Low-Energy Demand and Sustainability

Is it possible to achieve the Paris Agreement goals without relying on carbon dioxide removal (CDR) technology just by lowering the global energy demand? How could such a scenario be achieved and what moral questions and sustainability concerns must be addressed?

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When talking about emission pathways to achieve the Paris Agreement goals, the five shared socio-economic pathyways (SSPs) are often the first to come to mind. Out of these, the *Sutainable Development Pathway* (SSP1) is considered to have the lowest socio-economic challenges to mitigation as well as adaptation [1]. However, some of these pathways still rely on energy production through fossil fuel in combination with carbon capture and storage (CCS) or bioenergy and CCS (BECCS), which are forms of carbon dioxide removal technologies. There is some controversy as to who should pay for these negative emission technologies, as is discussed here [2]. Apart from the high cost issues, there are major concerns connected to almost every form of carbon capture and storage. For example, BECCS' positive effects on direct greenhouse gas emission substitution, market opportunities, employment etc. are outweighed by studies showing that it causes displacement of land use and deforestation and endangers food security and biodiversity [3]. In chapter 2 of the ICC special report on global warming of 1.5 °C, the take on using carbon dioxide removal technologies is aptly summarised:

> "CDR deployed at scale is unproven, and reliance on such technology is a major risk in the ability to limit warming to 1.5 °C." [1]

In their paper titled "*A low energy demand scenario for meeting the 1.5 C target and sustainable development goals without negative emission technologies*", Grubler et al. introduced another scenario, the so-called Low-Energy Demand (LED) scenario [4]. As the title of the paper suggests, they advocate for a pathway which does not rely on carbon dioxide removal and instead focuses on lowering the global energy demand. Paradoxically, this trend does not necessarily mean halting innovation, urbanisation and digitalisation but instead, as the authors argue, could come about as a consequence of those very concepts. Currently, only 40 % of global primary energy are available to end users as useful energy [4]. Therefore, increasing energy efficiency through innovation on the one hand and anticipating transformation of consumer habits on the other hand are key elements when attempting to cut down on total energy demand. This narrative is illustrated in Fig. 1.

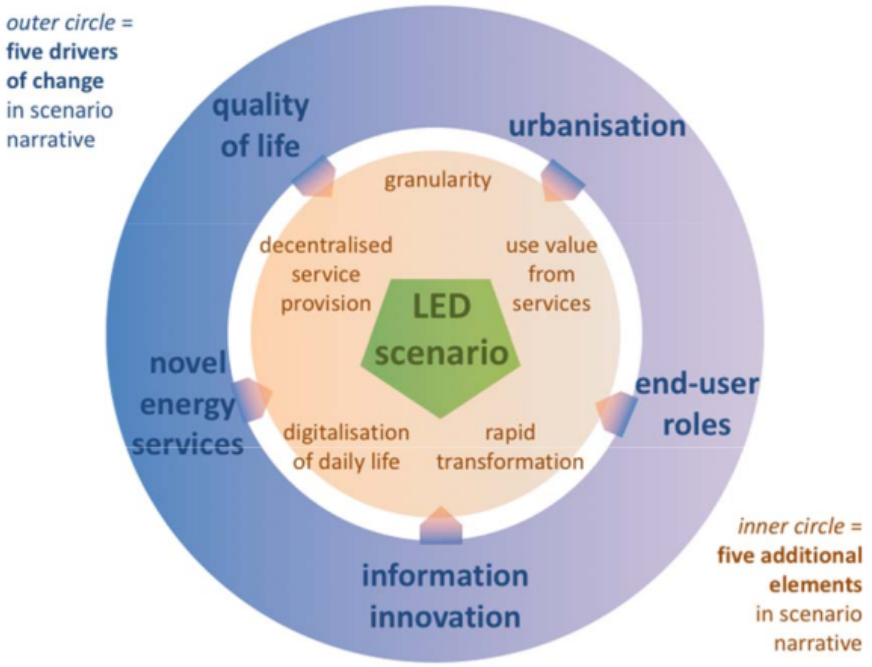

Figure 1: The LED scenario narrative: The outer circle represents the five drivers of change, namely urbanisation, end-user roles, information/innovation, novel energy services and quality of life. The argument is that advancement in these five fields naturally entails developments which can be beneficial in lowering the final energy demand (inner circle). Figure taken from [4].

In order to understand how this goal could be achieved, one first needs to recognise where our currently high energy demand comes from. In fact, close to two-thirds of final energy demand is claimed by the material industry[1], which is also responsible for 72 % of direct industry-induced emissions [1]. Lowering the energy demand in this field of industry could be achieved by acting according to the principle: ***Reduce, Reuse, Repair, Recycle***. Reducing the use of industrial materials in general, promoting inter-industry cooperation in order to reuse materials between industries, increasing the quality and extending the lifetime of products and, of course, increasing recycling of materials.

In addition to lowering the global energy demand, heeding these guidelines could also boost quality of life; for example, owning high quality products with extended lifetimes grants more satisfaction than having to buy a new product every few months. Also, the role of end-users shifting towards lending, borrowing and sharing products instead of possessing them, as shown for instance by the emerging trend of car- and bike sharing services, leads to less material use overall. This is referred to as *Dematerialization* by the authors.

Expanding on the topic of transportation, growing demand for mobility does not necessarily mean growing demand for cars. In the context of urbanisation, densely populated areas have a lower carbon footprint per capita when considering residential floor space, energy used for heating[2] and distance travelled by car. In urban areas, mobility can

[1] counting steel, non-ferrous metals, chemicals, non-metallic minerals, and pulp and paper industries

[2] In an apartment building, excess heat is transferred to adjoining apartments while a freestanding house, especially if not well insulated, emits it inefficiently into the surrounding air.

be achieved by proximity of resources, for example when supermarkets, restaurants, entertainment possibilities etc. lie within walking distance or are easily accessible by public transport. Therefore, if approached correctly, urbanisation can be an opportunity instead of a threat in battling the global climate crisis. However, resources must be administered to urban planning to face the challenges that come with designing future towns and cities: developing and deploying sustainable building materials, minimising area sealing as much as possible, designing car-free areas while still offering high accessibility through barrier-free infrastructure, proper water management and accounting for enough green spaces. Besides having a positive effect on biodiversity and quality of life for nearby residents, the latter can provide local cooling to combat the effects of future heat waves. [5]

A different aspect to transport and travel in modern times has become quite relevant in the ongoing global pandemic, namely "virtual substitution of physical travel", as phrased by Grubler et al. The past months have shown us that it is, in fact, possible to replace many in-person meetings with virtual conferences, thereby reducing ground traffic and aviation emissions. A more detailed discussion of the parallels between battling both global crises can be found here [6].

Digitalisation, like urbanisation, is another example of a "two-edged sword". While the infrastructure needed to meet the increasing demand for online services requires extensive amounts of materials and electricity, digitalisation also offers promising possibilities of increasing efficiency in many sectors. For example, smart grids make decentralised energy supply systems possible that can incorporate an increasing share of renewable energy sources. Upcoming technologies like smart homes and self-driving cars have the potential of cutting down on unnecessary emissions through avoiding redundant heating or traffic jams etc. , although there is also the possibility of a rebound effect. For example, according to the results of the research study *smart**home**rösrath*, that provided more than 120 households with smart home technology and monitored their energy consumption over the course of two years, only 57% of participants were reported to consume less energy while for the other 43% the overall energy consumption actually increased [7]. Similarly, streamlining traffic through smart technology could in fact make cars more attractive as a method of transportation and as an end result lead to more overall traffic and therefore more emissions and material use, even if they run on electricity instead of fossil fuels. As a counterargument to this, Grubler et al. bring up evidence for demand saturation (e.g. indications of "peak car travel") but admit that policies should be brought about to counteract the rebound effect.

Another point made by Grubler et al. with regard to digitalisation is that the final energy demand could be reduced through device convergence, as illustrated in `Fig`. 2. The idea of this particular example is that one smartphone incorporates the functionalities of many other devices, therefore potentially reducing the standby-energy use by a factor close to 30, while the theoretical cutback on power consumption by a factor of almost 100 is even more impressive. However, this is a rather simplified representation, since it is easy to imagine that a person might still own, for instance, a smartphone AND a TV set AND a tablet or game console. On the other hand, not everyone owning a smartphone today would have necessarily owned and used all those other devices before the smartphones were invented.

Within the narrative of the LED scenario, an increase of devices per capita (counting those providing "cooking, lighting, hygiene, entertainment, communication, and other

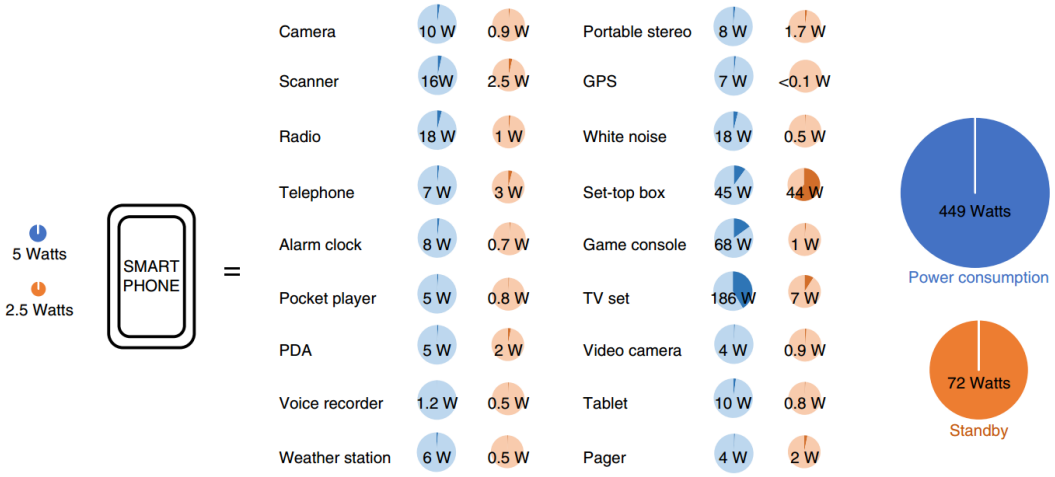

Figure 2: The authors argue that, in theory, one modern smartphone could replace over 15 different end-use devices. This is used as an example to explain reduced energy demand through digitalisation and device convergence.
Figure taken from [4].

useful services principally within the home" [4]) is still expected, with said number doubling by 2050 in the "Global North" (minority world) to 42 and tripling in the "Global South" (majority world) to 24 devices per capita. Nonetheless, these numbers are claimed to be lower than those foreseen by other scenarios, e.g. the GEA efficiency scenario, which predicted 49 and 25, respectively [8]. Even though the LED scenario anticipates a small reduction of the gap between minority and majority world in this regard, the average consumer of the minority world will still have about 175% more devices than someone from the majority world.
It should be noted at this point that during the life cycle of a device like the iPhone 11, the majority ($\approx 80\%$) of carbon emissions produced stem from the production of the device, not customer use [9]. This goes back to the high energy demand of the material industry, as explained earlier in this article. Therefore, buying a completely new device every one or two years is not feasible. Instead, granular technology should be encouraged, driven by innovation, enhancement of quality of life and end-user roles, as shown in `Fig`. 1.
The final important point concerning lowering global energy consumption is how to address increasing food demand, which is expected to rise by 70-100% globally. To achieve the goal of higher quality of life, diets everywhere must converge towards being healthier and more varied, which means increasing nutritious calorie intake for the 815 million people suffering from undernourishment while also lowering the risk of chronic diseases and obesity due to excessive and one-sided diets, which according to the authors mainly affects the population of the "Global North and increasingly [...] the affluent population segments in the Global South" [4].
In general, this means supporting diets that rely less on red meat and dairy products and are more plant-based, depending on the agricultural resources of the area. The rapidly growing population of India, for example, is expected to continue consuming a notably low amount of animal products within the LED scenario narrative (following historical trends). As a rough guide,the EAT-Lancet commission recommends in their

report on *Food in the Anthropocene* that a healthy diet from sustainable food systems and within planetary bounds should only include 250 g of dairy and 15 kcal of beef or lamb per day [10], the latter corresponding to approximately one medium-sized steak per month. These changes in diets could be achieved through an increase in consumer awareness and climate policy incentives, e.g. carbon taxes on the products associated with the highest green house gas emissions.
At first glance, the LED scenario may have seemed almost utopian in its assumptions about sustainable developments coming about as a natural consequence of progress, yet closer examination of the main points shows that many of these developments lie within the realm of the possible. However, certain policy (and consumer) changes are necessary and urgent. As the authors put it:

> "These are important, but not insuperable, challenges towards a cleaner, cooler, healthier world in which high-quality living standards are enjoyed by all." [4]

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