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Sustainability Energy: Concept and Definition in the Context of the Energy Transition - A Critical Review

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Sustainability Energy: Concept and Definition in the Context of the Energy Transition—A Critical Review

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Abstract: The term sustainable energy is very familiar to all of us yet its exact definition or meaning has so far been vague. To date the widely adopted definition of sustainable energy has been inspired by the definition of sustainable development formulated more than 30 years ago in Our Common Future - the UN's Report of the World Commission on Environment and Development. The current definition conceals the true spirit of the Report and it has some ramifications. It raises the question as to whether we have put too much emphasis on attaining the future dimension of sustainability in the middle of the situation where the energy survivability is in fact the real issue in many parts of the world. In this paper the role of energy in sustaining livelihoods of low income communities is discussed. Existing definition of sustainable energy that the whole world seems to have embraced is looked at critically and its downsides exposed. The identified pillars of sustainable energy and the associated issues is discussed and the need for an additional pillar, i.e. affordability is discussed and called for. This paper will argue that *global* definition of sustainable energy seems inappropriate and should be jettisoned and a more realistic definition should be embraced taking into account local attributes and factors. The current push for transition from use of conventional energy sources to a more 'cleaner' energy has further exacerbated the issue of energy affordability that have made the conditions even more dire for so many groups of world population. In the midst of this situation, those who push for a rushed energy transition seem to be those who also produce unsustainably high carbon footprint but who can easily offset their carbon foot-print through the 'net-zero' concept.

Keywords: affordability; energy efficiency; energy justice; energy survivability; energy transition; renewable energy; sustainable development; sustainable energy

1. Introduction

In a recent article published in the Australian Financial Review, McCubbing & Fowler [1] reported on the raise of energy affordability issue among low income Australians while in the other hand "*Wealthy Australians are buying solar panels and ordering electric cars ...* ". This is occurring in one of the World's developed countries, among the richest in terms of its natural (including energy) resources, and a member of Organisation for Economic Co-operation and Development (OECD) [2].

Energy is one of the major drivers for the sustainable livelihood of low income communities. According to Vera and Langlois [3], energy "*is vital for eradicating poverty, improving human welfare and rising living standards*." The same researchers point to the following facts all of us already aware of. That is, that "*Electricity particularly … is an important and sometimes irreplaceable input to modern productive activities, dissemination of information and other services industries*" [3], p 879.

Many other studies (e.g. [4]) have demonstrated the link between increased energy demand and rising living standard in the form of "*increased income among the poor and near poor*". Rising living standard - as they observed in developing countries - increases the need for energy consuming appliances. These new appliances function among others: to ease the physical efforts to perform daily activities (for instance: electric or gas stove) or to move from one place to another (motor vehicle), to attain thermal and visual comfort (air conditioners and lights), communication (hand phone),

entertainment (music player/recorder, television), education, etc. The above observations are good examples of how energy plays a crucial role in helping people to survive, and to some extent to start enjoying more comfortable life, and to empower them to prepare for better future.

The current push for the energy transition from "dirty" conventional energy resources to a "cleaner" energy resources can potentially threaten – or in many situations have already started threatening - the little luxury this low income community have started and are currently enjoying. Sustainability is a luxurious word for them. The energy transition push has pushed them back to the state of *survivability*.

This paper revisits the widely cited / adopted definition of sustainable energy and its pillars. It proceeds by contrasting the state of survivability with the state of sustainability of groups of people having different level of access to resources. This is followed by a detailed discussion on how the definition was formulated and its ramifications. Important elements or messages originating from the Brundtland Report [5], which inspired the definition, are resurfaced. The paper also critically looks at *horizontal* (current) as well as *vertical* (future) dimension of sustainability and contends that its current (widely adopted) definition has put too much emphasis on the vertical dimension and largely overlook the horizontal dimension with all its implications. The two sustainability paradigms are briefly discussed to give a perspective on pathways to sustainability. The identified pillars of sustainable energy and the issues associated with them are discussed. Affordability has been often neglected in the discussions of sustainable energy, and it should be formally declared and adopted as a new pillar. In dealing with immediate issues of sustainable energy, global definition seems inappropriate and should be jettisoned and a more realistic definition should be embraced taking into account local attributes and factors. The paper also critically look – albeit briefly - at energy transition, its challenges and ramification. Is the world ready for such a transition? Is a hasty energy transition the solution to the sustainable energy issue? Many seem to have been trapped into believing this, amidst the constant and consistent narrative that the earth will be soon be doomed. An unnecessary and tragic by-product of this is a new mental health issue called: eco-anxiety, defined as "*a chronic fear of environmental doom*"[6].

2. What Is Sustainability ?—Overview of current Definitions

At one stage, Oxford English dictionary [7] defined sustainability as "*the ability to be maintained at a certain rate or level*". Another definition given by the same dictionary at that particular time was: "*avoidance of the depletion of natural resources in order to maintain an ecological balance*" [7]. About 6 years later, the definition is slightly changed to: "*The quality of being sustainable at a certain rate or level*"[8]. The word sustainable is currently defined as "*capable of being maintained or continued at a certain rate or level*"[9]. Despite minor changes in wording of the definition, the meaning is essentially unchanged.

The above definition implies that the ones concerned already taste the goodness and abundance of resources which is the logical reason to sustain them. Sustainability in this context means prolonging the periods through which this state of abundance can be enjoyed. This also means that the state of abundance should be enjoyed not only by present generation but also by future generations. Sustainability second definition in [7] takes into account the impact of resources extraction on the environment.

The level of energy consumption per capita in developed world is many times that in the developing world, making it relevant or imperative to approach the situation using the term *sustainability*. This is in stark contrast with the situation in developing world (and even within certain groups in developed world) where people are still in the state / stage of very limited energy consumption mainly to sustain their very basic lifestyle. For these groups of people and communities, *energy for survival* or *energy survivability*, may be the more appropriate term to depict their energy consumption affair. *Survivability* implies the existence of threats and or emergency situation. There are many examples of such threats that are part of our daily lives, or the lives of many groups of communities.

In the tropical region, many communities are used to live in and survive persistent hot and humid air (also called: thermal discomfort) and this seems to have largely been dismissed as "*normal*",

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"*that's how people live in the tropics … !*". However, anecdotal observation seems to point to the different or interesting reality. Malls and shopping centres are filled with people from all walks of life enjoying being there as long as they possibly can. They may not buy a thing, but they enjoy being there. Why ? There are many reasons, but one should not overlook the fact that at malls or shopping centres, people feel thermally comfortable, air is cooler and drier – enabling peoples' body heat to dissipate, which has been explained thermodynamically and confirmed by an earlier study of thermal comfort [10]. They enjoy more space there as opposed to when they are in their houses or sheds. They also experience audio and visual comfort in there from adequate lighting levels and generally lower decibel noise, plus musical entertainment.

The above anecdotal observation seems to have been confirmed by a International Energy Agency (IEA) report which observed that homeownership of air conditioning (AC) systems is directly related to the people's income and economic development [11]. The same report also noted the faster increase of AC systems ownership in "*hottest and most humid countries*". The natural adjustments such as observed in [12] therefore can be considered as "*merely a delayed pursuance of real thermal comfort due to economic unaffordability*" [13] and cannot simply dismissed as *normal* or *natural*. In other words, people of low income level are as eager as people of high income when it comes to pursuing various kinds of comfort, including – in this case – thermal comfort. This explains why simplistic but seemingly scientific approach to various kind of human subjective comfort – such as thermal comfort [14] – should be revisited.

These examples of pursuit of this little free luxury show how people endeavor to escape the survivability state in open air and in their own homes and want to enjoy a more comfortable state of life. Unfortunately, for so many people, such a little luxury can only be found in the commercial buildings, malls and shopping centres. And so, when these people want to escape all these kinds of discomfort, they have to go to these crowd-attracting places.

Recurring physical and psychological inconvenience or discomfort due to hot or cold weather, heavy rain, flood, traffic jam etc. are still commonplace in many parts of the world, and therefore *survivability* is in fact their main concern. To these groups of people, the new term "*climate crisis*" or "*climate emergency*", a term coined by people who may never experience the state of survivability, is in fact a daily reality, and not necessarily due to the impact of *climate change* or *global warming* but due to their inability to afford creating their own comfortable climate chamber in the form of more energy efficient house and more efficient appliances. In these circumstances, the term sustainability is simply irrelevant. It is the survival of this people that is at stake. In such a circumstances, vertical (future) dimension of sustainability is irrelevant; and it is the horizontal dimension (present generation) which is often ignored.

Since - as mentioned above – energy plays a crucial role in sustaining comfortable life, the currently very low energy consumption level per capita of the majority of people living in developing world – and in low income community in developed world - must be raised to a more acceptable level, not just let staying at the *survivability* level.

Table 1 summarises the issues regarding the terms *sustainability* and *survivability*. As shown, the people in the *sustainability* group (those very much concerned with sustaining their existing enjoyment of current resources and wishing to pass them to future generations) are enjoying the state of abundance, they also enjoy overconsuming of resources and generating more wastes. On the other extreme, the *survivability* group is struggling with all kinds of scarcity (housing, food, energy, water supply, etc.). They may have untapped resources in their vicinity, but their consumption level of resources and services is often less than they deserve as human beings.

Table 1. "Sustainability" vs "Survivability" Group.

"Sustainability" Group	"Survivability" Group
State of abundance	State of scarcity
Over-consumption	Under-consumption

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Waste	Waste
Environmental degradation (mainly due to over consumption and waste)	Environmental degradation (due to lack of technologically sound means of mining, tapping, processing and utilising the resources)

Both groups of course are posing degrading impact on environment but for different reasons. The *sustainability* group impacts on the environment are due to overconsumption and associated waste. The survivability group on the other hand, creates environmental degradation due to the lack of technologically sound and economic means of *mining*, *tapping*, *processing* and *utilising* the resources.

3. A Critical Look at Existing Definitions of Sustainable Energy

In a report on *Energy Efficient Design* - quoting the Brundtland commission report [5]- Ambrose et al. [15] presented the sustainable energy definition as:

"*Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs (Brundtland Commission, 1987).*" (The underlined words are from the author o this review paper).

A definition similar to [5,15] can be found in the document prepared by Lemaire [16] called "Glossary of Terms in Sustainable Energy Regulation" which reads: "*Sustainable Energy: Effectively, the provision of energy such that it meets the needs of the future*[1] *(present) without compromising the ability of future generations to meet their own needs. (See Sustainable Development). Sustainable Energy has two key components; renewable energy and energy efficiency.*"

The definitions of sustainable energy in [15,16] are essentially an adoption of definition of sustainable development from Brundland commission report [5] with the word 'energy' replacing the word 'development'. Many other scientific articles and reports online (or printed texts) adopt the same definition.

Two keywords in this definition need special attention, namely: *present generation* and *compromise*. The *present generation* should mean: - all people living currently in this very planet, with no exception. However, as mentioned earlier the needs of the majority of this present generation have not been met, they have not been satisfied. In other words, the needs of the majority of the present generation have been already or currently being *compromised*. In short, to date the horizontal dimension of sustainable energy has largely been ignored and the focus has been on the vertical dimension. This can easily be explained through the fact that energy policies at national and global levels have largely influenced – if not directed or controlled – by the previously mentioned *sustainability* group.

Only through the acknowledgment of this situation and making a concerted effort to improve it can the noble goal of sustainability be achieved. Unfortunately, the current definition does not seem to have adequately addressed this very concern; hence, it needs critical review and revision. This presentation does not attempt to present an alternative to existing definition; however, it will draw attention to a number of elements found in the Brundtland Report [5] which should be conveyed in the new (revised) definition.

4. How Was Sustainability "Defined" in Brundtland Report?

The document from which some words were adopted to formulate the sustainable energy definition is titled "Our Common Future" [5] and is the Report prepared by the World Commission on Environment and Development of the United Nations. This report is popularly known as the Brundtland Report, named after the Gro Harlem Brundtland who chaired the commission and who wrote the foreword for the Report.

[1] The word "future" here was probably meant "present".

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The Report consist of an Overview titled: *Our Common Future - From One Earth to One World and the Main Report Our Common Future*. Both the Overview and the Main Report contain the words that appear in the Sustainable Energy definition being discussed.

The first heading of the Overview of the Report contains a sub-heading "3 Sustainable Development" which consists of four paragraphs, i.e. paragraph 27 – 30. As shown, the first sentence of first paragraph (p. 27) contains a group of words "*meets the needs of the present without compromising the ability of future generations to meet their own needs*" that are employed to define the term *sustainable development* as we know today. And this definition was also directly borrowed to define the term *sustainable energy* as we know today.

Unfortunately, the current definition of sustainable energy ignores the important aspirations and messages contained in paragraph 28 – 30 of the Report shown in Table 2.

Table 2. Main Elements of Sustainable Development in Brundtland Report (1987).

No	Message
1	sustainable development requires "*meeting the basic needs of all and extending to ALL the opportunity to fulfil their aspirations for a better life*."
2	that endemic poverty "always be prone to ecological and other catastrophes."
3	that the Report requested that the poor "*get their fair share of the resources*" to sustain economic growth"
4	sustainable development entails political systems that secure *effective citizen participation in decision making* and by greater democracy in international decision making
5	that sustainable global development "*requires that those who are more affluent adopt life-styles within the planet's ecological means - in their use of energy, for example*."
6	that "*painful choices have to be made*."
7	that "*sustainable development must rest on political will*."

The explicit definition of the sustainable development is presented in the first sentence of first paragraph 1 of Chapter 2: Towards Sustainable Development:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
- the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

The main elements - the main spirits of the Report regarding sustainable development – are missing from the sustainable energy definition that have been embraced today. Without further elaboration, all the 7 elements listed in Table 2 can hardly be seen as having been implemented in any policies at any level after the publication of this Report. Perhaps one exception to this statement is in regard to element 6. It is not an exaggeration to say that almost all "*painful choices*" being made / implemented compromised the needs of the majority of present generation who are in the survivability state / group: rising energy bills, deprivation from basic energy needs, etc.

5. Attempted Revision of "Sustainable" Definition

There are a number of attempts to redefine the sustainable energy. One such attempt was by Tester et al. [17] who proposed the following definition: "*A dynamic harmony between the equitable availability of energy-intensive goods and services to all people and the preservation of the earth for future generations*".

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This new definition, however, has not yet gained widespread attention. On the positive side, people has started being familiar with the inspiring terms such as *energy justice* [18] and *climate justice* [19].

While the current definition of sustainable energy – inspired by Brundtland Report - talks about the need of current generation (horizontal dimension) as well as the need of future generation (vertical dimension), it lacks the detail or clarity as to how that needs – especially of present generation - be satisfied. This lack of detail or clarity may have been the main cause of controversies in energy policies formulated at national, regional and global levels.

6. Pillars of Sustainable Energy

Having discussed the main drawbacks of the current definition of sustainable energy, it is worth looking at its pillars or main components. Researchers have identified energy efficiency and renewable energy as the twin pillars of sustainable energy [20]. The reasoning behind this is as follows. Assuming no economic growth, energy efficiency will slow down the growth of energy demand. However, economic growth is always needed, and therefore energy efficiency alone will not curb the energy demand; in fact, it provides stimulus to increased energy demand. An increased renewable energy uptake is aimed to reduce the reliance on fossil fuel, which is still the main sources of energy. In existing systems, energy efficiency will make better use of renewable energy in terms of its reduced system size and cost.

In order to reach that *ideal* situation, significant investment is required to improve the energy efficiency and renewable energy technologies. For the latter, there are a number of solar technologies such as discussed in [13] which have limited technical and commercial viability due to their inherent technological drawbacks. In another instance, energy efficiency performance of a solar energy system was ignored in its rating methodology whose main aim is to boost the renewable energy production [21–23]. In addition, not every region has good renewable energy resources. As a result, in general, prior to the technology maturity the cost of such systems is economically prohibitive. Which is why in many cases - where massive government intervention is required to significantly increase the uptake of renewable energy - subsidy is inevitable. To date in many cases the subsidy has been enjoyed mainly by those who can afford to install the renewable systems.

A little more than 40 years ago, a *Global Power Grid* in which renewable energy would play the main role was proposed [24]. A recent review on the possibility of this idea within Australian – Asian region [25] was to some extent inspired by this grand vison. While this intercontinental grid connection is technically viable, economic, social, political, and managerial challenges are almost insurmountable, at least for the foreseeable future [25].

The omission of the 'affordability' [26,27] as a pillar has mixed results so far; on the one hand the technology advancement gives rise to technological innovations and reduced price of renewable energy systems. But this has come at the expense of low income communities suffering from escalating energy prices. In case of Australia, for instance, affordability has made solar power an option only for middle to high income households, with low income left behind [28] with increased energy bills.

Even those who can afford and already installed renewable energy systems, in this case rooftop solar PV systems, their dream of much low energy bills are already shattered by decreasing feed-in-tariff for the energy production they export to the grid, currently at $0.05/kWh or less [29].

For households that intend or already installed rooftop solar PV system, Saman [29] discussed a number of practical methods to maximise the savings. These include: (1) use of efficient appliances, (2) running appliances during times of high solar radiation, (3) choosing a retail electricity plan that best matches the need. While the first two approaches are implementable, they may not all practicable due to technical and economic reasons for some of the system owners. While it is true that energy efficient appliance will reduce energy consumption in some circumstances, it may actually boost energy consumption in other situation, especially for those people with high income where energy efficiency measures will enable them to explore and enjoy further kinds of comfort. This is of course against the appeal made in the Brundtland Report [5] which urges people "*who are more affluent*" to

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"*adopt life-styles within the planet's ecological means - in their use of energy ...*" Households also do not have much choice in terms of "retail electricity plan". Energy retailers keep adjusting their profit margin amidst aggressive penetration of solar rooftop systems on the grid.

A relatively recent study conducted on energy consumption among low income earners [30] indicated that because of their already very low energy consumption level, further reduction in energy consumption could result in compromise of their (thermal) comfort. This is inline with the survivability state discussed in Section 2.

This brief discussion should now help clarify why renewable energy should not always be associated with sustainability. The Brundtland report [5] use the term *sustainable form of renewable energy* which implies that some of renewable energy resources and systems cannot be sustainable alternative to conventional energy sources / systems. Without formal declaration by energy policy decision makers to add *affordability* as the third pillar of sustainable energy, the role of renewable energy in sustainable energy transition are limited. In fact, for the sustainable energy definition to properly work to avoid *compromising* the needs of low income groups of the present generation, economic affordability must be the pillar that need to be highlighted at decision making level. This can only be addressed if sustainability is formulated at the national or country level, *not* at the global level, where the voices of those whose need are hardly heard and often compromised. The beautiful and inspirational wording of the Brundtland Report is a direct witness to this observation and assertion.

7. Sustainability, (Un)sustainable and (Un)just Energy Transition

Energy transition concept is perhaps as old as the history of mankind. Energy is crucial to human survival; and, as human knowledge improves, the ways energy are produced from various sources and utilised constantly change, in line with human technological advancement. Hence, naturally, energy transition has been an integral part of human civilization.

In the current discussion, however, we should focus our attention to the energy transition being pushed globally by the world institutions – notably institutions under the umbrella of United Nations (UN). In this context, energy transition has been defined as "*a continuing process requiring long-term energy strategies and planning, with a country-tailored focus on applying appropriated energy technologies to reach net-zero emission*" [31]. Net-zero emission means "*achieving an overall balance between greenhouse gas emissions produced and greenhouse gas emissions taken out of the atmosphere*" [32].

On paper, this definition is quite appropriate; it emphasizes the role of individual country in choosing appropriate technologies to reach the "net-zero emission". In reality, however, the push for energy transition is practically associated with proposals for total abandonment of conventional fossil fuel resources and accelerated switch to renewable energy sources deemed to be cleaner. This happens at COP28 meeting in Dubai where some countries want the COP28 draft to include the words: *phase-out* [33]. It can also be observed that this UN-led annual forum is not a very effective forum to discuss let alone to come up with the solution to the impact of the so-called climate change. This is evidenced by several declarations during the forum from various groups representing countries with common interests on the particular matter [34].

Fossil fuels have been playing a crucial role in raising community living standard in many parts of the world. In essence, these poor communities cannot go without fossil fuels which they need to transport their products to the nearby community markets, to operate their fishing boats, to go to the town a few kilometers from their village to buy household needs, or simply to ease their physical burden by cooking using kerosene stoves, etc. An article in an UN Chronicle [35] conveys some invaluable points in relation to emission reduction which are still relevant today. These include: (1) emission reduction should not mean abandonment of fossil fuels, (2) inline with the arguments laid out in Section 6, energy efficiency and renewable energy are not sufficient, (3) there are many energy systems that cannot simply be replaced by renewable energy systems, (4) the aggressive push to phase-out fossil fuels will not be considered a reasonable solution by developing countries that have untapped fossil fuel resources.

In short, in its implementation, energy transition should always be inspired by the noble ideas breathed into the discussion and definition of *sustainability* in Brundtland Report [5] to avoid unsustainable and unjust transition.

8. A Brief Note on the Urgency to Act "Now"

From the author's anecdotal observation, there are at least three reasons why some people are skeptical about the urgent call to act "now" in relation to actions to minimise the impacts of climate change or global warming. *First*, there seems to be a personal anecdotal observations or thoughts that point to the fact that the impacts of the so called global warming may not necessarily be always disastrous. For instance, a rather warm temperature may in fact benefit the people in colder climatic zone – especially the low income group - in terms of reduced heating energy requirements. These are the present generation mentioned in the Brundtland Report [5] whose need is being compromised by practically all policies on climate change, global warming, sustainable energy and energy transition. This is inline with Gates' own experience and observation [36], p.26.

Secondly, there seems to be *business as usual* among people who are in the forefront of the campaign against the impact of climate change / global warming. For instance, Gates admitted that his "*carbon footprint is absurdly high*" [36], p.14 although he pledged to be caron neutral in 2021 [36], p.15. Another very relevant and related example is annual events discussing climate change which create significant amount of carbon footprints (CF) [37]. Using common sense, people can easily make a comparison between the CF of those who travel to attend such a meeting with the CF of those who live in the condition of survivability (see Section 2) on a daily basis, who have no fridge on their kitchen, who also do not add environmental burden to nature by opening the cans of their refreshing drinks, whose children travel few kilometers daily to reach school to prepare for their future. Again, these are the group of people classified in the Brundtland sustainability definition as present generation whose needs are being compromised on a daily basis! On the positive side, despite their survivability struggle on daily basis, they and their children do not suffer the new mental health disease of the 21st century: the eco-anxiety, in which those who are suffering from it see no future for them perhaps because they think the water level will reach their neck or that they could not cope with the unbearable heat even though they currently enjoy comfortable life in their air-conditioned house. These two examples fail to show the lead to the way to avoid the so called climate disaster.

Thirdly, the mainstream narrative has been on *mitigation* while the other option – the *adaptation* – has been largely overlooked. It is interesting or, rather, surprising that Gates [36] who advocated mainly for the mitigation option failed to refer to a book who advocated for adaptation [38] that was published earlier. Since energy transition will impact all humanity, it is a common sense to expect that all the stakeholders – including experts with opposing opinions - should consider as many options as possible before adopting the most viable option(s) technologically, economically, socially, and environmentally.

Skepticism discussed above should not be construed as *burying the head in the sand* attitude; rather, it should be considered as positive contribution towards identifying / establishing more sustainable pathways that avoid compromising the need of current generation – especially those who are in the *survivability* state. This kind of skepticism, the author believe, is much more valuable and constructive than the alarmist attitude that has caused some people to suffer eco-anxiety. This new mental health issue would have not come into being had the so called *climate experts* come up with more careful statements which can be easily misunderstood by public. Credit should be directed to Gates [36] who admitted that climate science, our knowledge about how climate 'is changing' is far from being settled [36], p.24. Unfortunately, such honest statements or acknowledgements will never be as *viral* as the alarmist news the public watch on television or social media platforms on daily basis.

9. A Brief Note on Complexity of Climate Modelling/Forecasting

The main reason for our limited understanding of the climate, according to Gates, is that it is "*mind-blowingly complex*". Our tools to study such complexity are computer models which are "*far*

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from perfect" [36], p.24. And in order to gain a little grasp of what is going on in such a complex scientific object, experts make many simplifying assumptions. Assumptions made by researchers or experts should also make them humble and every time they go public with their scientific findings they should not forget to remind public about the limitations of their findings. On the other hands, public should always be warned about limitations of science; in fact, they should always start with skeptical attitude [39]. This is not to dismiss science as *lacking value* or *lacking credibility*; rather – on the contrary – it makes the science stronger as it is built on more solid foundation. Those interested in climate models should refer to [40] whilst recent IPCC Report on climate change discusses in detail its impact, human adaptation and vulnerability [41].

10. Who Should Define the Sustainable Energy?

It is clear that "global" definition of sustainability (including in this case the sustainable energy) is practically irrelevant, potentially prone to misuse and abuse and in fact can prolong the "survivability" period for some groups of people. A more realistic approach is to define the term with local attributes and factors taken into account. After all, it is the local prevailing conditions that dictate the options or paths to sustainability. Therefore, rather than entirely focus on "future", there should be a concurrent effort to look for solutions to the following challenges or issues:

Firstly, the empowerment of *survivability* groups to get better access to more "reasonable" level of enjoyment of resources. One of recent examples of potential success of this approach comes from fishery. According to a research [42], securing fishing rights to and rebuild traditional small scale community fisheries around the world could recover the global fish populations to a healthy level. Such an approach could be adopted to energy sector. After all, the uncertainty of secure supply of energy to the majority of people who are at stage of survivability often leads to "self-initiative" of exploiting whatever resources available at hand at the expense of the environment. In that case, not only future generation of that community who are at risk but also themselves. Therefore, the key solution to this problem is to provide them at least the basic needs that enable them to improve their own quality of life. This of course rests on the political will of those in decision making positions.

Secondly, to look for more "rational" pathways of exploitation and sharing of resources for the benefit of present and future generations. Sustainability is viewed from two opposing paradigms, namely: the "weak sustainability" paradigm and the "strong sustainability" paradigm [43,44]. The tenet of the "weak sustainability" paradigm can be summarized as follows: future technology will take care of the needs of future generation. In this paradigm, the issue of scarcity is "*resolved through substitutability between natural capital and human made capital*". On the other hand, the "strong sustainability" asserts that not all the natural capital are substitutable – some parts need to be preserved [44]. On paper, the weak sustainability looks like focusing on the needs of the present and 'forget' about the needs of the future generations and trusting these needs into the hands of "backstop technology" ([45] as cited in [46]). However, given the issues currently being faced by the developing world in their effort to provide adequate level of energy to their people and to maintain or boost the momentum of their development, their emphasis on the caring of the present generation is logically and reasonably understandable.

This paper does not attempt to delve further into these two competing sustainability paradigms. However, it is worth noting the interesting discussions on this topic through the emergence of *entropy* (and the *Second Law of Thermodynamics*) concept into the thinking of sustainability theorists such as [44,47].

Who then should define the (energy) sustainability? This shall be the scope for political decision at national and regional levels. Inputs from academia is central to the proper formulation of the term at the political level. Unfortunately, it seems, many decision makers often simply chose experts, i.e. those who provide them expert advice to enable them formulate policies - in this case on energy transition and sustainable energy - *at random*. An article written by Sutherland and Burgman [48] discussed how these advisers "*make judgements and predictions*". According to this article, due to various '*cognitive frailties*' such as "*experts' values, mood, whether they stand to gain or lose from a decision, and by the context in which their opinions are sought*" their expert advice may not be always accurate or

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reliable. The policy makers should be aware of all the above frailties when choosing the most reliable expert advice and avoid being "*starstruck*" by expert seniority, publication record (with its own very real issue with the flawed process [49]), memberships of various scientific or professional bodies, etc. [48].

In a nutshell, the decision makers should be aware that advice they receive from the experts they choose may not be necessarily the best advice from the field due to various several factors mentioned above. In addition, in any scientific field, scientific opinions can vary within the broad spectrum. For instance, in carrying out cost-benefit analysis of a renewable energy system, intermittency and required storage capacity – which can be expressed in a word: *reliability* - have become a matter of dispute between those who favor such a system and those who are skeptical or against it [50,51]. In such a controversial scenario, it is unwise for any decision maker to simply take side *at random*. A wiser approach would be: to invite the experts with opposing scientific views to present their respective opinion. This may not result in a consensus but at least it will help the decision makers to *take side* more wisely and convincingly.

11. Conclusions and Recommendations

1. Energy is one of the major drivers for the sustainable livelihood of low income communities. Lack or limited access to energy makes this group vulnerable and stuck to the state of survivability. Their seemingly very natural adaptation to harsh environment such as hot or cold weather should not be considered 'normal', as if they do not deserve a more comfortable conditions like others with easy access to abundant resources, including energy.
2. Current definition of sustainability, including energy sustainability, has practically betrayed the spirits of the Brundtland Report from which the definition originated. Many elements, aspirations and noble messages of the Report have essentially been overlooked, resulting in the needs of the majority of present generation being compromised. This can be explained among others by the fact that almost every energy policy at local, national and global levels hardly mentions *energy affordability* as the third pillar of energy sustainability.
3. Energy policies at every level so far have benefitted those people in the *sustainability group* who have already tasted the goodness and abundance of resources which seems to be the reason why this group is in the forefront in demanding *concrete actions on sustianabilty*. The benefits includes subisidies to various energy systems which are still a luxury for the *survivability* group.
4. Contrary to common perception / believe, renewable energy is not always identical to a pathway to sustainability. Intermittency, reliability, geographical conditions and associated cost are among the drawbacks in adopting these type of energy sources.
5. As the energy affairs of nations and regions are greatly diverse and complex, the global definition of (energy) sustainability is totally unjustifiable. A definition that takes into account the local context is more realistic, desirable and bring more fairness to the present generation whose needs are being compromised on daily basis and who are at constant predicament of survivability.
6. The is no energy policy decision without social and economic consequences; yet, in majority of cases, it is the poor who suffer a lot, at least at the initial stage of the technological advancement. Question to be answered and reflected on will then be: should we continue to follow this classic path in our common goal of attaining sustainability?
7. Our knowledge as to why and how climate changes is far from settled. It is a very highly complex scientific object. To study such a complex phenomenon scientists rely heavily on computer models which are far from perfect. Scientists who work on these highly complex scientific objects have to make many simplifying assumptions whose ramifications on the modelling outcomes cannot be easily quantified. As such, the political decisions based on this is very vulnerable to unpredictable error with unpredictable impacts. Therefore, it is crucial that any advice coming from the so called experts in this field has to be further schrutinized. Such a scrutiny mechanism needs to be established and should consist of experts from multidiscpilinary scientific backgrounds, including those opposing the mainstream scientific narratives.

8. Energy transition has been an integral part of human civilsation and as such it is inevitable. However, hasty transition without properly considering all factors can potentially lead to more serious disaster than disasters that are supposed to be avodied.

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References

1. McCubbing, G., Fowler, E. Energy affordability exposes brutal divide between rich and poor – an article in Financial Review published on 2 February 2023 - https://www.afr.com/companies/energy/energy-affordability-exposes-brutal-divide-between-rich-and-poor-20230202-p5chex (Accessed on 6 December 2023).
2. Australia and Oceania: Resources: - https://education.nationalgeographic.org/resource/oceania-resources/ - (Accessed on 30 November 2023).
3. Vera, I.; L. Langlois. Energy indicators for sustainable development. *Energy* **2007,** 32(6): 875-882.
4. Wolfram, C; Shelef, O; Gertler, P. How Will Energy Demand Develop in the Developing World? *J. Economic Perspectives* **2012**, 2691, 119-138.
5. Brundtland Report, 1987 - The World Commission on Environment and Development - Our Common Future. Oxford: Oxford University Press.
6. Dodds, J. The psychology of climate anxiety. *BJ Psych Bulletin* ***2021***, 45, 256–256, doi:10.1192/bjb.2021.58
7. Oxford English Dictionary online - https://en.oxforddictionaries.com/definition/sustainability accessed 30 August. 2017.
8. Oxford English Dictionary online - https://www.oed.com/search/dictionary/?scope=Entries&q=sustainability – Accessed 30 November 2023.
9. Oxford English Dictionary online - https://www.oed.com/search/dictionary/?scope=Entries&q=sustainable - Accessed 30 November 2023.
10. Fanger, P.O. *Thermal Comfort: Analysis and Applications in Environmental Engineering*; McGraw Hill Book Company: New York, NY, USA, 1970.
11. Dean, B.; Dulac, J.; Morgan, T.; Remme, U.; Motherway, B. The Future of Cooling: Opportunities for Energy-Efficient Air Conditioning; International Energy Agency: Paris, France, 2018. https://www.iea.org/futureofcooling/ (accessed on 20 December 2021).
12. Feriadi, H.; Wong, N.H. Thermal comfort for naturally ventilated houses in Indonesia. *Energy Build*. ***2004***, 36, 614–626.
13. Halawa, E.; Bruno, F. Energy Performance and Thermal Comfort Delivery Capabilities of Solid-Desiccant Rotor-Based Air-Conditioning for Warm to Hot and Humid Climates—A Critical Review. *Energies* **2023**, 16, 6032. https://doi.org/10.3390/en16166032.
14. Halawa, E.; van Hoof, J. The adaptive approach to thermal comfort: A critical overview. Energy Build. 2012, 51, 101–110.
15. Ambrose, M.; Delsante, A; Miller, A.; Tucker, S.; Bell, J.; Demirbilek, N.; Mead, N.; Wales, N. Research Project No: 2002-063-B-02 Final Report Sustainable Subdivisions – Energy Efficient Design - Cooperative Research Centre for Construction Innovation, Brisbane, 2004.
16. Lemaire, X. Glossary of Terms in Sustainable Energy Regulation - REEEP / Sustainable Energy Regulation Network – August 2004 - Revised September 2010 – Renewable Energy & - Efficiency Partnership – http://www.reeep.org/sites/default/files/Glossary%20of%20Terms%20in%20Sustainable%20Energy%20Regulation.pdf - p. 10. – no longer available at the time of finalization of this manuscript, but was accessed around 2017.
17. Tester, J.W.; Drake, E.M.; Driscoll, M.J.; Golay, M.W.; Peters, W.A. Sustainable Energy – Choosing Among Options – Second edition – The MIT Press. 2012, p. 10.
18. Jenkins, K.; McCauley, D.; Heffron, R.; Stephan, H.; Rehner, R. Energy justice: A conceptual review. *Energy Research & Social Science*. **2016**, Vol. 11, 174-182.
19. Robert, J.T.; Parks, B.C.;: Ecologically Unequal Exchange, Ecological Debt, and Climate Justice - The History and Implications of Three Related Ideas for a New Social Movement. *Int. J. of Comparative Sociology*. **2010**, vol. 50(3–4): 385–409 - DOI: 10.1177/0020715209105147.

20. Prindle, B.; Eldridge, M.; Eckhardt, M.; Frederick, A. The twin pillars of sustainable energy: synergies between energy efficiency and renewable energy technology and policy. ACEEE Report Number E074. 2007.
21. Commonwealth of Australia (Department of Industry). Product profile: solar hot water heaters. Commonwealth of Australia (Department of Industry) eEquipment Energy Efficiency (E3) Committee; 2014 [, http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Product_Profiles/Water_Heating/Solar_Hot_Water/Product-Profile_Solar-Water-Heaters_August-2014.pdf. This document was accessed on 7 November 2014 for the preparation of paper in Ref [22]. It is no longer available.
22. Australian Government. Solar water heaters e MEPS and labelling requirements. 2014. Energy Rating website, http://www.energyrating.gov.au/products-themes/water-heating/solar-water-heaters/meps-and-labelling/. This document was accessed on 14 November 2014 for the preparation of paper in Ref [22]. It is no longer available.
23. Halawa, E.; Chang, K.C., Yoshinaga, M. Thermal performance evaluation of solar water heating systems in Australia, Taiwan and Japan - A comparative review. *Renewable Energy* **2015**, 83,1279-1286.
24. Fuller, R.B. Critical Path; St. Martins Press: New York, NY, USA, 1981.
25. Halawa, E.; Shi, X; Nepal, R.; Sari, N.H.; James, G. The Prospect for an Australian–Asian Power Grid: A Critical Appraisal. *Energies* **2018**, 11, 200; doi:10.3390/en11010200.
26. Halawa, E. Penalty-reward-pinch (PRP) design for improving sustainability of existing commercial buildings – Chapter 3.1 in: Sustainable retrofitting of commercial buildings – Warm Climates – edited by R. Hyde, N. Groenhout, F. Barram and K. Yeang. Earthscan – Routledge – Taylor and Francis Group, 2013.
27. Lee, M.; Park, D.; Saunders, H.: Asia's Energy Adequacy, Environmental Sustainability, and Affordability: An Overview - ADB Economics Working Paper Series no 398 - Asian Development Bank, 2014.
28. Linnenluecke, M.; Marrone, M.; Best, R. Solar power can cut living costs, but it's not an option for many people – they need better support. – *The Conversation* 2023- https://theconversation.com/solar-power-can-cut-living-costs-but-its-not-an-option-for-many-people-they-need-better-support-201090 - accessed 30 November 2023.
29. Saman, W. How to maximise savings from your home solar system and slash your power bills, The Conversation 2023. https://theconversation.com/how-to-maximise-savings-from-your-home-solar-system-and-slash-your-power-bills-197415 - Accessed 21 November 2023.
30. Trombley, J., Halawa, E. Can further energy reductions be achieved through behaviour changes in low income households? - *Energy Procedia*. **2017**, 121, 230 – 237.
31. Energy Transition. – United Nations Development (UNDP) Website: https://www.undp.org/energy/our-work-areas/energy-transition , Accessed 7 December 2023.
32. What does net zero emissions mean? - Climate Council Website: https://www.climatecouncil.org.au/resources/what-does-net-zero-emissions-mean/ - Accessed 13 December 2023.
33. COP28 climate talks go into overtime amid standoff over fossil fuels - https://www.aljazeera.com/news/2023/12/12/cop28-climate-talks-go-into-overtime-amid-standoff-over-fossil-fuels - Accessed 2023.
34. Summary of Global Climate Action at COP 28 – https://unfccc.int/documents/636485 – Accessed 13 December 2023.
35. Foster, S.; Elzinga, D. The Role of Fossil Fuels in a Sustainable Energy System - *UN Chronicle* **2015**, No. 3 Vol. LII, Sustainable Energy - https://www.un.org/en/chronicle/article/role-fossil-fuels-sustainable-energy-system - Accessed 13 December 2023.
36. Gates, B. How to Avoid a Climate Disaster. Allen Lane, 2021.
37. Greenpeace International website. Davos revealed, as global leaders head into World Economic Forum - https://www.greenpeace.org/international/press-release/57867/hundreds-of-ultra-short-private-jet-flights-to-davos-world-economic-forum/ - Accessed 7 December 2023.
38. Lomborg, B. False Alarm: How Climate Change Panic Costs Us Trillions, Hurts the Poor, and Fails to Fix the Planet, Basic Books, 2020.
39. Dove, S. Assumptions of science: 5 reasons you should be skeptical. - https://www.shawndove.com/assumptions-of-science/ - Accessed 7 December 2023.

40. Flato, G.; Marotzke, J.; Abiodun, B.; Braconnot, P.; Chou, S.C. ; Collins, W.; Cox, P.; Driouech, F.; Emori, S.; Eyring, V.; Forest, C.; Gleckler, P.; Guilyardi, E.; Jakob, C.; Kattsov, V.; Reason, C.; Rummukainen, M. Evaluation of Climate Models. 2013 In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
41. IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.
42. Costello, C.; Ovando, D.; Clavelle, T. Global fishery prospects under contrasting management regimes, *PNAS*, **2016**, vol. 113 no. 18, 5125–5129.
43. Kuhlman, T.; Farrington, J. What is Sustainability? – *Sustainability* **2010**, 2, 3436-3448; doi:10.3390/su2113436.
44. Săveanu, M. Energy and the economics of sustainability. The entropy Paradox. *Management of Sustainable Development*. **2014**,Vol. 6(1), 1-5. - DOI 10.2478/msd-2014-0002.
45. Dasgupta, P.S.; Heal, G.M. Economic Theory and Exhaustible Resources, Cambridge: Cambridge University Press, 1979 – as cited in [42].
46. Levy, A. From Hotelling to Backstop Technology, Department of Economics, University of Wollongong, 2000 https://ro.uow.edu.au/commwkpapers/25/ - Accessed 13 December 2023.
47. Fleissner, P.; Hofkirchner, W. Entropy and Its Implications for Sustainability - In: Dragan, J.C., Demetrescu, M.C., Seifert, E.K. (Eds.), Implications and Applications of Bioeconomics, Proceedings of the Second International Conference of the E.A.B.S., Palma de Mallorca, 1994, Edizioni Nagard, Milano 1997, 147-155.
48. Sutherland, W.J.; Burgman, M. Use experts wisely. *Nature*. **2015**, Vol. 526, pp. 317 – 318.
49. Smith, R. Peer review: a flawed process at the heart of science and journals. *J R Soc Med.* **2006**, 99(4): 178–182; doi: 10.1258/jrsm.99.4.178.
50. Younis, A.; Benders, R.; Ramírez, J.; de Wolf, M.; Faaij, A. Scrutinizing the Intermittency of Renewable Energy in a Long-Term Planning Model via Combining Direct Integration and Soft-Linking Methods for Colombia's Power System. Energies 2022, 15, 7604. https://doi.org/10.3390/en15207604.
51. Antonini, J. Nuclear Wasted: Why the Cost of Nuclear Energy is Misunderstood. The Mackinac Center Website - https://www.mackinac.org/blog/2022/nuclear-wasted-why-the-cost-of-nuclear-energy-is-misunderstood. Accessed 18 December 2023.