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Industry 4.0:
Sustainability Assessment of Manufacturing Industry

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Introduction to Sustainable Industry

- Sustainability: means to continue at a fixed rate*
- Sustainable Industry provides**:
  - Energy efficiency
  - Conservation of resource
  - Low-waste production
- Example: Sustainable Manufacturing Industries

Source*: "Google Defination“
Source **:” Wikipedia”

Sustainability in Industry 4.0

- Industry 4.0 proposes inclusion of the characteristics of the previous industry revolution in more sustainable way.
- Industry 4.0 or the fourth industrial revolution
  - A comprehensive industrial revolution
  - It incorporates globalization and emerging issues.

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

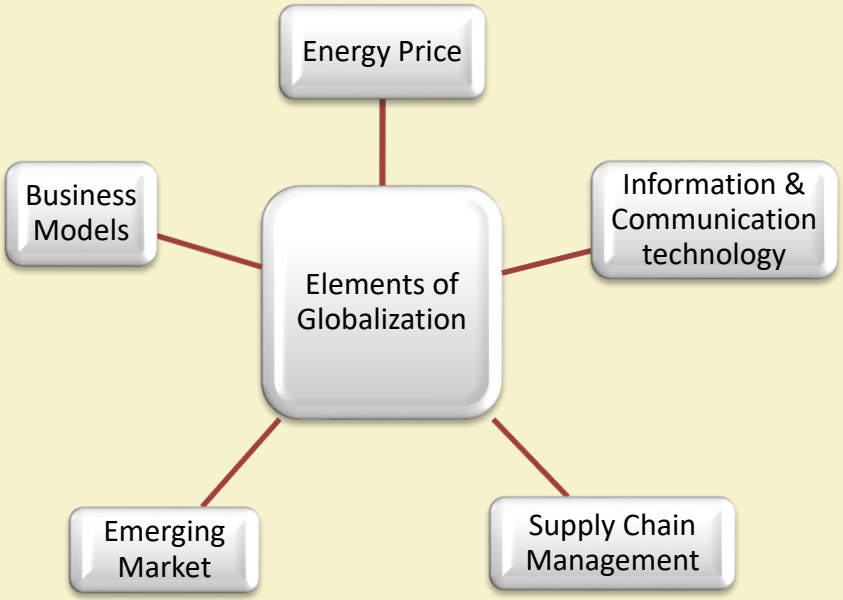
Sustainability Assessment

- Manufacturing industry is considered as
  - Base of modern industrialized society
  - Corner stone of world economy
- Strong manufacturing base stimulates other aspects of the economy of any country
- Evaluation of S/SD or sustainability assessment of manufacturing industry in Industry 4.0 incorporates evaluation of relevant issues and performance metrics

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Introduction to Globalization Issues

- Globalization is one of the drivers of sustainable industries
- Globalization issues affect the sustainability of any development/ manufacturing
- These issues are one of the most fundamental requirements



Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Supply Chain Management (SCM)

- Strategic function in manufacturing industry
  - Many different stages including supplier, production system, and customer
  - Sequencing the stages for the whole system
- The most important stage in SCM is selection for outsourcing components/parts or raw material
- SCM must have environmental concerns: Climate change, contamination and resource consumption

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Information and Communication Technology (ICT)

- Main nervous system of any manufacturing industry
  - In absence of ICT, no communication within the enterprise
- Share information between customer, producer, and supplier
- Examples of ICT
  - Enterprise Resource Planning (ERP)
  - Wireless Communication Technology
  - Global Positioning System (GPS)
  - Radio Frequency Identification (RFID) system

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Energy Prices

- For enterprise, less energy consumption brings significant economic advantages
- Main issues: Energy supply at reasonable price
- Increase in energy price affects sustainability
- Reduction in energy consumption form non-renewable sources and increase in energy consumption form renewable will have significant positive effect in sustainability.

Emerging Markets

- Markets: able to meet the standards of newly developed, innovative product
- Issue: difficult to identify all of the world's emerging markets
- Emerging markets are expected to be found in developing countries

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Business Models

- **Mass Customization:** incorporates the knowledge including international and local cultures
- Business Models ≅ Mass Customization
- Business Model:
  - Strategic approach
  - Maximizing economic profits for an enterprises
  - Taking into account competitive benefits, promoting product value

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Introduction to Emerging Issues

- **Emerging Issues:** changes in manufacturing industries based on the world-wide aggressive competition
- Major aspects in case of sustainable development in designing manufacturing industry.

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Technology

- One of the important issues in sustainability.
- Advancement in technology facilitates manufacturing with
  - High quality products
  - Low-cost products
  - Reduces manufacturing time
- Role of technology advancement in global market
  - Converting from traditional system to automated system
  - Introducing more agility and flexibility

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Government Regulation

- Necessary to protect public and private sector
- It consists of Enterprise Requirements for achieving government purpose such as demands for better services and low cost goods
- Government Regulation
  - Prevents the manufacturing industry from unfair competition
  - Enact laws to provide suitable environments for the employees

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Government Regulation

- Employment
- Advertising
- Labor
- Environmental
- Safety And Health
- Privacy

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Government Regulation

- Employment & Labor rules represents laws
  - Concerning wages/salaries
  - Benefits (e.g. retirement plans)
  - Compliance with health and safety issue
  - Proper working condition
  - Expatriate employee issue (e.g. Visas)
  - Equal opportunity in employment (including promotion)
  - Provisioning of Authority or High ranking position

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Government Regulation

- Advertisement Regulation focuses on
  - Protection of customers
  - Firm honesty about a product
  - Information regulation publicly
  - Transparency on distribution and manufacturing process

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Government Regulation

- Environmental rules
  - Maintained by Environmental Protection Agencies(EPA)
  - Maintains clean air, reduction of chemical effects in soil, river
- Privacy Regulations
  - Safety procedure to sensitive information collected during hiring process
  - Information includes ID card, names, personal information, personal history, health condition, and banking information
  - Inappropriate disclosure of this information risks legal issues

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Government Regulation

- Safety and Health regulations
  - Ensures healthy working environment
  - Enterprise must distribute information on maintaining a healthy workplace to avoid dangerous events
  - Need to update safety regulation information due to yearly changes in Governments

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Population Growth

- Monitoring population growth is important for manufacturing industry
- It affects
  - Industry growth
  - Food supplies
  - Fertility
  - Sociology
  - Economics
  - Politics
  - Industry Location
  - Use of Available lands

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Population Growth

- Three different category of countries based on population growth
  - Developed
  - Emerging
  - Developing
- Population growth of countries (developing and disadvantaged) > Population growth of countries (developed and advantaged)

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Population Growth

- Based on the United Nations (UN) report, population growth from1950 to 2050
  - Reduced between 32 to 13 % in developed countries
  - Increased between 8 to 20 % in emerging and developing countries
- Economic view on population growth
  - Pessimistic
  - Optimistic

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Population Growth

- Pessimistic view of population growth
  - Hinders the economic growth
  - Consumes most of the economic investments in safety, need for schools, hospitals, universities
- Optimistic view of population growth
  - Dissemination of knowledge and information
  - Increases globalization issue such as trade and commerce

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Population Growth

- Despite the advantages of population growth, if there is no plan to control it, it would turn out to be disaster for any developing country
- Human capital and respective skills are one of the most important aspects of manufacturing industries.
- Example: A location of manufacturing industry requires politics and skill level provided by the local population

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Economic Crisis/Recession and Depression

- Economic crisis takes place over a duration not more than a few months
- Recession: exponential decline in economic activity
  - Commence after economic crisis arrives at the activity peak
  - Completion after economy arrives at its trough
  - Duration: more than few months but not more than two years
  - Observable on gross domestic product (GDP), actual income, employment, industrial production, and wholesale-retail sales

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Economic Crisis/Recession and Depression

- Depression: extremity of recession
  - Observed by exponential unemployment increase
  - Reduction in available credit
  - Significant reduction in trade and commerce
  - Huge number of bankruptcies
  - Volatility in currency value
  - Duration: more than two years

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Economic Crisis/Recession and Depression

- An economic crisis and recession → observing reduction in prices of few major commodities
- Increasing productivity and reduction in cost is one of the solution
- Applying same solution, it takes more time to recover form depression
- Example of avoiding crisis→ The main economy of manufacturing location should not be based only one resources

Consumption of Natural Resources

- One of the biggest issues in contrast of economically sustainable development
- As natural resources are main source of revenue in developing countries, it is one of the major source of social conflicts
  - Mining
  - Oil and Gas extraction
  - Demography shifts
  - Difficult economic situations
  - Negative societal behavior
  - Politics
  - Technology

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Consumption of Natural Resources

Renewable

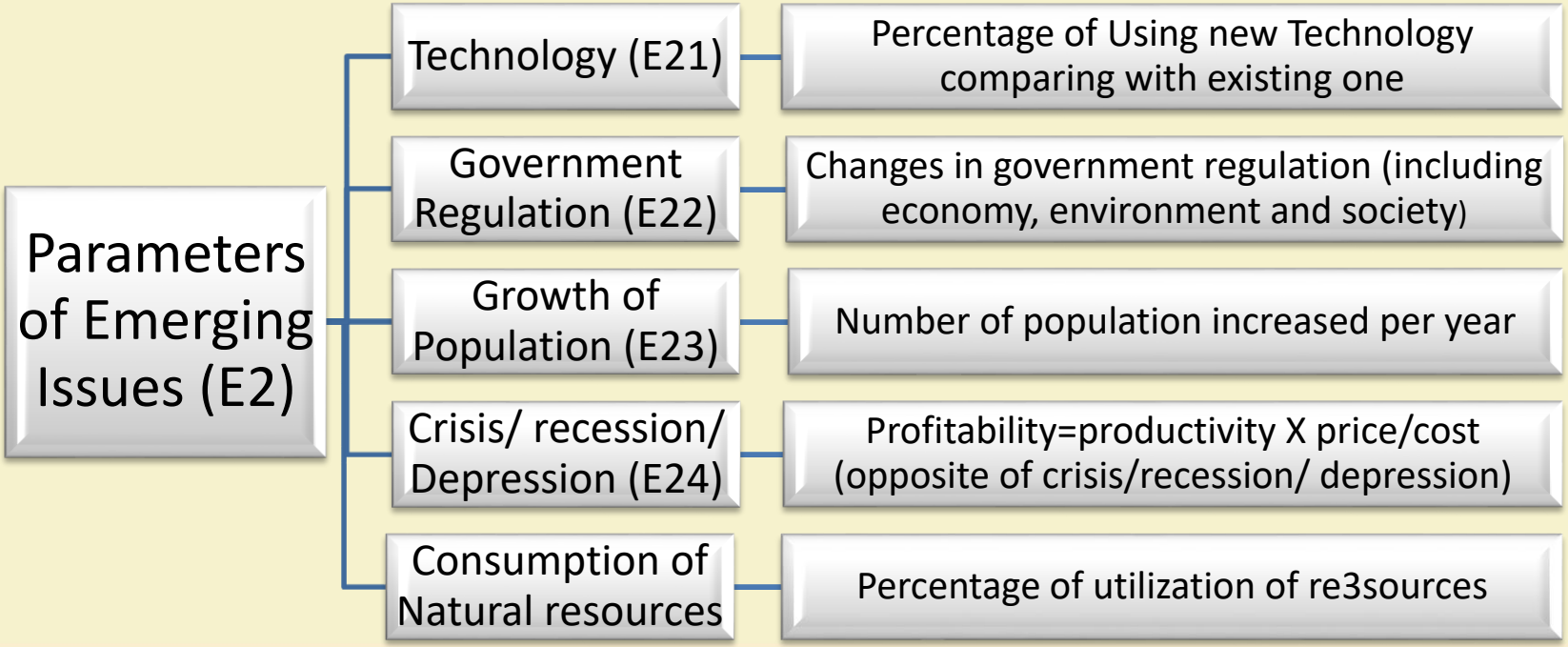
- Naturally Available
- Source: Solar, Air, Water, Wind etc.
- Renewable energies can be generated easily

Non-renewable

- Usage is selective based on the type of the industry
- Source: Coal, Oil, Gas, etc.
- Can not be recycled

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Sustainability Assessment of Emerging Issues



Sustainability Assessment of Emerging Issues

- Sustainability/Sustainable development
  - $S/_{SD_{E2}} = f(E21, E22, E23, E24, E25)$
  - $S/_{SD_{E2}} = \left(I_{E21}^{Y_{E21}} . I_{E22}^{Y_{E22}} . I_{E23}^{Y_{E23}} . I_{E25}^{Y_{E24}} . I_{E25}^{Y_{E25}}\right)$
  - Where $I_{E2i} = S_{E2i}/E2i$,
  - S_{E2i}= The change towards the sustainability
  - Y_{E2i}= Exponent of the change towards sustainability (S_{E2i}) of $E2i$

References

[1] Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503.

[2] Garbie, I.H., Parsaei, H.R. and Leep, H.R., 2008. A novel approach for measuring agility in manufacturing firms. International Journal of Computer Applications in Technology, 32(2), pp.95-103.

[3] Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer.

Thank You!!