POLICY BRIEF #26

ENERGY PATHWAYS TOWARD SUSTAINABLE FUTURES TO 2050 AND BEYOND

Developed by:

International Institute for Applied Systems Analysis

12TH FEBRUARY 2018

DRAFT FOR PUBLIC CONSULTATION

This document is a part of a series of Policy Briefs being developed to support SDG7 review at the UN High-Level Political Forum to be held in July 2018. The objective is to inform intergovernmental discussions by providing substantive inputs on SDG7 and its interlinkages with other SDGs prepared through inclusive multi-stakeholder consultation processes. The development of these Policy Briefs is coordinated under the auspices of the Ad Hoc Informal Multi-stakeholder Technical Group of Advisors on SDG7.

If you want to provide comments on this Policy Brief, please visit:
https://sustainabledevelopment.un.org/EnergyConference/documentation

KEY MESSAGES

Sustainable Development Goal (SDG) 7 includes three targets: universal access to energy services by all; doubling the rate of energy intensity improvement; and doubling the share of renewables (in final energy), all by 2030. Scientifically, these goals are based on six sustainable development pathways of the Global Energy Assessment (GEA, 2012). The required financing for achieving these goals translates into doubling current global energy investments to about $2.5 trillion per year and more than quadrupling the current energy access investment to some $40-60 billion per year. These are ambitious but achievable goals with appropriate policy frameworks and institutional support. There are many pathways in the more recent literature including IEA, IRENA scenarios and community pathways developed for the International Panel for Climate Change (IPCC) which meet some of the SDG7 targets by 2030. In particular, the world is on a good track to achieve increasing shares of renewable energy and also great progress has been made in reducing energy intensity and access. The new scenarios, as well as the original GEA pathways, extend the sustainability transformation into the future beyond 2030. The role of energy continues to be a key to achieving sustainable future for people and support functions of the planet. The sustainable energy pathways show it is possible to harmonize human need for greater energy services without transcending planetary boundaries. They also show this is not merely a supply-side issue, but importantly that end-use patterns have to change as well. In addition to technological and institutional changes, human behaviour needs to be transformed from energy-intensive toward sustainable lifestyles. The positive spillovers would include adequate food, clean water, better education and thereby reduction of poverty, gender inequalities, as well as, reduction of air pollution and greenhouse gas emissions. Therefore, the achievement of SDG7 would have a multiple benefit in catalysing other SDGs, notably the ones on the UN agenda in 2018, namely SDG6, 10, 11 and 15. Recently, a number of initiatives have been organized to assess full benefits of achieving SDG7 for other goals to 2030 and beyond, which requires understanding possible trade-off and especially synergies.

Sustainable Energy Pathways and the SDGs

The Role of Pathways in SDG7

Energy is one of the first research areas to use systems analyses to develop scenarios and pathways of future developments. Well-known contributors are Shell scenarios, World Energy Council, International Energy Agency, Energy Modeling Forum, and IIASA to mention just a few. Both narrative and quantitative energy pathways were developed already in early days including variants that lead to sustainable futures. The pathways in the literature clearly demonstrate energy is the key for human development.

Yet, Millennium Development Goals (MDGs) did not have an energy goal even though energy is essential for development. The Global Energy Assessment (GEA) with about 500 authors and reviewers across the world was designed to provide a comprehensive, science-based perspectives on sustainable energy futures, quantitative pathways and policies how they could be achieved. The UN SG's High-Level Advisory Group on Energy and Climate change (AGECC) has called on the UN system and its Member States to commit themselves to two complementary goals: 1. Ensure universal access to modern energy services and 2. Reduce global energy intensity by 40 percent rate all by 2030. The successful adoption of these measures would reduce global energy intensity by about 2.5 per cent per year, approximately double the historical rate. The third target to double the share of renewables in final energy to 30 percent also by 2030 was added later. The three targets are based on six sustainable development pathways developed in GEA and other literature particularly work of IEA on access and IRENA on renewable energy. The Vienna Energy Forum (VEF) has confirmed the three targets and subsequently they were also adopted by the UN Energy and UN SG's High-Level Group on Sustainable Energy for All.

Thus, there was a strong evidence-based knowledge on which SDG7 was rooted. The three goals adopted in 2015 by the UN General Assembly mirrored closely the original AGECC and VEF formulations. There are many pathways in the more recent literature including scenarios developed for the IPCC which meet the SDG7 targets by 2030.

Are we on track to achieving the SDG 7 targets?

The world is on a good track to achieve increasing shares of renewable energy and also great progress has been made in reducing energy intensity and access. However, we are far from doubling the rate of energy intensity improvement as well as achieving sustainable energy access for all (see Brief on Energy Access). Thus, these two targets need additional efforts and strong support to be achieved. A key question both in pathways and in future developments in general is whether the aspirational and ambitious SDG7 goals can be achieved through incremental improvements or if they require transformational change. This question is important for the roadmaps to 2030 and even more for sustainable pathways that go beyond.

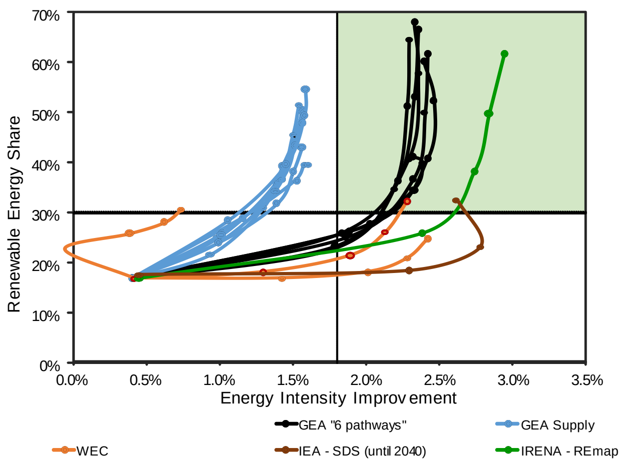


Figure 1. Renewable energy shares and energy intensity improvements to 2050 in 10 year steps. Green quadrant indicates SDG targets for renewable energy share and energy intensity improvement. Six GEA sustainability, IRENA Remap and IEA SDS scenarios are shown that clearly fulfil the two SDG7 targets. All GEA pathways fulfil the third target of universal access to energy services. It also displays recent pathways from the literature. (Source: based on data from GEA 2012, IRENA 2017, OECD/IEA 2017 and WEC 2017)

Energy transformation beyond 2030

The more recent scenarios as well as the original GEA pathways extend the sustainability transformation into the future beyond 2030. The role of energy continues to be a key to achieving sustainable future for people and support functions of the planet. The sustainable energy pathways show that it is possible to harmonize human need for greater energy services without transcending planetary boundaries.

One of the six GEA pathways emphasizes a future where renewable energy sources play a particularly important role. Recent literature abounds with discourse what would be the ultimate limit for renewables, namely whether they can provide all needed energy needs. Exceedingly high contributions of renewables are conceivable with the caveat that this needs to occur in conjunction with efficiency improvements and sustainable behaviours especially in end use.

In this GEA pathway (cf. figure below) already by 2030 the renewable share increases to more than 55 per cent of gross final energy consumption and continues to grow toward the middle of the century. In conjunction with this large role of renewable, energy efficiency improvements avoid almost 40 per cent of potential demand especially in end use. Efficiency is the largest "source of energy" in the six pathways.

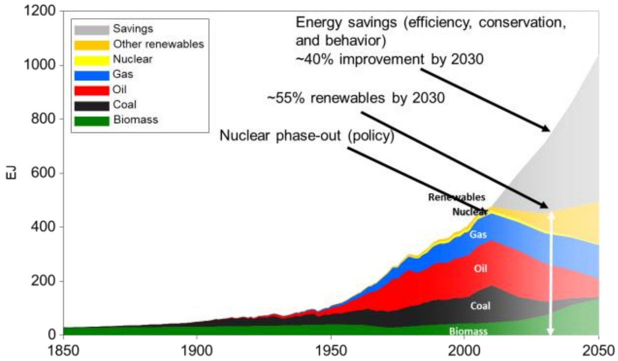


Figure 2. Global energy requirements in one of the six GEA pathways that informed SDG7 targets. This pathway emphasizes the role of renewables, other in the set of six pathways higher roles of fossils and nuclear. All fulfil the three SDG7 targets and also SDG13 and many other dimensions of sustainable futures. (Source: GEA 2012)

Reduction of energy intensity is central to achievement of sustainable energy futures across a wide range of pathways in the literature. A reasonable question to ask is whether this is feasible both in the short and the long run. In both cases vigorous policies not just on the supply side but especially in end use are essential.

A number of studies indicate, based on the second law of thermodynamics, that efficiency improvement potential is huge because the current efficiency in those terms might be on the order of only a few per cent. Realization of this potential in practice is another story.

Another perspective is given with the evolution of energy per capita and human development index. With development, ever less energy is required to achieve high levels of the index. With further progress, it can be expected to decrease even further.

In fact, the current average per capita energy needs are in the range of about 0.8 of the index meaning that total energy need not increase much anymore in the future, but also that inadequate distribution must be improved and especially those excluded need to be served to afford decent life.

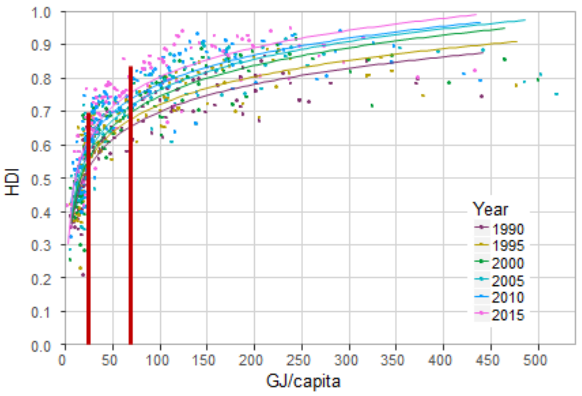


Figure 3. Per capita energy is shown with the human development index (HDI) indicating that after an initial rapid increase the improvements of HDI start to level off at high levels of per capita energy. Current average per capita global final energy is about 70GJ/capita achieving values in excess of 80 percent HDI index. (Source: updated from Steinberger & Roberts 2010)

There are many energy pathways in the literature, well over a thousand. Many pursue sustainable energy futures. Across the scenarios, the roles of different energy sources as well as the role of efficiency varies. GEA pathways, in general, and the six related to SDG7 portray possible futures including those with a large share of nuclear as well as futures with continued reliance of fossil energy, but all six achieve three SDG7 goals.

Interlinkages with other SDGs

SDG 13

Many of the scenarios in the literature are related to achieving SDG13, namely stabilizing emissions to reduce global warming below 2oC compared to preindustrial levels. One of the major constraints for sustainable energy pathways is the global carbon budget. For stabilizing at below 2oC about 600 to 800 billion tons of CO2 can be emitted and for 1.5oC only some 200 billion tons or so. In other words, this budget will be exhausted in no time with current energy-related annual emissions of some 36 billion tons CO2 per year.

One of the ways forward to reach climate goals is with huge efficiency improvements and vigorous increase of renewables as shown in the GEA pathway in the Figure above. The other ways are to continue the reliance on fossil energy in conjunction with carbon capture and storage. Nuclear is also an option in pathways that assume public acceptance and resolution of the proliferation challenges. In all cases, pathways including recent literature and GEA, indicate that net-negative emissions would be required to achieve SDG13 with stabilization at below 2oC. The lower the stabilization level, the higher is – ceteris paribus - the need for net-negative emissions in order to stay within the remaining carbon budget for the respective stabilization levels. Afforestation is an obvious option for achieving net negative emissions. Another is sustainable use of biomass in conjunction with carbon capture and storage. This de facto removes carbon from the atmosphere, which however also implies to have storage reservoir sin place that are virtually leakage-proof over time scales of 1000 years or so. Net-negative emissions have important implications for the energy sector and if needed in the future both carbon capture and sustainable biomass need to be scaled-up and deployed at large scale as soon as possible.

SDG 15

Energy is essential for food security as it provides motive power, production of fertilizers, food processing and transport. At the same time an important connection of pathways to SDG15 relates to the impacts of energy on land use but also potential conflict for land use for energy and food. This is not only related to biomass as an energy source. Other potential conflicts are there also in the case of other renewables and fossil energy especially with respect to air and water pollution.

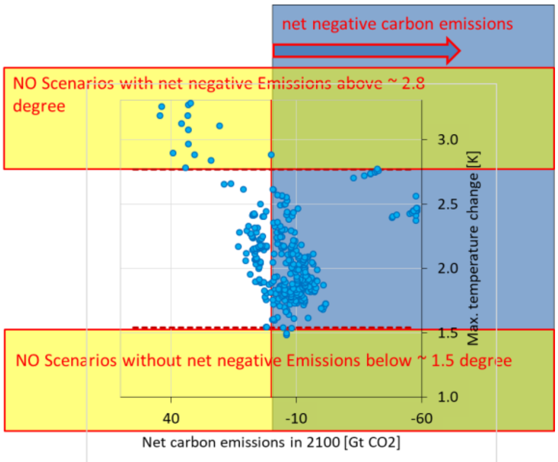


Figure 4. Emissions pathways in the literature indicate for low climate stabilization levels, say between 1.5 and about 2.7oC stabilization, a very high share of pathways have huge net-negative emissions by 2100. (Source: IAMC AR5 Scenario Database)

SDG 6

The energy sector is responsible for ca. 15 per cent of global water withdrawals, mainly for cooling of thermoelectric power plants (IEA 2012). Thus, there is a strong connection to SDG6 on water. The GEA pathways shown above with high shares of renewables do not pose a huge challenge for water withdrawals averaged for the world, but may do so in some regions especially in arid areas that are likely to increase with continued climate change. However, other of the six GEA pathways that rely more on fossils and carbon capture and storage need ever increasing water withdrawals. This is one of many cases of possible trade-offs and synergies among the SDGs.

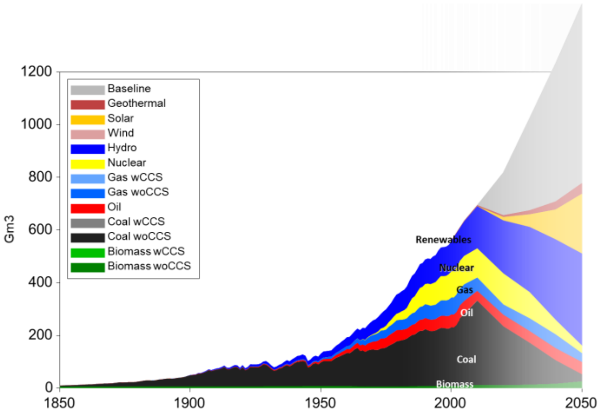


Figure 5. Water withdrawals for the GEA pathway with high share of renewables indicating the water demand shifts from coal as its share in energy declines toward renewables including hydropower. (Source: GEA 2012)

SDG 11

Another of the great challenges is the rapid urbanization in the world relating to SDG11. In the highly-developed countries of the world most of population lives in urban areas or urban sprawl. Globally, just over half of the people live in urban areas, mostly small to medium size cities. This share is however to rise to about two-thirds by 2050.

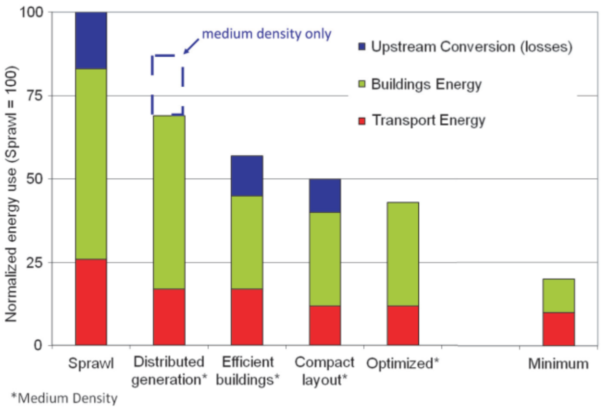


Figure 6. Model simulations for a 'synthetic' city with 20,000 inhabitants suggest improvement potentials of at least a factor of two each by buildings that are more energy-efficient and by a more compact urban form, energy system optimization through distributed generation and resulting cogeneration of electricity, heat, and air conditioning adding another 10–15 per cent improvement in urban energy use. (Source: GEA 2012)

Without building efficient future cities for the people, including some 800 million people still living in slums and informal settlements, energy demand would continue to increase.

Cities can have very high levels of efficiency assuming sustainable developments such as "closed metabolism" with full recycling and "urban mining", and collective transport just to mention a few of radical changes in sustainable energy pathways.

Policy Implications and Recommendations

- Need to double energy investments to some $2.5 trillion per year till 2030 with further increases beyond. These investment needs however go along with substantial savings in operation costs and positive externalities so that they would cost-effective in the long term.
- Attracting capital is a major challenge because most investment today are oriented toward high yields in the short term rather than sustainable gains in the long run. In particular the high up-front investment needs require new models of de-risking.
- Vigorous investment in Science, Technology and Innovation (STI) needs to complement deployment and diffusion.
- STI and deployment of new technologies offer the opportunities of learning by doing and rapid decrease of costs making the transformation to sustainable energy future affordable.
- Energy policies should consider multiple-benefits and potential synergies with other SDGs. This would also decrease the costs of the transformation.
- Sustainable policies are a must because volatility of regulatory mechanisms blocks long-term investments.
- Integrated policy frameworks and new institutions are required for achieving the synergies across SDGs.
- New behaviours and emergence of sustainable social norms and values are central to the energy transformation toward sustainable future.
- Focus on demand side on efficient services, rather than energy per se – negawatts instead of megawatts
- The transformation of the energy system offers a window of opportunity for developing countries to leapfrog toward sustainable futures.

References

GEA, 2012: Global Energy Assessment - Toward a Sustainable Future, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria.

Grubler, A., X. Bai, T. Buettner, S. Dhakal, D. J. Fisk, T. Ichinose, J. E. Keirstead, G. Sammer, D. Satterthwaite, N. B. Schulz, N. Shah, J. Steinberger and H. Weisz, 2012: Chapter 18 - Urban Energy Systems. In Global Energy Assessment - Toward a Sustainable Future, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria, pp. 1307-1400.

IRENA, 2017: Perspectives for the Energy Transition investment needs for a low-carbon energy system. Chapter 3, REmap Scenario.

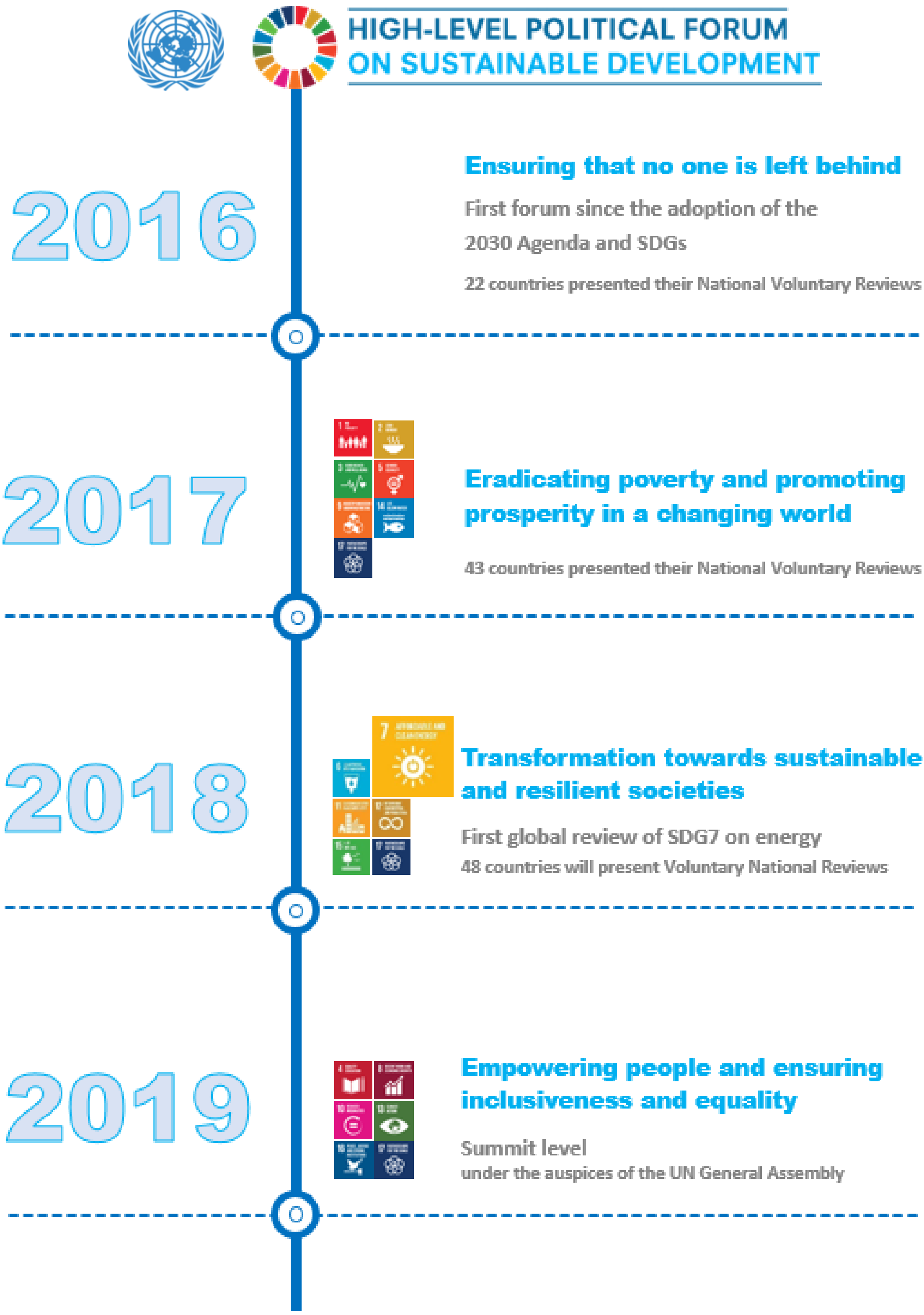
IAMC AR5 Scenario Database, 2104: available at: https://secure.iiasa.ac.at/web-apps/ene/AR5DB/

Steinberger, Julia and Timmons Roberts, 2010: From constraint to sufficiency: The decoupling of energy and carbon from human needs, 1975–2005, in Ecological Economics, Vol. 70, Iss 2, 425-433.

OECD/IEA, 2017: World Energy Outlook 2017. Paris, France.

WEC, 2016: World Energy Scenarios 2016. World Energy Council. London, UK.

[Additional references still to be added.]



For further information, please contact:
Division for Sustainable Development
Department of Economic and Social Affairs
United Nations
https://sustainabledevelopment.un.org/