balance" supply and demand (i.e., to try to get supply to equal (=) demand with demand coming second (i.e., as residual, so that it can be sold into the market).

The general material balance technique simply accounts for where things come or go, and how their total number (or amount) changes.

The following is the generic material balance expression::

In - Out + Generation - Consumption = Accumulation

- Wherein,
  - "In" and "Out" are the inputs and outputs to the system, respectively.

In other words, a material balance plan derives accumulation (or, demand).

A material balance table shows:

1. Quantities of inputs, and total input quantity.
2. Quantities of outputs, and total output quantity.

Example, coal (in physical units, kilograms):

Sources	*with* Quantity	Uses	*with* Quantity
Production center 033A	200	Product A383	600
Production center 033B	900	Product A384	200
Total	1100	Total	80

3.2.28 Network environmental analysis and planning

A.k.a., Material flow analysis and planning, resource flow analysis and planning, material life cycle analysis and planning.

Network environment analysis starts off with the understanding that there are behavioral, structural, and functional effects within a network, because a network is a system. In general, the conception of "observable" means any activity measurable in terms of quantifiable effects on the environment, whether arising from internal or external stimulus. Something which is observed or experienced is an output of something prior, an input. Here, state-space mathematics provides a mathematical framework for computing a networked component's response to inputs:

1. inputs (Z_t) received into state (X_t)
2. create a new state (X_t + 1), and
3. produce associated outputs (Y_t + 1)

Two equations are derived from this initial model:

1. The state transition function

   $Z_t \bullet X_t \rightarrow X_t + 1$

2. The response function

   $Z_t \bullet X_t \rightarrow Y_t + 1$

Network environment analyses are typically done on input-output model data. It is possible to diagram economic and ecological (material and informational) networks for the purpose of analysis. A network analysis of a given economic environment is likely to include (Fath et al., 1999):

- **Pathway analysis** - enumerates number of pathways to travel in a network (enumerates options).

The path analysis is the basis for the three functional analyses.

1. **Flow analysis** - identifies non-dimensional flow intensities along indirect pathways.

   $g_{ij} = f_{ij} / T_j$

2. **Storage analysis** - identifies non-dimensional storage intensities along indirect pathways.

   $c_{ij} = f_{ij} / x_j$

3. **Utility analysis** - identifies non-dimensional utility intensities along indirect pathways.

   $d_{ij} = (f_{ij} - f_{ji}) / T_i$

Each of the functional analyses is derived from a different relationship of the flow-storage data, and is used to determine different properties of the system.

The functional flow and storage values transform a structural input-output model into an operational systems model (Read: an operational economic systems model). The combination of system structure and function underlies system behavior and is sufficient to determine the values of the network properties.

In networks, structure and function are analyzed using mathematical models based on flows and storages.

4 Optimal production design planning and analysis

A.k.a., Optimal production calculation protocol optimal production protocol, product design alignment inquiry, production design protocol, production design computation, production controls, macro-economic resource-based calculation, macroeconomic calculation (macro-economic, macroeconomic); global access calculation, solution design viability inquiry.

The decision system of community uses a formalized production calculation process for all serviced productions, which are a function of optimized design in production, distribution, and recycling. In other words, technical service designs are optimized in their *total design efficiency* by optimizing production, distribution, and recycling. These are micro-calculation constraints placed upon decisioning in the system. It is important to remember that evolution implies constraints - evolution doesn't pick the least efficient path; evolution selects for efficiency (e.g., being able to avoid predators and preserve resources is efficient if you are trying to survive and procreate). Hence, we select for efficiency processes so that we can maximize the work that we can do. Inefficiency just uses up unnecessary resources.

In some sense, the following "strategic design statements" could also be considered to be 'network resilience' design principles (or at scale, "protocols"). And, in order to apply these principles toward the "arrival at" or "construction of" a common decision [space] there must concurrently exist trusted transparency to information about the iterative, digital [model/simulation] construct and material structure of the total habitat community (over time).

In community, we live in an openly navigated and steered environment [for our resilient adaptation toward a higher potential state of expression]. Herein, a resource-based economy may be referred to as a massively decentralized and distributed resiliency network for resource transformation and transport by formalized protocol. It is a resource-based system designed for an adaptive fulfillment orientation using a set of emergently defined variable measures formulated into a conditional statement known as a protocol.

Production must be calculated based on:

1. Demand (quantity and preference).
2. Availability (production and stock).
3. Objectives (flows and controls).

4.1 Design efficiency and design optimization

The term design efficiency refers to the *optimized efficiency function* and the resulting *optimized efficiency* *standards* for calculating the feasibility, viability, and ultimately, acceptability (i.e., socially optimal; usability) of design solutions. 'Efficiency standards' are the 'standards' to which a given design must conform -- they assess the feasibility of the design and determine whether its encoded orientation is divergent from our values and ultimate direction. This 'feasibility assessment' is calculated automatically and algorithmically. Everyone can *adapt* as well as *audit* its design, which creates system-wide transparency and encodes an accountability incentive into the system. The system maintains this characteristic due [in part] to its de-centralized form, and the structural design of the protocol itself that makes it open to auditing by its users. This is real [world] technical efficiency. (Joseph, 2013)

Optimization and strategic efficiency processes are encoded via a set of 'protocols' and 'feasibility inquiries' into the total calculating decision system wherein the decision space becomes one of anticipatory design.

Broadly speaking, design efficiency has three general elements:

1. **Labor efficiency** becomes consumed by automation and human labor exists where desired and required.
2. **Material efficiency** refers to how well the population utilizes the raw materials of the Earth; including the materials we can create (i.e., material sciences).
3. **Systems efficiency** controls for weakness in the system.

The macro-calculation is a set of four functional process requirements (a rule structure) that all solutions (acceptable solution designs) must adapt to; each of which relates to a stage of material cycling (design, production, distribution, and recycling):

1. *Optimized* **design efficiency**: All product designs must adapt to optimized design efficiency function (sub-process).
2. *Optimized* **production efficiency**: All product designs must adapt to optimized production efficiency function (sub-process).
3. *Optimized* **distribution efficiency**: All product designs must adapt to optimized production efficiency function (sub-process).
4. *Optimized* **recycling efficiency**: All product designs must adapt to optimized production efficiency function (sub-process).

In other words, all service-objects (products, services, etc.) must be well designed, and meet efficiency standards. These material cycling functional process requirements (rules) can be composed into a functional protocol (or macro-calculation). There are two primary parts to the macro-calculation: the production function and the design efficiency function). The production function

4.2 Design calculation

> *A.k.a., The material function, the production function, economic optimization, the global production and distribution protocol.*

The design calculation is a linear process involving decisional aspects of material production and material cycling, from design, to production, to distribution, and recycling. The calculation may be otherwise be described as a supra-function (supra-process or protocol). This function uses dynamic feedback from an earth-wide accounting system about all relevant resources that pertain to all production and general materials cycling. In a sense, this is a sustainability protocol for material cycling (i.e., it allows humans to sustainably cycle materials through its habitat service sub-systems).

4.2.1 The production calculation function

The **production function (production efficiency macro-calculation)** exists to maximize the design efficiency of solutions to human economic-resource fulfillment (note: this is a rule structure). The sustainability of a society can be planned through the use of a production protocol (function, $\mathbf{f}_p$) in which the properties of all planned [habitat service phase] elements are maximized (→ *max*):

Protocol: $\mathbf{f}_p\ (\mathbf{E}_{design}\ , \mathbf{E}_p\ , \mathbf{E}_{dist}\ , \mathbf{E}_r\ ) \rightarrow max$

This is a protocol: production [of service-products, solutions] is a function that includes (a calculation of total design efficiency, a calculation of production efficiency, a calculation of distribution efficiency, a calculation of recycling efficiency) all of which are to be maximized.

Wherein,

1. $\mathbf{f}_p$ - a production **function[al]**

   A. $\mathbf{E}_{design}$ - total design efficiency
   B. $\mathbf{E}_p$ - **production** efficiency
   C. $\mathbf{E}_{dist}$ - **distribution** efficiency
   D. $\mathbf{E}_r$ - **recycling** efficiency
   E. → *max* - maximize

A solutions (products) must meet or adapt to the current efficiency standard. All designs must adapt to:

1. Optimized design efficiency function (sub-process).
2. Optimized production efficiency function (sub-process).
3. Optimized distribution efficiency function (sub-process).

4. Optimized recycling efficiency function (sub-process).
5. Optimized recycling conduciveness function (sub-process).

4.2.1.1 The optimized design efficiency process (process 1)

The efficiency of a design ($\mathbf{E}_{design}$) can be described by a design function ($\mathbf{f}_{design}$) in which the properties of all planned design elements are maximized:

$$\mathbf{E}_{design} = \mathbf{f}_{design} (\mathbf{t}_d , \mathbf{A}_{design} , \mathbf{N}c , \mathbf{c}_r , \mathbf{H}_L)$$

Design efficiency = the current design efficiency standard, which is a function of the optimization of (maximized durability, maximized adaptability, maximized standardization, maximized recyclability, maximized automation)

The current efficiency standard is labeled as: $\mathbf{E}^i_{design}$

Wherein,

1. $\mathbf{E}_{design}$ - **total design efficiency**

   A. $\mathbf{E}^i_{design}$ - the current design efficiency **standard**
   B. $\mathbf{f}_{design}$ - design efficiency **function[al]**

   1. $\mathbf{t}_d$ - evaluative sub-process to determine **durability** of design and compute acceptability.
      i. Designs are strategically maximized for durability; strategically maximized durability. Designs account for performance loss due to environmental extremes and time under usage/storage. For example, in concern to performance loss, lithium battery operation fluctuates with temperature. Early 21st century electric lithium car batteries are at their peak performance when the weather is 21c. Anything above or below that will result in a significant performance loss, which must be accounted for.
   2. $\mathbf{A}_{design}$ - evaluative sub-process to determine **adaptability** of design and compute acceptability.
      i. Designs are strategically maximized for adaptability; strategically maximized adaptability.
   3. $\mathbf{N}c$ - evaluative sub-process to determine minimum number of **genre components** of design and compute acceptability.
      i. Designs are strategically maximized for standardization; strategically maximized standardization.
   4. $\mathbf{c}_r$ - evaluative sub-process to determine **recycling** conduciveness of design and compute acceptability.
      i. Designs are strategically maximized for recyclability; strategically integrated recycling conduciveness.
   5. $\mathbf{H}_L$ - evaluative sub-process to determine **human effort** expenditure (or "labor") of design and compute acceptability.
      i. Designs are strategically maximized for automation; strategically conducive for labor automation.

A product's design (i.e., a solution) must meet or adapt to these criteria. The efficiency of a design is conveyed

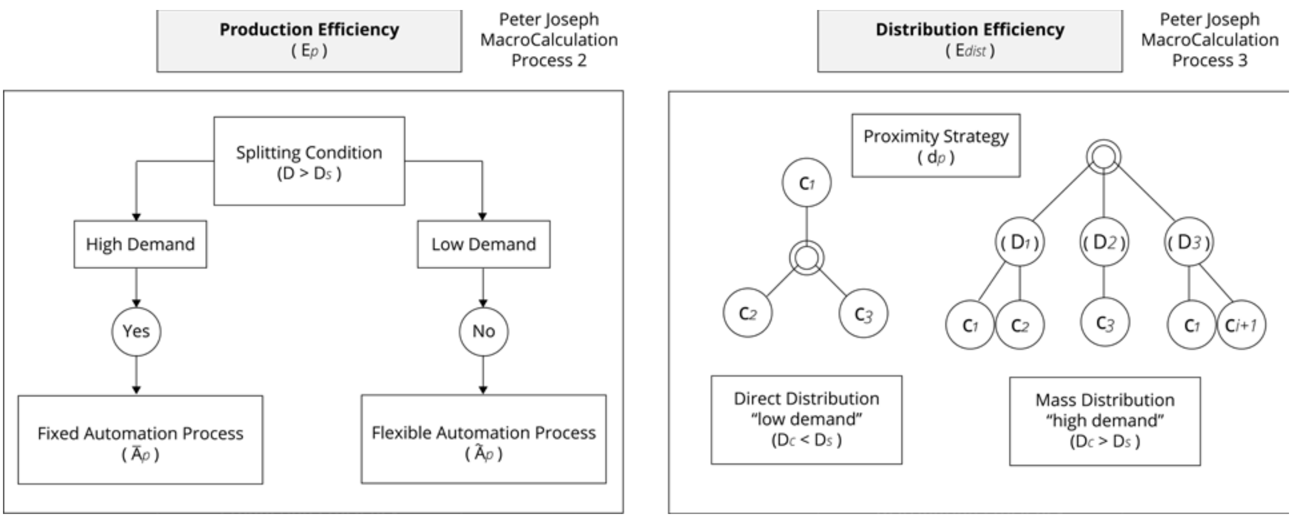

Figure 38. *Macro-economic calculation for production efficiency and distribution efficiency processes.*

by how well it meets the specified efficiency criteria set by the current efficiency standard E^{i}_{design}. And, what a population desires is the maximization of functional efficiency.

The five evaluatively efficiency inquiry sub-processes are:

1. **Strategically maximized durability (t_d)**

   Maximized durability is an element of the current design efficiency standard.

   A. [Strategically] Maximized durability is calculated as:
   - $\mathbf{t}_d \in \mathbf{E}^{i}_{design}$

   B. Total durability is a list of the durability of all individual components of a system:
   - $t_d (d_1 , d_2 , ... , d_i)$

   C. It is possible to optimize the durability of each designed component:
   - $d^o_1 , d^o_2 , ... , d^o_i$

   D. Maximize total durability of all components of the solution or system, by optimizing each individual component to its maximum:
   - $t_d (d_1 , d_2 , ... , d_i) \rightarrow \max , t_d = t_{max} (d^o_1 , d^o_2 , ... , d^o_i)$

     Solutions ought to be produced as strong and long-lasting as relevant, based on materials selection and materials replacement (i.e., interchangeability). Optimized durability refers to the strategic material integrity of the projected [service] system, and also, its outputs (i.e., usable products/goods; technology). Herein, the concept, “strategic”, is important; it qualifies the optimization of durability to account for the factor of time in its operatively predictable [lifespace].

     This micro-calculation is a synergistic design calculation [upon a network transport protocol] where the notion of the “best” material for a given purpose is always relative to other inputs; notably, the parallel production needs that also might require that type of material. A ‘community’ does not “waste” materials; it coordinates the utilization of materials. In other words, the decision to use a specific material is assessed not only for its use in a specific [construction] task, but also by comparing it to the needs of other productions (pre and post, and trending), which require similar efficiency.

Nothing exists outside this systems-centric comparison. All production decisions (modifications to our common heritage) are made with consideration of the largest system as our reference, and they are transparent.

In concern to planning, a “service production’s” life [space] is planned for, so that we may

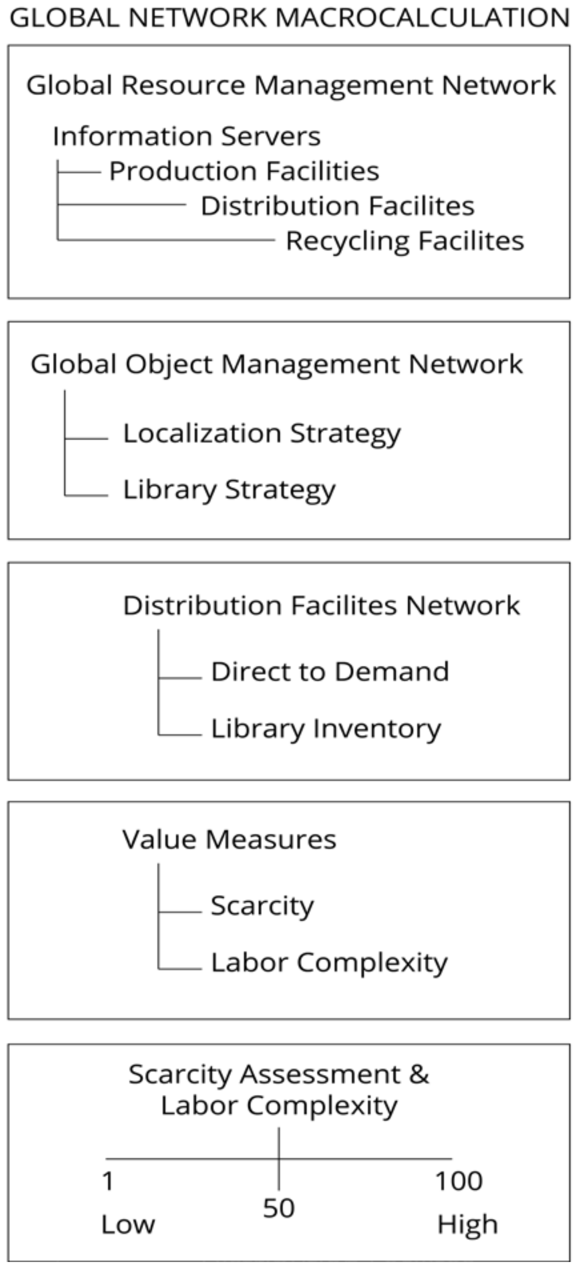

Figure 39. *Simplified macrocalculation for a global access network.*

replace (i.e., 'extropy' - export entropy) and interchange.

2. **Strategically maximized adaptability (A_{design})** - design for the highest state of flexibility for replacing component parts in engineered product[ion] services. Here, designs facilitate the ease of replacement of components and services as needed [through modularity standardization] to maximize the full lifespan of the product[ion] (Read: calculate for '*extropy*' - the exportation of entropy by replacement). Different production components have different rates of change and this means a system of "adaptability" and active "updating" can be foreshadowed through trend analysis, with the resulting [predictable] expectations built into an existing design to the best degree possible. When products are integrated into "production services", then adaptation can be *modularized*, systematically producing a more resilient form of a system.

   At the core of "lifespace/lifetime design" is design-for-disassembly and for modularity. Design-for-disassembly is synonymous with a user's ability to "look under the hood" of a certain device (if it just open source or in the case of AI, it assists you in understanding itself), and to audit its systems. Whereupon, interface modules are physically efficient interchangeable units of functionality; they have 'compatibility'. Modules are interchangeable units of functionality.

   Optimized adaptation occurs [in part] due to universal standardization (or 'integration'), and the structures that are produced may be said to be "integral" to the overall purpose of the system. Essentially, services and products are designed to be modified, adapted, and otherwise update through 'integrated modularity'.

3. **Strategic and universal standardization of genre components (N*c*) | Interoperability** - all new designs either conform to or replace [if they are updated] existing component designs, which are either already in existence or outdated due to an evolution in technical efficiency. In other words, compatibility is being accounted for here. "Genre" standardization includes not only the standardization of a product, but is more specifically referring to the application of standardization throughout the whole of the habitat service system. Universal standardization is essentially a set of optimized protocols set upon a massive parallel information sharing transport [protocol] network. The result is a universal compatibility of all components associated to a given service genre. In early 21st century society, this lack of standardization is a source of not only great waste, but great instability in the functioning of common goods and its stressful inefficiencies have social ramifications. This logic applies to every scale of genre component, from the habitat service systems themselves to itemized in-service technical productions. Essentially, production services are standardized in prototypical ways through trusted protocols that maintain a continuously integrated dynamic. The elements of a system must be compatible.

   Herein, strategic standardization is represented by the variety of genre components available:

   $$\mathbf{g}^1_c, \mathbf{g}^2_c, \ldots, \mathbf{g}^i_c, \ldots, \mathbf{g}^{Nc}_c$$

   The goal of a trusted and cooperatively explored environmental "game" is to work together to minimize the total number of genre components (**N***c)* in our creations. Herein, the standardization of the trust processes will enable the potential of lowering the number **N***c* to its possible knowable minimum.

   It is optimal to simplify the way materials and the means of production are used, so that the maximum number of goods can be produced with the least variation of materials and production equipment for the highest potential fulfillment of everyone.

4. **Strategically integrated recycling conduciveness (c_r)** - every design must conform to the current state of re-cyclable possibility. The dissassembly and/or breakdown of any good must be anticipated and allowed for in the most optimized way. The current state of component and material re-use is optimized within the very design of the [production] service itself. Note, this does not happen in early 21st century society, in any efficient way. In the Community, when a products useful lifespan is complete, then it is returned for direct reprocessing. Herein, there are de-composition and recycling protocols, which are built into the manufacturing system.

   The system is optimized toward "closed loop" manufacturing where 'waste' is the feedstock for other life essential processes. Fundamentally, there is no such thing as "waste" in the natural world. In early 21st century society, most people give very little consideration to the role of material regeneration, and how the design practices of any given society must account for this if it is to remain sustainable. It may be interesting to note here that the very idea of 'regeneration' has a detrimental impact on market competition, for it connotes its design corollary, 'abundance' -- abundance de-constructs markets. An abundance of any material resource will either reduce price/profit for market entities that deal in the commodity, or it will kill the market for the material entirely.

The idea of "cradle-to-cradle design" (or re-cycleability and compatibalism) refer to the idea that once a product is obsolete 100% of the material can be used elsewhere, which may involve inclusion in another technology or decomposition into a more elemental form.

5. **Strategically conducive for labor (H_L) and automation ($\mathbf{A}_L$)** - this means that the current state of optimized and automated production as well as human [labor] input is directly taken into account. This is denoted by human labor **($\mathbf{H}_L$)** and automated labor ($\mathbf{A}_L$). Automated labor refers to the application of "mechanization". All transactional [task] effort may be calculated so that we have the automation conduciveness/applicability data [probabilities] available to us in decisioning. Herein, the design of decisions are the most conducive to the current state of production with the least amount of human energy expenditure, where humans desire. This means that a given service design will account for the dynamic state[d mixture] of labor and automation; wherein, we design the removal of human involvement whenever desired possible by more by efficient design. Also, part of the efficiency equation is to make the production easy to re-produce by automated means, taking into account the current state of automation technology.

   We understand the benefits of "appropriate automation" of production or other tasks whenever repetitively banal, dangerous, or otherwise intrinsically unrewarding. These tasks can be carried out with computer robotics assistance in place of human labor.

   Herein, two general facility types are distinguished: one for high demand or mass production and one for low demand or short-run, custom goods. The high-demand facility is a more "fixed-type" system and the short-run demand facility is a more "flexible-type" system. "Fixed automation", also known as "hard automation," refers to an automated production facility in which the sequence of processing operations is fixed by the equipments configuration. It is fast, but has less variation in output design capacity. "Flexible automation" can create more variation, but the disadvantage is the time required to reprogram and change over the production equipment. These terms are common to the manufacturing and robotics industry when it comes to production facility design.

   Human effort (labor) is reduced to its desired design minimum:

   $$\mathbf{H}_L / (\mathbf{H}_L + \mathbf{A}_L) \rightarrow \min$$

   This is the expression in its expanded form:

   $$\mathbf{H}_L (\mathbf{I}_1, \dots, \mathbf{I}_i) / \mathbf{A}_L (\mathbf{I}_1, \dots, \mathbf{I}_i) \rightarrow \min$$

   Here, labor complexity means estimating the complexity of a given production. Complexity, in

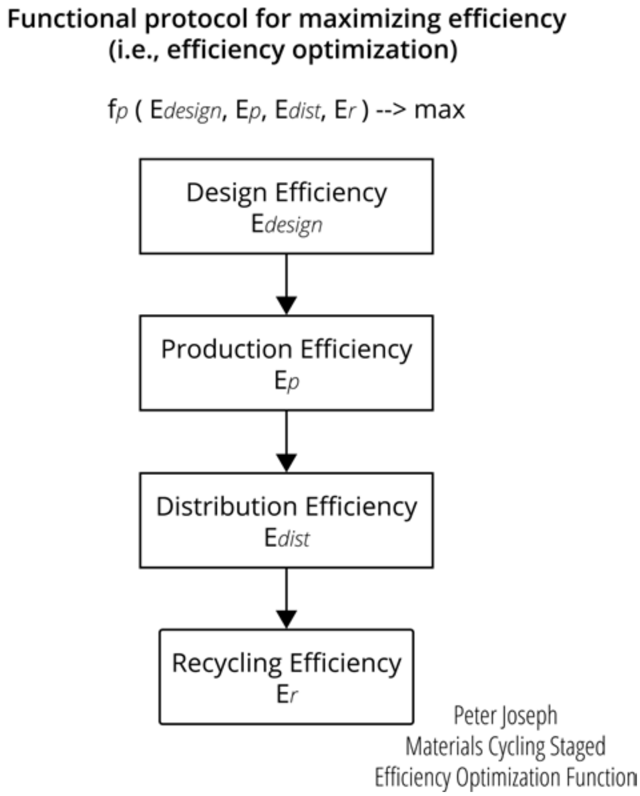

Figure 40. *Macro-economic calculation for maximization of total efficiency during the materials cycling process stages of design, production, distribution, and recycling.*

the context of an automated oriented economic sector can be quantified by defining and comparing the number of “process stages”. Any given good production can be foreshadowed as to how many of these “stages”of production processing it will take. It can then be compared to other good productions, ideally in the same genre, for a quantifiable assessment. The units of measurement are the stages, in other words. For example, a chair that can be molded in 3 minutes, from simple polymers in one process will have a lower ‘labor complexity’ value than a chair which requires automated assembly down a more tedious production chain with mixed materials.

Levels of automation score (levels of automation):

1. Automated without human supervision control and self-sustaining (full automation, no human effort required)
2. Automated with human supervision control and self-sustaining
3. Automated with human supervision control and non-self-sustaining

These three levels include:

1. Monitoring; supervisory control (automated or human).
2. Human operations management - work flow, stepping the process through states to produce desired end result. Maintaining and optimizing the process: shifts, hours, minutes, seconds.
3. Strategic planning and logistics for automation. Establishing the planned schedule, metered use, delivery of automation in years, months, weeks, days, shifts.
4. Sensors to automate data collection.
5. Algorithms to automate data processing.

4.2.1.2 The optimized production efficiency process (process 2)

Production efficiency is notated as: $\mathbf{E}_p$

Production efficiency ($\mathbf{E}_p$) moves a demanded production to one of two production facility types*:

1. High demand (mass products)
2. Low demand (customized products)

** This is a common distinction in manufacturing*

A class determination is used to split demand into two [production] categories with a splitting variable, $\mathbf{D}_s$. Here, the choice of production type/facility is based upon the nature of the production's requirements. The following expression represents the splitting condition (is a simple decision with a threshold calculation):

If $\mathbf{D} > \mathbf{D}_s$ Then $\bar{A}_p$ Else $\tilde{\mathbf{A}}_p$

All product designs are filtered by a demand class determination process (**D**). The demand class determination process filters based on the standard demand splitting value ($\mathbf{D}_s$) set for low demand or high demand. All low consumer demands are to be manufactured by the flexible automation process and all high consumer demands are to be produced by the fixed automation production process.

If demand is greater than the splitting value of demand, which is a threshold, then fixed automation is used; and, if it less than the threshold value, then flexible automation processes are used for production.

The ‘high demand’ category assumes fixed automation $\bar{A}_p$ **($\mathbf{a}_i$)**, meaning unvaried production methods ideal for high demand/mass production. The ‘low demand’ category uses flexible automation $\tilde{\mathbf{A}}_p$ **(t , $\mathbf{D}_c$(t) , $\mathbf{a}_i$)**, which can produce customizations, but usually in shorter

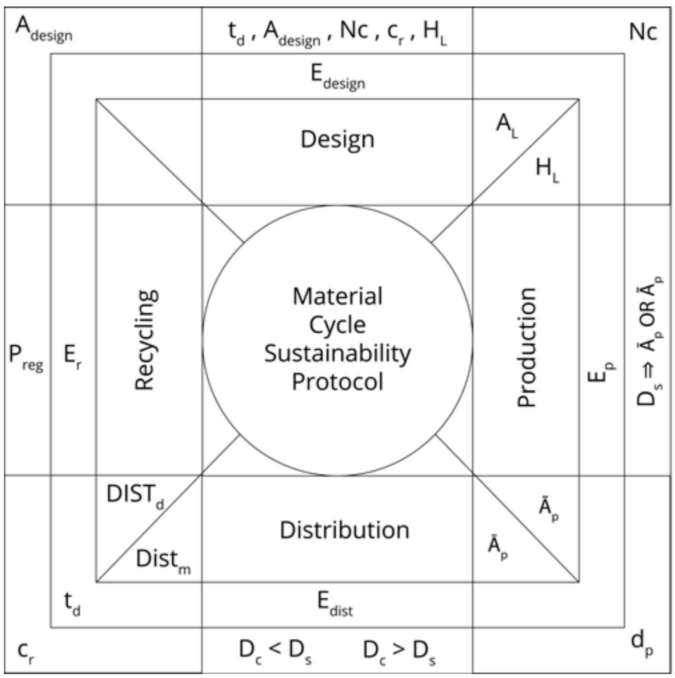

Figure 41. *Material cycle sustainability macro-calculation function. The four phases of the development of service systems with common resources are: design, production, distribution, and recycling. This is an optimization function for the maximization of efficiency in order to cycle materials sustainably throughout the habitat. This protocol combines with economic calculations and a parallel inquiry process in order to materialize service systems for the mutual fulfillment of all of humankind.*

runs. Hence, this schematic assumes only two types of production facilities are needed (fixed and flexible automation). However, there could be more production facility types based upon production factors that generate more splitting conditions.

For example, most product designs are filtered by a **demand class determination** process. The demand class determination process filters based on the standards set for [Low Demand] or [High Demand]. All Low Consumer Demand product designs are manufactured by the 'Flexible Automation' process. All High Consumer demand product designs are to be manufactured by the 'Fixed Automation' process.

The manufacturing of all demand (low and high consumer demand) products designs will be regionally allocated for production as per a Proximity Strategy ($\mathbf{d}_p$) of the manufacturing facilities.

4.2.1.3 The optimized distribution efficiency process (process 3)

Distribution efficiency is notated as: $\mathbf{E}_{dist}$

After process 2, the product design is now a product to be distributed to the consumer (user). At this stage, there is the application of optimized distribution efficiency. Most products are allocated to occupying entities with some georeferenced location.

As with process two, there are two categories for demand, each with a separate distribution process:

1. Low User Demand (a.k.a., low consumer demand) products follow the 'direct distribution' process ($\mathbf{DIST}_d$).
2. High User Demand service productions follow the 'mass distribution' process, which would likely be the libraries, access centers, or direct to user where possible ($\mathbf{DIST}_m$).

Economic Materials Categories:
The Material (Habitat) Cycle Sustainability Protocol

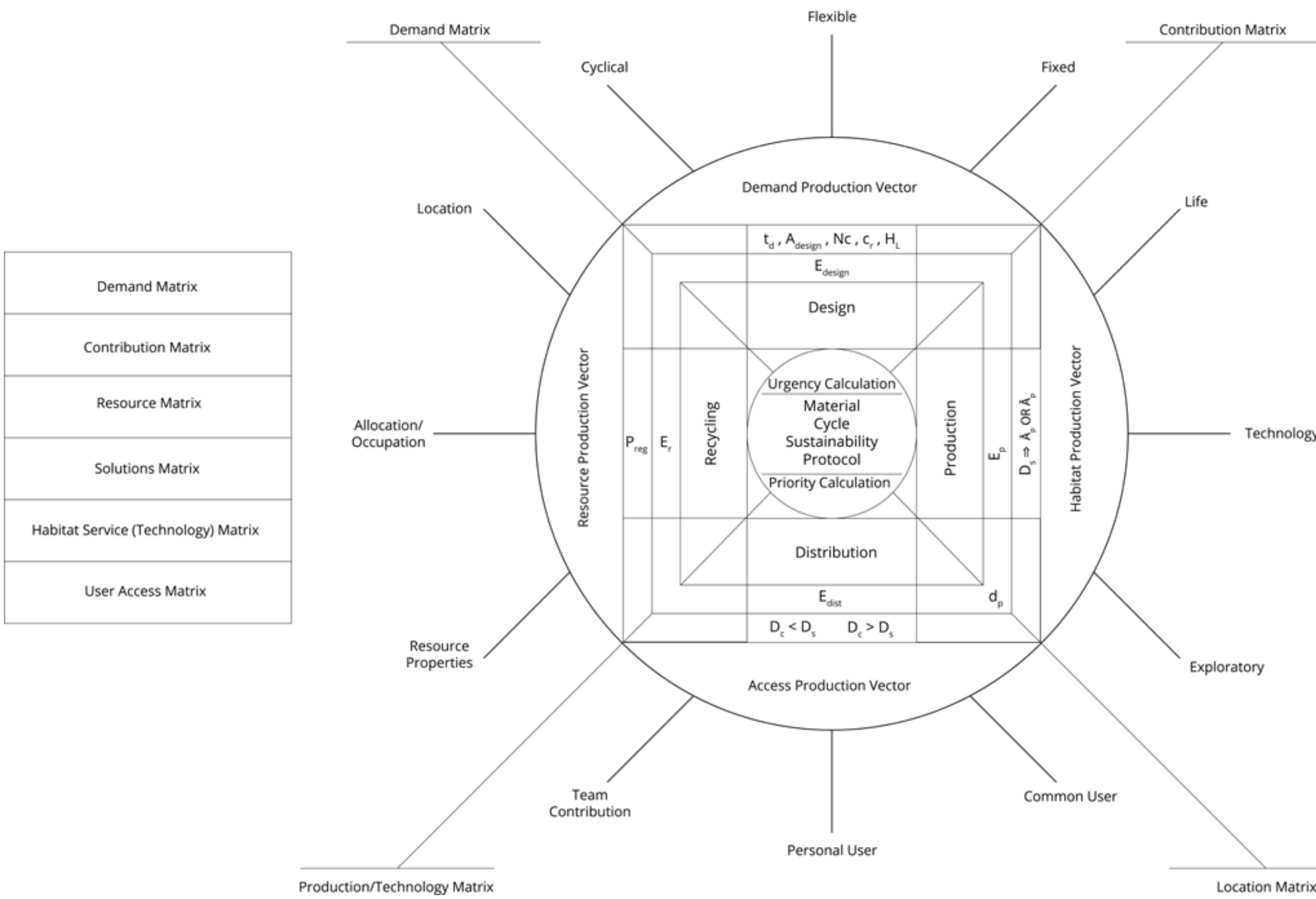

Figure 42. *Figure shows the matrices that must be designed and calculated for by the production decision protocol.*

Both the Low User Demand and High User Demand product will be regionally allocated as per the Proximity Strategy ($\mathbf{d}_p$), as before.

A class determination is used to split demand into two [distribution] categories with a splitting variable, $\mathbf{D}_s$. In general, the $\mathbf{D}_s$ for process 2 and 3 are the same $\mathbf{D}_s$.

1. In low usership demand situations ($\mathbf{D}_c < \mathbf{D}_s$) distribution is direct to the user.
   A. Direct distribution - low demand.
2. In high usership demand ($\mathbf{D}_c > \mathbf{D}_s$), distribution is logistically arranged through a planned massive distribution model involving access centers, storage centers, and direct to user elements.
   A. Mass distribution, high demand.
   B. In this case, generally, the product goes to intermediary facilities, such as libraries ($\mathbf{D}_i$) to provide accessibility to the potential users/ consumers ($\mathbf{C}_i$) .

The proximity localization strategy ($\mathbf{d}_p$) involves the prioritization of localization in terms of:

1. **Sourcing** of materials used in production is localized & raw material re-production are localized.
2. **Production** and **recycling** is localized.*
3. **Production machinery** used in the production process is localized [at a prioritization scale].*
4. **Distribution** maintains distributed localization.

*** 3D printing** - *localized distributed manufacturing based on digital fabrication. 3D printing is a form of localized and distributed production.*

4.2.1.4 The optimized recycling efficiency process (process 4)

Recycling efficiency is notated as: $\mathbf{E}_r$

Products, materials and their life-cycles, may be designed for recyclability (recycling) and/or reuse (re-use) in the following ways:

1. Produced objects can be re-used and re-purposed:
   A. Produced objects can be re-used - whole or part of the product is simply re-used.
      1. The most basic form of re-use is a library, but this is outside the context of production. Here, no part of the object is replaced; the product is directly resued (i.e., this is direct re-use).
      2. In concern to production, when objects are returned to maintenance, and a part is replaced, the rest of the object is not replaced, it is simply re-used (possibly with cleaning). This is "parts-replacement" reuse (i.e., parts re-use).
   B. Produced objects can be re-purposed (a.k.a., up-cycled) - all or part of the product is re-purposed for another use. This occurs when components are not recycled, but instead re-purposed into another production cycle (typically, for a different product).
2. Produced objects can be disassembled mechanically, chemically, and electromagnetically:
   A. Mechanical recycling - changing the object via mechanical methods to make it more usabale or de-composible.
   B. Chemical recycling - changing the object via chemical methods to make it more usable or decomposible.
   C. Electromagnetically recycled - changing the object via electro-magnetic methods.

Protocol: All voided (no longer used) products will follow a recycling-regenerative protocol:

- $\mathbf{P}_{reg}$ is the primary regenerative protocol for $\mathbf{E}_r$.
- The $\mathbf{P}_{reg}$ protocol includes a scarcity measurement for resources (materials) and solution resource configurations (in which resources may be locked for periods of time). The scarcity value is placed on a numerical scale from 1 to 100. One would denote the most severe scarcity with respect to the current rate of use - and 100 the least severe. Fifty would mark the steady-state dividing line. For example, if the use of wood lumber passes below the steady state level of 50 - which would mean consumption is currently surpassing the earth's natural regeneration rate - this would trigger a counter move of some kind - such as the process of 'material substitution' (for example, the replacement for wood in any given future productions, finding alternatives).

5 Assembly complexity index and analysis

A.k.a., Product complexity, production complexity, assembly complexity inquiry, assembly complexity index analysis and inquiry assembly index, assembly theory, account for object history and reproducible recursions, complexity analysis, hierarchy analysis.

Assembly thinking deals with understanding how parts come together to form a whole and the implications of this process. In the realm of system assembly, the term "assembly" denotes not only the physical [construction of] objects, but also their complexity and the historical context of their development. Identifiable by their replicable forms, objects serve as the cornerstone for understanding assembly complexity. The process of assembly delineates the evolution of these objects, emphasizing the significance of their formation and the intricacies of their interconnections within a system. System assembly thinking accounts for objects for which identical copies can be found, and analysis therein allows for determinations of whether those objects are complex or not.

The organization and integration of components into complex structures is essential for understanding how different parts of a production system come together to function as a whole. Assembly complexity analysis examines the factors involved in assembling components into a final product (e.g., a habitat), including the identification of bottlenecks or inefficiencies. Herein, the result of the analysis is an assembly index for every produced service-object that acts as a quantitative measure that evaluates the complexity of assembling a product from its components. This can guide optimization efforts by highlighting areas where simplification can reduce costs and improve efficiency.

Assemblies are characterized by the following attributes:

1. **Contingent histories:** An assembly describes the possible historically formative steps/histories of objects. Each assembly carries a unique

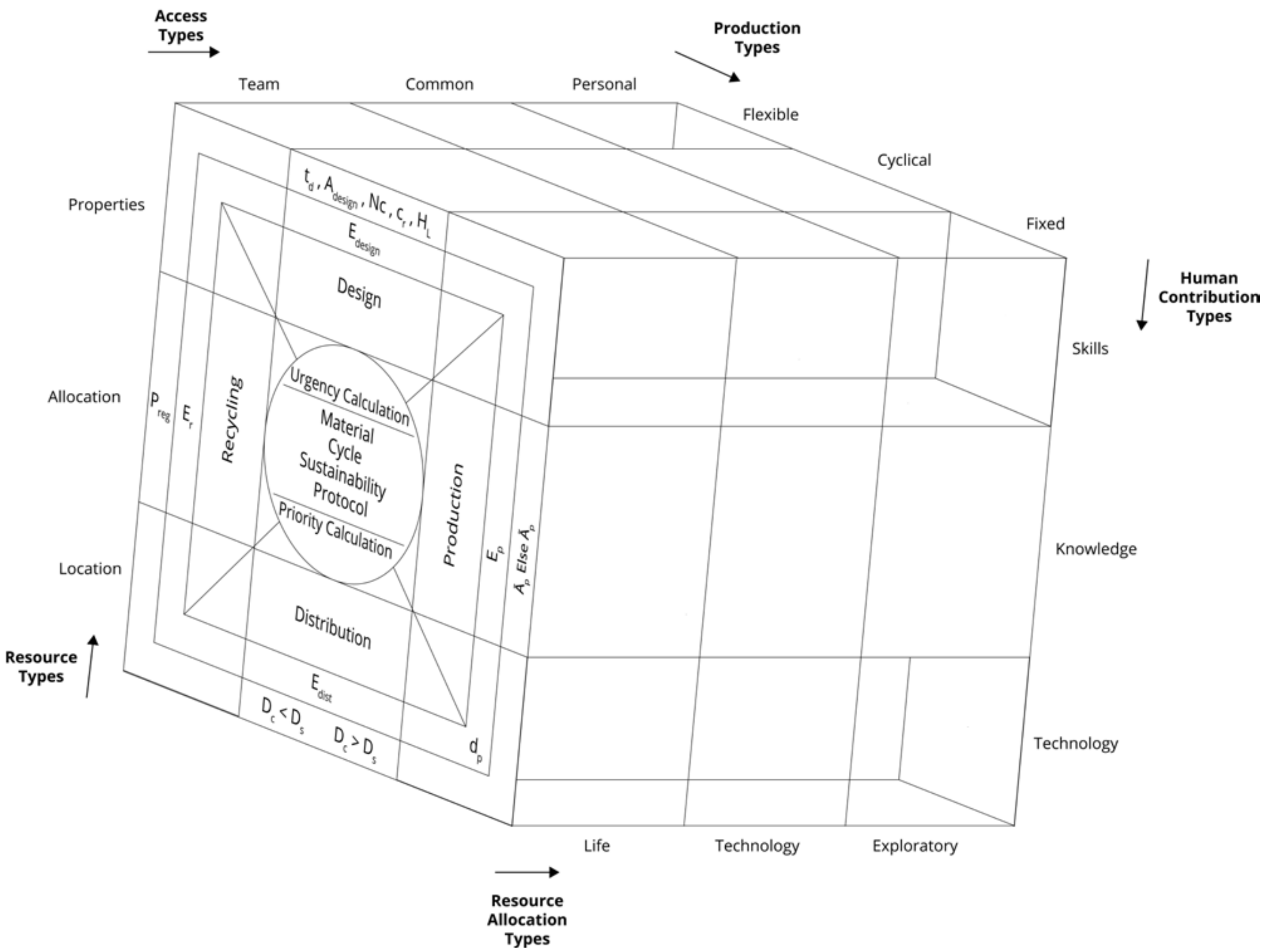

Figure 43. *Figure shows a three dimensional matrix for the production calculation.*

developmental history, contingent upon various factors that have led to its current state. All assemblies have contingent histories. The assembly formula considers production processes not as static entities but as evolving assemblages with defined formative histories.

2. **Hierarchical composition:** Assemblies are built upon prior levels of construction, where components created at earlier stages become integral to subsequent levels of assembly. The assembly formula counts assembly steps.
3. **Enabling new assemblies:** Existing assemblies lay the groundwork for the emergence of more advanced assemblies, making what was once improbable, possible and viable. Pre-existing assemblies provide the necessary base for developing more intricate and advanced assemblies.
4. **Evolutionary significance:** The process of assembly reflects the evolutionary progression of structures, whether biological, mechanical, or societal. The more technical products already exist, the more innovations become possible by combining them. Combination and selection are the same mechanisms in evolution.
5. **Analytical insight/utility:** Assembly analysis is instrumental in recognizing the complexity within systems and is key to designing efficient and effective structures across various domains of life. The study of assembly processes is crucial for discerning system complexity and is instrumental in the design and optimization of both technical and socio-technical structures.
6. **Dynamic and static complexity:** Assembly complexity can be viewed through the lens of both static and dynamic states of objects—ranging from the tangible (solids, liquids, gases) to the conceptual (plasma, transfer, addition, and subtraction).
7. **Assembly "space":** This concept captures the knowable parameters of assembly—the number of steps required and the complexity inherent in each step. It maps out the pathway an object takes from its most basic components to its final form, reflecting the system's memory. It can include a host of other variables related to assembly, such as power usage, labor time, etc.

All technologies, and all socio-technical organizations, are assemblies with different levels of assemblage and complexity, wherein:

1. Concepts plan or describe the movement of objects.
2. Objects are located to exist and may be moved into positions (locations), orientations (directions), rotations (spins), and translocations (two or more locations).

Herein, assembly complexity can be seen from two viewpoints:

1. Assembly complexity using the static objects (solids, liquids and gas).
2. Assembly complexity using the dynamic concepts of objects (plasma, transfer, addition, and subtraction).

Any assembly has two core static, knowable values (a.k.a., assembly "space"; i.e., A assembly complexity inquiry, analysis includes the following factors of assembly):

1. **Number of steps to assemble.**
2. **Complexity of assembly at each step.**
   A. Mineral resource usage (MR).
      1. Fixed.
      2. Transitory.
   B. Non-mineral resource usage (nMR).
      1. Fixed.
      2. Transitory.
   C. Power resource usage (PR).
   D. Labor resource usge (LBR).

Within the context of human habitats, which are complex socio-technical systems, the principles of assembly are applied to construct and coordinate living services. These habitats are step-by-step compositions of varying complexity, serving as the prototypical units of community assembly. They encapsulate a mix of concepts and objects designed to fulfill a spectrum of functions. Within each habitat, support services are categorized and accessed through layers of personal, communal, and InterSystem teams, culminating in a global network that represents the broader supra-assembly of interconnected habitats.

Objects represented in an information system, have histories to their formation (as an intrinsic property), mapped as an assembly space. The assembly "space" is defined as the pathway by which a given object can be built from elementary building blocks, step-by-step, using only recursive operations. For the shortest path, the assembly "space" captures the minimal memory, in terms of the minimal number of operations necessary to construct an assembled object based on objects that could have existed in its past. Here, it is the total set the of currently existing products, and their feedback relationships that constitute the memory of the system. Of note, a mode of production also has memory encoded into the set of products it currently produces and hold stocks of. (Sharma, et. al., 2023)

The assembly formula, expressed through summation notation, can be used to measure (in the context of complexity) the shortest path required to reconstruct (copy) a system, reflecting its degree of complexity and potential evolutionary history. All assemblies are composed of a number of steps, that lead to the assembly of objects into a supra-functional objects (Read: target assemblies). In community, habitats are socio-technical assemblies with different levels of construction and operation complexity. Habitats are constructed and operated through step-by-step procedures, with varying degrees of complexity at each step. In community, the habitat unit is the prototypical complex of a useful mix of concepts and objects. Here, habitats are the prototypical user assembly unit. Within each habitat there are three primary categories of support service; each with its own set of sub-assemblies (all accessed within the context of personal, common, and InterSystem team access). The global (networked habitat configuration) is it's supra-assembly.

Assembly pathway are initialized and composed of:

1. **A set of basic building blocks** (there are objects at the beginning).
   A. Masses (objects).
   B. Information (concepts).
2. **Joining operations** construct the assembly with blocks (events and actions occur to objects and concepts).
   A. Knowledge (information technology).
   B. Tools (physical technology).
3. **Re-use** (Read: reproduction, recursion; wherein, there is memory of what is made, memory of assemblages of objects).

Once the pathway for a new object has been discovered, the production of an object (copy number greater than) gets easier as the copy number increases; because, a high copy number implies that an object can be produced readily in a given context. Thus, the hardest discovery is making an object for the first time, which is equivalent to its discovery, followed by making the first copy of that object. But, once an object exists in very high abundance, it must already be relatively easy to make. Hence, the overall assembly complexity (A) scales linearly with copy number for more than one object (for a fixed requirements set ("cost") per object), once a process (object+technique) has been discovered. (Sharma, et. al., 2023)

An assembly, as a unit of functional data, captures the amount of memory necessary to produce a selected configuration of a historically contingent object assembly, by usage of some materials and techniques. Here, the definition of 'object' is simple and rigorously defined. An 'object' is finite (has shape), is distinguishable, persists over time and is breakable (divisible to atoms and threads) such that the set of constraints to construct it from elementary building blocks is quantifiable (measurable) and with qualifiable utility (functionable). A more generalized conception of an object-assembly is anything that can be broken and built.

The more complex a given object, the less likely an identical copy can exist without selection of some information-driven mechanism that generates that object. An object that exists in multiple copies allows the signatures describing the set of constraints that built it to be measured experimentally. More copies of the object mean more "abundance" of that object.

At the molecular level, there are tools to measure types and arrangements of molecules. Mass spectrometry is one such tool that can be used to measure assembly for molecules; because, it can measure how molecules are built by making bonds.

The more complex a given object, the less likely an identical copy can exist without selection of some information-driven and power-driven mechanisms that generates that object. An object that exists in multiple copies allows the signatures describing the set of constraints that built it to be measured experimentally and reverse engineered.

Material Reconfiguration of Resources For the Production of Access

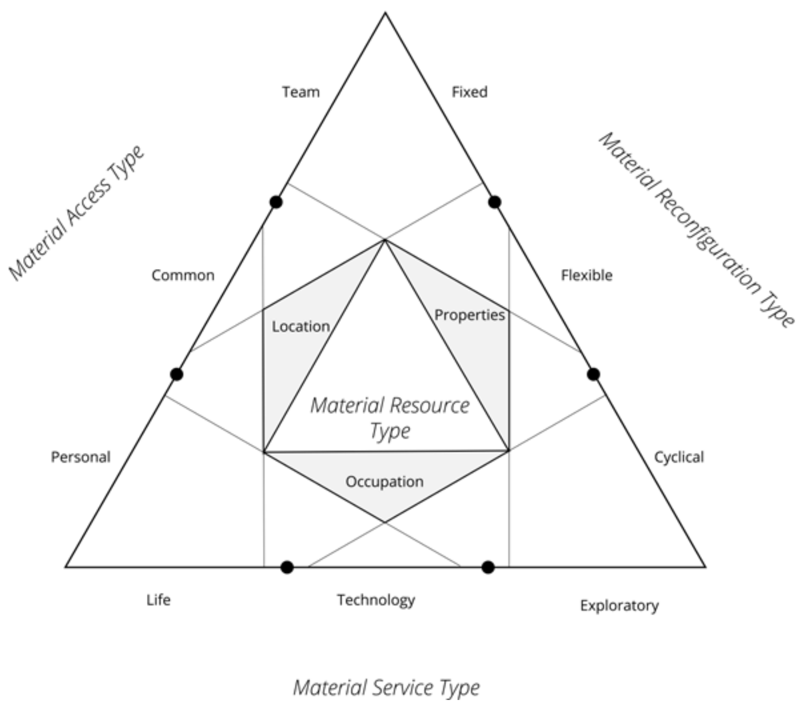

Figure 44. *Diagram of the convergence of access, reconfiguration, and service through the allocation of resources with properties to specified locations.*

The key observable properties of objects are (an assembly is a function of two quantities) (Sharma, et. al., 2023):

1. The number of copies of the observed objects.
   A. Copy number (copy count).
2. The objects' assembly index (quantify one or more factors of an assembly process; such as, steps on a minimal path to producing the object or the complexity of the object itself).
   A. Assembly index value, result, "A" or "AI".

CLARIFICATION: *The term "index" does not refer to the variable "i". Here, "index" refers to the assembly index "A" or "AI", which is a calculated value representing some aspect of an assembly's composition.*

The properties of an assembly are definable using mathematical formula. The assembly index (AI or A) formulae assess a composite measure (e.g., complexity, "steps","concentration", etc.) based on individual component contributions, but the specific variables and their interpretations differ, reflecting the distinct contexts in which the assembly formula used.

NOTE: *The most basic example of an assembly index is a flint arrowhead, and the assembly index is the number of steps to shape the tool (using another stone to knap off parts of the final tool.*

The value of the overall assembly complexity (A) gives manufacturers and designers an idea of how complex the assembly process will be, which can influence the cost, time, and feasibility of manufacturing a product. A higher assembly index suggests a more complex and potentially time-consuming and costly assembly process, whereas a lower index indicates a simpler, likely more cost-effective assembly.

The term "index" in the context of "assembly index" and other similar metrics originates from the Latin word "indicāre," meaning to indicate or to point out. In various academic, scientific, and practical fields, an index serves as a quantitative indicator or a measure that points out or reveals the relative position, value, or condition of a subject under consideration. The use of "index" in such terms signifies its role in providing a standardized reference point for comparison, evaluation, or measurement. The index for which the assembly is being compared to is the economization of human need fulfillment (i.e., efficiently and effectively meeting human need completion, cyclically).

The choice of the word "index" in terms like "assembly index" emphasizes the function of these metrics as tools for revealing insights into specific aspects of interest, in this case, the assembly process, and in specific, the number of assembly steps and complexity. By quantifying complexity or efficiency, the assembly index serves as a pivotal reference in economic/habitat production decisioning, embodying the etymological essence of indicating or pointing out critical information.

Assembly indexing is the process of indexing different assemblies based two real-world quantizable phenomena:

1. The difficulty (intelligence and complexity) of discovering a new object, and, once discovered,
2. The difficulty of copying the object (which, becomes easier to make, easier to replicate/duplicate, and apply recursive decision-production, over time),
   A. which, is indicative of how intelligent selection was required to discover and make it in the first place. (Sharma, et. al., 2023)

In application, objects are defined as histories (an intrinsic property of their formation, an "index"), mapped as an assembly "space". The assembly "space" is defined as the pathway by which a given object can be built from elementary building blocks, using only recursive operations. For the shortest path, the assembly space captures the minimal memory, in terms of the minimal number of operations necessary to construct an observed object based on objects that could have existed in its past.

The assembly index can be estimated from any complex discrete object with well-defined building blocks, which can be broken apart. At every step, the size of the object increases by at least one. The number of total possible steps, although potentially large, is always finite for any object (because, all objects are finite only), and thus, the assembly index is computable in finite time. Finding more than one identical copy indicates presence of a non-random process generating the object. (Sharma, et. al., 2023)

To construct an assembly space for an object, one starts from elementary building blocks comprising that object and recursively joins these to form new structures, whereby, at each recursive step, the objects formed are added back to the assembly pool and are available for subsequent steps. (Sharma, et. al., 2023)

For any given object i, define its assembly space as all recursively assembled pathways that produce it. For each object, the most important feature is the assembly index "AI", which corresponds to the shortest number of steps (least complexity) required to generate the object from basic building blocks ("lengths"):

1. Chemical assembly "length" (micro-resource assembly).
   A. Chemicals (and micro-organisms).
   B. Bonds.
   C. Bonds to time, and intermediary production materials to time.
2. Frictional assembly "length" (macro-resource assembly).
   A. Mineral and biologics.

   B. Distance.
   C. Distance to time, and pressure to time (acceleration and reproduction).
3. Electromagnetic assembly "length" (information-communication).
   A. Electric minerals and synthetic phtosynthesis.
   B. Electromagnetism.
   C. Power to time, and signal to time.
4. Computational assembly "length".
   A. Computers.
   B. Mathematics.
   C. Compute to time, and intelligence to time.

A even more simplified way of looking at the hierarchical building blocks of all assemblies is:

1. Atoms.
2. Minerals:
   A. Elements.
3. Biologics:
   A. Simple organic molecules.
   B. Amino acids and nucleotides.
   C. Proteins and DNA chains.
   D. Cells.
   E. Multicellular organisms.
4. Ecosystems of mineral and biological objects.

In this way, assembly-complexity accounting can be done for each of the phases of production:

1. Materials assembly index (MA).
2. Means of [habitat] production assembly index (MeA).
3. Final [habitat] service-object assembly index (SA).
4. Disassembly assembly index (DA).

It is relevant to note here that there are similarities between assembly step analysis and algorithmic information dynamics (a.k.a., algorithmic information theory). In assembly-step complexity analysis, the result is a measure ("index") of an object's complexity, but it is not a measure of algorithmic complexity (and yet, it could be considered algorithmic, if a copy is the target of analysis, because of the algorithmically recursive steps needed to reproduce it as a copy). The assembly index (ai) is the smallest number of joining operations needed to create an (assembled) object. It is based on the idea that the formation of complex structures depends on specific assembly pathways. The final product depends on the initial conditions and the "story" (history) of the assembling building blocks. The assembly index (ai) is a measure of an object's complexity, but it is not a measure of algorithmic complexity. Algorithmic information dynamics relates to, but does not undermine the usage of assembly-step analysis for life detection and production economization. The reasons for this are: 1) assembly indices are not intended to be optimal measure of compression (although they are alike), and 2) assembly theory deals with the problem of randomness by focusing on copy number, which is not directly considered in algorithmic information dynamics.

5.1 Summation formula notation

A.k.a., Summation notation, sigma formula

Summation formula notation is a mathematical convention used to express the sum of a sequence of terms that follow a specific pattern, which is defined by the formula inside the summation. The sigma sum notation, denoted by the Greek letter (Σ), which is a mathematical symbol that indicates the summing of a sequence of terms defined by a formula. This compact representation allows for the concise expression of long sums, where the variable beneath the sigma indicates the starting index and the variable above denotes the ending index of the summation.

The formula useful in assembly complexity and economic production plan analysis because it provides a quantitative framework for aggregating individual assembly attributes across an entire system, enabling precise evaluation of overall production intricacies. By incorporating the complexity factors of each component into a single index, it allows for the optimization of design and resource allocation, thereby facilitating more efficient and cost-effective manufacturing strategies.

The sigma-sum formula:

Sigma formula | Sigma notation

2 *< end value (last value, 2)*
sum | sigma (∑) > Σ (3i - 1) *< rule/formula (...)*
index (i) > i = 1 *< start value (first value, 1)*

$$\sum_{i=1}^{2} (3i - 1)$$

- wherein,
  - i = index, or any letter used to represent the running index counter that iterates over the sequence the index tracks which term the sequence currently being summoned.

5.1.1 Assembly complexity factoring

A.k.a., Assembly factor, complexity factor.

In each version of the assembly summation notation form, the complexity factor (assembly index) a_i can be used in three ways:

1. a_i as the "Complexity Factor" of the i^{th} **type/unit of 'object'**.
   A. a_i reflects the inherent complexity in production (manufacturing, assembling, disassembling, etc.) a particular type of object. For example, if the object is a microprocessor, a_i would be high due to the complex design, and resource and technique precision required.

2. a_i as the "Complexity Factor" of the i^{th} **copy of 'object'**.
   A. a_i varies for each copy of an object, possibly reflecting variations in the production process or differences in materials used for different batches.
3. a_i as the "Complexity Factor" of the i^{th} **assembly step of 'object'**.
   B. a_i is specific to each step in the assembly process. For example, soldering components onto a circuit board might have a different a_i compared to testing the completed board.

Using summation notation to construct an assembly complexity index of [habitat] service-objects allows for:

1. Evaluating and comparing the complexity of different products.
2. Optimizing individual steps in a [societal-habitat service system] production (i.e., assembly line).

5.1.2 Exponential assembly complexity index analysis

In step analysis, the overall assembly complexity index (A) is defined as the length of the shortest assembly pathway. Framing the assembly index as the number of steps necessary to assemble something shifts the perspective to the complexity and efficiency of production processes. Understanding the concept of the "assembly index" of a system is paramount in making informed decisions within society. As a crucial sub-process inquiry, analyzing the assembly index sheds light on the intricacies of production processes, resource allocation, and overall system efficiency. The assembly index serves as a metric to quantify the complexity and efficiency of assembly processes within a system. By delineating the number of steps necessary to assemble a product or execute a process, it provides invaluable insights into resource utilization, workflow optimization, and potential bottlenecks. Consequently, a comprehensive understanding of the assembly index empowers decision-makers to streamline operations, enhance productivity, and allocate resources judiciously to meet community needs effectively.

The exponential assembly-complexity index formula requires:

1. Objects that can be found in identical copies.
2. Identification of whether the objects are complex or not.

Here, the assembly index formula can assume an exponential relationship for complexity modeling, where the Assembly Index (A) is calculated in a way that increases in complexity have a disproportionately greater impact on the assembly index. The following is an exponential assembly index formula where each assembly step has an exponential factor based on its complexity rating. The formula is understood as a sum of terms, each representing an individual assembly step, which accounts for the complexity of that step and its sequence in the overall process. The following basic assembly formula applies to all things that are made out of a hierarchy of components. Here, an assembly is defined as the total amount of selection necessary to produce a secondary 'unit' of objects (assembly), quantified using the equation:

Formula:

$$A = \sum_{i=1}^{N} e^{a_i} \left((n_i - 1) / N_T\right)$$

- where an assembly index of overall complexity, A =
  - a sum over, $\sum$.
    - all possible arrangements/steps of a system, N.
    - combining how complicated they are to assemble, e^{a_i}.
    - multiplied with how many copies are seen, n_i (or, n_i - 1), over
    - the total possible number of objects, copies of objects, or steps in the assembly process, N_T.
  - N = total number of assembly steps -- the last assembly step; the total possible arrangements/steps of the system (starting with *i*=1 and ending with N).
  - a_i = "complexity factor" or "assembly index" of the i^{th} type of object, the i^{th} copy of an object, or the i^{th} assembly step.
    - a_i = number-count of steps to construct the object from sub-components.
    - How many steps are directly required to build; how complicated is it to assemble?
  - e = Euler's number, which is a natural factor that adjusts for the improbability of the object/molecule existing.
    - e is the base of the natural logarithm (approximately equal to 2.71828).
  - e^{a_i} = the exponential complexity factor, where a_i represents a complexity factor that now has an exponential impact on the Assembly Index.. Euler's number to the power of the "assembly index". Here, ^{a_i} is weighted in terms of improbability (e). The use of this exponential function suggests that as the complexity factor increases, the impact on the assembly index grows exponentially, rather than linearly.
    - e^{a_i} is an exponential function in terms of the number-of-steps.
    - e^{a_i} could represent any weighting factor or efficiency coefficient for component *i*.
    - What is the adjusted number of steps (based

on life-likelihoood, or some other factor)?

- $((n_i - 1)/N_T)$ = a scaling factor based on the sequence of the assembly step, with n_i being the sequence number and N_T the total number of steps. This term adjusts the exponential impact based on the sequence of the step within the total process, providing a scaling factor that diminishes the first step and increases towards the last.
  - The expression $((n_i - 1) / N_T)$ measures the concentration (prevalence, ratio) of each component *i*, in the assembly, adjusted by subtracting 1 for normalization purposes.
- n_i = the number of objects of type *i* (copy number; the number of objects that can be found in identical copies).
  - n_i could be the number of component *i* units
  - n_i could be the number of molecules of type, *i.*
  - n_i could be the number of machines of type, *i.*
  - How many copies of the object are there?
  - $(n_i - 1) == 0$, only if there is only one copy of the object/molecule, otherwise it grows linearly with number of copies. It is assumed the object was not assembled. If copy number = 0, then $(0-1)/N_T = 0/N_T = 0$, which drops the entire assembliness of the equation to A = 0.
- N_T = the absolute total number of objects, molecules, steps in the assembly. The total possible sum of all options. Assembly formula is applied to a collection of N_T objects or steps.
  - N_T could represent the total number of all components.
  - N_T could be the total number of components.
  - N_T could be the total number of molecules.
  - N_T could be the total number of machines.
- The "depth" (step count) of a linearly expanding assembly pool has objects that combine at step $a_i \rightarrow a_i + 1$, where an object at the assembly index a_i combines with another object from the assembly pool.
- i = an indexed (counted) variable used in the summation notation. A placeholder that runs from 1 to n (the total number of copies), allowing the formula to sum the square of the proportion a_i for each copy in the total. It is essentially a counter in the formula that iterates over each element in a series.
  - Indexed variable ("i"): This is a variable that changes its value during the summation process. In the formula, it starts at 1 and increases by 1 with each iteration, continuing until it reaches "n," which is the total number of elements (or copies) being considered.
  - Summation notation: The symbol ∑ (sigma) indicates that a sum is being calculated. The variable "i" underneath the sigma tells us where to start counting (usually from 1), and the "n" above it indicates where to stop.

NOTE: *Normalizing by the number of objects in the assembly allows one assembly to be compared between assemblies with different numbers of objects.*

The formula provide for calculating a version of an assembly index "A," which is a sum of terms related to individual assemblies within a system:

1. A: This is the overall Assembly Index ("A" or "AI"). It is a singular value that represents the cumulative measure of assembly complexity for the entire system being analyzed. It takes into account the individual complexities of each assembly within the system and aggregates them into one comprehensive index. The value of A gives the overall complexity of the entire system.
2. a_i: refers to the individual complexity or attribute of each specific assembly within the system, indexed by by *i*. In the summation part of the formula, e^{a_i} would be calculated for each assembly, and a_i could represent a variety of factors such as the complexity, steps, time, or resources required for that specific assembly. The a_i values are specific to each part or step in the process and are not the aggregated measure; rather, they contribute to the overall assembly index A when summed together.

5.1.3 Linear-complexity assembly index[ing]

Here, the assembly index formula can assume a pure linear relationship for linear complexity modeling, where the Assembly Index (A) is calculated as the sum of the products of complexity (C) and time (T) for each step, assuming a linear relationship between complexity, time, and the overall index:

Formula:

$$A = \sum_{i=1}^{N} (C_i \cdot T_i)$$

- Where,
  - A = calculated-complexity [index] of assembly (a.k.a., Asssembly Index, AI).
  - C_i = complexity rating of the i^{th} assembly step, based on predetermined criteria (e.g., technical difficulty, skill-level required).
  - T_i = time required for the i^{th} assembly step.
  - N = final/last assembly step.

The same formula could use sustainability in place of time as a required factor of account and then divide (ratio)