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ENERGY AND SOCIETY: TRENDS TO 2040

Abstract: As the global population increases and becomes more affluent, the demand for energy will increase. The sources of energy will be diversified away from fossil fuels. This paper explores the implications for global and local society of changes in the energy mix as fossil fuels are augmented by renewables and nuclear energy. It is based on *Megatrends and How to Survive Them: preparing for 2032* by Patricia Lustig and Gill Ringland (Cambridge Scholars Publishing, 2018).

Diversified energy sources are likely to contribute to a re-distribution of the current economic and political power between countries. The changing energy mix will reduce the geo-political importance of securing access to oil supplies, and so may cause economic downturns in areas such as Saudi Arabia and Alaska, which export oil. Renewables also offer reduced timescale of implementation of energy sources, and small scale investment.

Intermittency of supply from renewables may lead to variable energy pricing, and innovative ways of storing energy. Their distributed nature — as in solar panels on domestic roofs — has a major impact in countries without extensive electricity grids. Solar power is sufficient for lighting and so can enable students to undertake homework after dark.

Key words: *energy diversification, renewables, geo-political changes, energy transition*

1. INTRODUCTION

This article is based on work developed through assignments with many leading organisations to develop their responses to the changes over the next

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twenty years, and previously published in *Megatrends and How to Survive Them: preparing for 2032* [1].

After defining "a trend" we start by reviewing the current trends in energy and the impact on society. We then explore where these might take us by 2040. We discuss what could deflect the trends and conclude with some thoughts about how to prepare Millennials for 2040.

2. WHAT IS A TREND?

A trend is a way of describing one aspect of possible futures (and of course the past). It is not a forecast — it's a direction of travel. We contrast a forecast — a single point in the future — with the realistic approach of exploring the direction of travel of a trend, noting that both timing and direction cover a range of possible futures.

Sometimes it is hard to spot major changes as they unfold. However, major trends in the energy sector and in society are happening now and have effects both now and in the longer term. In this paper we focus on energy and society. These are of course, correlated with other trends such as demographics and urbanisation, mobility and global warming. In the book [1] we discuss the links — in this paper we focus on demand for energy, sources of energy, and impacts on local and global society.

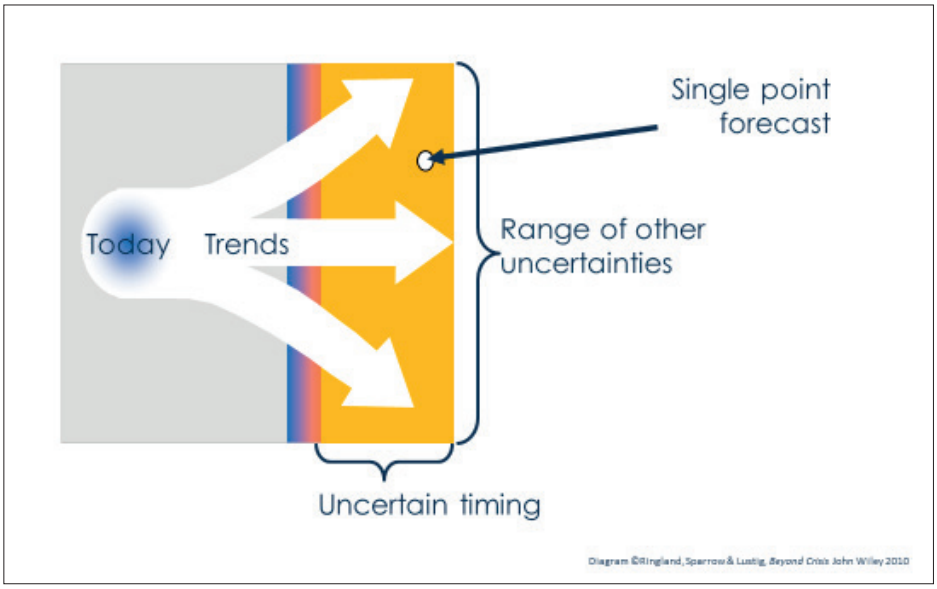

Fig. 1. Trends are not forecasts

3. CURRENT TRENDS

3. 1. DEMAND FOR ENERGY

Society depends on energy. Electricity is becoming the major form of energy used. In developed nations we expect our electricity to be available 24/7. Nations that don't yet have a constant supply of energy, need and want it. There are currently about 1 billion people who do not have reliable access to electricity. The trend for increased energy demand is likely to continue.

As the population increases, demand for energy rises. As more people become middle-class, their demand for energy rises. And though the energy usage by industry per unit of production is decreasing, the increase in the usage of mobile phone and internet connections demands extra electricity for the network and to recharge batteries. The total demand in the figure below may be an overestimate of the increase in demand, as population forecasts are being revised [2], but is useful in illustrating the split between sectors of the economy and the increasing share of energy use in buildings due to domestic demand. Demand can be seen [3] to be dominated by transport, industry and buildings (including residential).

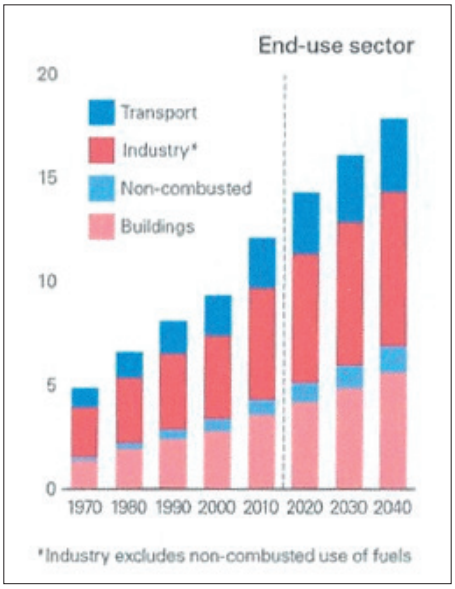

Fig. 2. Primary energy demand

3. 2. SOURCES OF ENERGY

Today there is enough fuel to generate the electricity we require from coal, gas, oil, hydropower, and nuclear. The challenge is to produce and distribute energy to support the growing demand. Pragmatically it is about understanding trade-offs and making the best choices with regards to the environment (CO_2 causing global warming, and pollution), the economy, and cost to consumers.

The energy infrastructure or grid is currently centralised to distribute electricity generated in power stations by fossil fuel, nuclear fuel, or by hydropower [4]. Fluctuations in electricity usage (peak times) are handled by capacity lying idle and ready to go on line when the need arises. While fossil fuels aren't going away, the use of renewables including nuclear is expected

to increase; what sort of energy we use will be mostly determined by availability and the cost to the consumer. Solar and wind energy depends on the sun and wind. These are not always available. At present, battery storage for large amounts of electricity is expensive and difficult, so fluctuations are evened out by conventional generation. Solar in particular can be generated at domestic or building level.

In 1993, when we (PL) moved into our Kathmandu home, we installed solar heating for our water (with a backup electric geyser when needed, as our children were young). By 2010 people were installing photovoltaic panels paired with an inverter (battery storage) to manage the dire electricity situation — there were weeks when there was only 4 hours of electricity a day from the grid.

Levelised cost compares the cost of generation of electricity from different sources. In a 2017 survey of levelised costs in the USA, nuclear generation had the highest cost, followed by coal generation, natural gas, solar, with wind generation being the cheapest. Solar cells have the advantage of modularity and low unit cost.

The dangers of pollution — polluted air, polluted seas, polluted ground and groundwater — are becoming more visible, and are becoming part of the discussion globally. This is not just about renewables but also a spectrum of emissions for various fossil fuels, from wood burning for cooking and coal-fired power stations at the top of the list to natural gas at the bottom [5] Changes within the range of fossil fuel usages include cleaner shipping (see box below [6]), less coal-fired electricity generation, and the next generations of internal combustion engines being more efficient and less polluting, as well as the move towards electric vehicles.

On January 1 2020, IMO 2020, the International Maritime Organisation's agreement that high-Sulphur fuel will be outlawed comes into effect. Ships will no longer be able to burn it in most of the world's biggest ports. There will be industrial winners (refineries and shale oil) and losers (tourism and cars). It will be good for the refineries in Texas, but bad for Europe. It will contribute to higher diesel and flight prices. Richard Joswick, an analyst for S&P Global Platts: "The (refining margins) ... Including diesel fuel and jet fuel could nearly double due to IMO 2020." Refineries need to retool to produce the lower Sulphur fuel, not enough are yet doing so.

What does this mean for us? It hasn't yet hit the news, but for those who drive diesel cars, or need diesel (farmers anyone?), it will mean higher prices. Farmer friends of mine (PL) hadn't heard of this — now they will be

buying red diesel in late summer so that they can fill their storage tanks before prices go up.

Decarbonisation of the fuel mix is proceeding slowly. Nuclear power generation in the OECD and USA is in decline with aging plants approaching decommissioning. Nuclear power is an increasing part of the mix in other parts of the world [7]. Electricity generation from natural gas has grown significantly over the last two decades [8] and finds in the USA are having a major impact. This is the only fossil fuel that is likely to continue to grow as it is the least 'bad' of the fossil fuel bunch. The reduction in generation from coal is being taken up primarily by wind and solar energy.

Coal power plants are being taken off line in OECD countries and China is slowing the growth of new coal powered electricity generation due to the pollution it causes. Many of China's coal powered plants are still less than 15 years old. In China, electricity is predominantly generated by coal powered stations. China is expected to increase the share of non-hydroelectric renewable energy to one-fifth of its energy mix by 2030 and reduce coal to three-fifths of its energy mix by 2020, with gas making up the difference [9].

India continues to build new coal powered electricity generation plants. India currently has about one third of its electricity from renewables (of which a very small part is nuclear) [10]. Today there are about 450 nuclear power reactors operating in 30 countries plus Taiwan: in 2017 these provided over one-tenth of the world's electricity [11].

The EU targets a switch to get three quarters of its energy from renewables by 2040 [12]. The electricity it gets from nuclear generation is likely to fall as nuclear plants age, with old coal-fired plants retired and replaced by a cleaner form of fuel.

Green And Away, a sustainable conference venue in Worcestershire, UK has for years had its own portable wind turbine and solar units to generate all the power for the venue.

In Latin America renewables already have a large share, much of which is from hydro-electric dams [13]. The Middle East and North Africa, and North America, export oil and shale fossil fuel, and internally are starting to invest in renewables to varying degrees [14]. In the USA, as in Europe, coal-fired and nuclear electricity generation is falling, plants are not being replaced.

All fuels require water in their production [15]. Bio-fuels (a small part of the mix, so we will not consider them further) require the most water per KWh, solar and wind power require the least. Water is a scarce resource and could increasingly constrain the mix of energy sources we use.

I (GR) am lucky enough to live in a classic 1930's house with a flat roof, situated on a hilltop. So, we investigated installing solar panels and linking the output to both our own usage and the grid. The process was amazingly trouble free — a survey was followed by a quotation. Installation took one day, and we started getting the benefit immediately.

Fossil fuel prices have remained relatively steady for the past few years. Price is dependent on country and the regulatory infrastructure involved, including subsidies available and taxation; some countries like Indonesia subsidise fuel costs to consumers. The price of electricity generated from renewables is falling as economies of scale (learning curve pricing) take effect and technology improves the efficiency of photovoltaic cells and wind turbines [16].

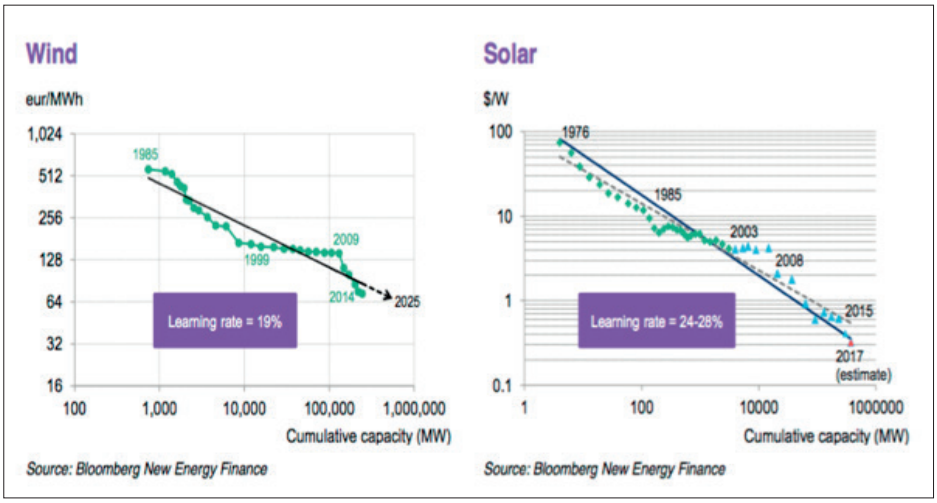

Fig. 3. Learning curve pricing

A friend (GR) runs a business in Europe and was taking a long trip to Vietnam and Cambodia, cycling for six months in rural areas. He strapped a solar cell to his bike and was able to keep his computer charged with day-time solar power and keep in touch with the business every night.

Internal combustion engine powered vehicles are becoming more efficient as engine technology improves. Electric vehicles may be more energy efficient overall, depending on the source of the electricity. Hydrogen fuel cell powered vehicles are in development, with prototypes in test [17].

3. 3. IMPACTS ON LOCAL AND GLOBAL SOCIETY

Changes in the mix of energy sources are already affecting global politics. Reduction in the use of coal and the shift to gas for electricity generation affects where the fuel comes from. Natural gas finds in the USA are reshaping the energy usage there, providing exports, and reducing the strategic need for allies in the Middle East [18]. Saudi Arabia has set up a Sovereign Wealth Fund to provide an income for when fossil fuels are less important [19] and Russia is focusing on developing the Northern Sea Route [20].

As countries and regions adopt solar and wind power, new technology, infrastructure and networks are needed to support this shift in energy sources with many new suppliers and business models. In Europe, wind power has been favoured by governments, with German suppliers dominant [21]. Chinese suppliers dominate the solar power market [22].

4. WHERE THE CURRENT TRENDS COULD TAKE US BY 2040

4. 1. DEMAND FOR ENERGY

The BP Energy Outlook 2019 edition [3] estimates the changes in demand by country and region. It suggests that most of the growth in demand will come from the developing economies where improved standards of living lead to increasing energy usage.

In Sub-Saharan Africa, massive distribution problems mean that there are countries where less than half of the population have access to electricity. This is expected to change by 2040.

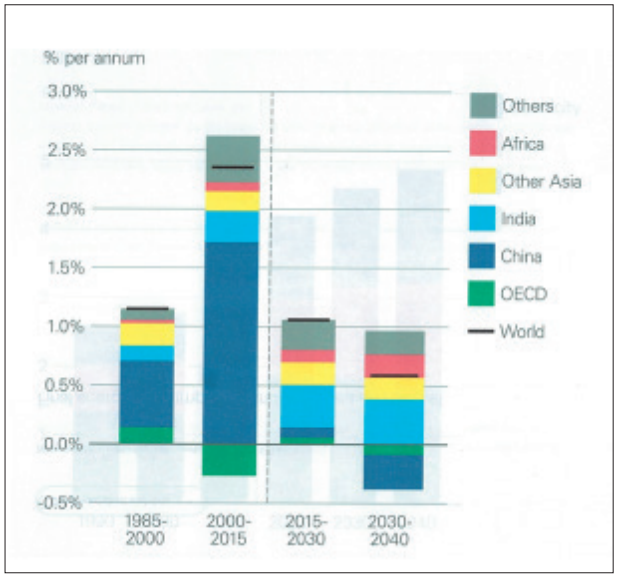

Fig. 4. Regional growth in demand

4. 2. SOURCES OF ENERGY

By 2040, energy costs are likely to be mostly be quoted as the price of electricity. Cooking is likely to be mostly by electricity, replacing wood burning, [23] and there are likely to be many more electric-powered vehicles in cities and for freight [24].

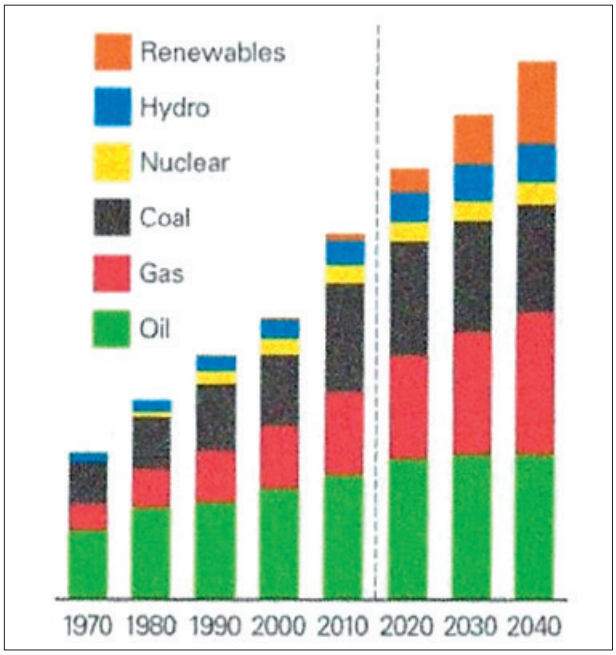

Fig. 5. Meeting the demand

The main switch from now to 2040 is from coal to renewable energy sources (including nuclear and hydro) for electricity generation [7]. Over 100 nuclear power reactors are on order or planned, and over 300 more are proposed. Most of the reactors currently planned are in the Asian region, with fast-growing economies and rapidly rising electricity demand. Improvements in the competitiveness of renewables indicate that by 2040 they are likely to, together with nuclear and hydro energy, provide at least half the increase in global energy production. Nuclear generation of electricity is a low carbon emission source, trade-offs being cost of plant construction and the risks inherent in the fuel source.

A friend of mine (GR) was on a trip to China and passed a large gleaming building by itself in the desert. He asked what it was and was told it was a nuclear power station. Expressing surprise, he was told "it is like you as a parent, you buy clothes bigger than is needed so that the child can grow into them ----"

To use solar energy, new buildings are likely to increasingly have their own solar installations to provide the power they need, along with batteries. The trend of falling costs of individual solar installations and micro wind generation is making it possible for more individuals and localities to have access to low cost energy.

A number of European countries will ban the sale of petrol and diesel fuelled cars after 2025, driven by the Paris Climate Agreement [25]. Other nations are likely to follow in varying timescales. Replacements are expected to be a mixture of EVs, shared and public transport, and possibly towards 2040, hydrogen vehicles. By 2040, Norway intends all short-haul flights leaving its airports to be on aircraft powered by electricity [26].

Intermittency of supply from renewables may lead to variable energy pricing, tempered by innovative ways for storing energy. Smart systems, likely to be common by 2040, could change the way we produce and consume energy, making it more abundant and much cheaper. An active area of development is storage technology. Examples include pumped hydro in Iceland and Norway [27] and a water-based battery prototype developed by Stanford researchers [28].

4. 3. IMPACTS ON GLOBAL AND LOCAL SOCIETY

A shift away from a dependence on fossil fuels is likely to contribute to a re-distribution of the current economic/political power and influence among countries. It is likely to reduce the geo-political importance of securing access to oil supplies and may well cause economic downturn in areas such as Saudi Arabia, Texas and Alaska which export oil [29].

Increasing energy demand means that some of the estimated one billion people without electricity today will have access by 2040. Micro-generation — particularly solar as learning curve pricing rolls through — is likely to become much more affordable. Solar energy has a large role in providing electricity to homes, allowing school children to do their homework in the evening (see Hans Rosling's *Factfulness* [30]). This will have a major impact on education, enabling more people to not only read books but access the internet and its riches.

In South East Asia there is a trend towards micro-generation with standalone grids in order to provide villages and people with electricity. These are usually based on renewable sources like wind, micro-hydro and solar energy, and use battery storage to increase the hours in which consumers can use electricity.

Energy prices are likely to be cheaper, so more de-salination plants could address water scarcity [31].

This could reduce pressures to migrate from desertifying areas. And cheaper, readily available electricity in rapidly growing cities is likely to address the pollution caused by cooking fires.

5. POSSIBLE DEFLECTIONS

A concerted effort worldwide to achieve the Paris Agreement would be more likely to affect the choice of sources of energy rather than decrease overall demand. Demand has been shown to be sensitive to pricing, as when counties ceased to be supplied with cheap energy by Russia in the 90's [32] and demand decreased dramatically. However, a policy of high prices would affect access to energy — particularly electricity — which is widely seen as a social good.

Nuclear accidents such as Fukushima [33], Three Mile Island [34] and Chernobyl [35] and accidents which could arise over the decommissioning of old nuclear plants could change public attitudes in China — and Asia generally — to nuclear power.

Nuclear fusion always seems to be 50 years away, yet it might surprise us all one day and could change the energy mix [36].

6. CONCLUSION: HOW TO PREPARE PEOPLE FOR 2040?

6. 1. WHO NEEDS TO BE PREPARED?

Alvin Toffler in *Future Shock* [37] spoke of the post-industrial society and how the pace of change was accelerating — the Tofflers emphasised how threatening people find change. They "coined the term 'futureshock' to describe the shattering stress and disorientation that we induce in individuals by subjecting them to too much change in too short a time".

Since that time, change has accelerated, with technology having a reach barely imaginable then. It is perfectly reasonable for existing governing structures to feel threatened — on the whole, older people are more likely to feel threatened by change. People who did not grow up with technology may find it hard to adapt.

However, Millennials and Generation Z — born after 1980 — have grown up with the idea of continuous change, and technology, and use it to connect, often to the despair of parents and teachers. This gives them the power of the network for global reach. So, we suggest that Millennials and Generation Z — who will be decision makers by that time — are the groups that need to get prepared for 2040.

6. 2. HOW CAN THIS BE DONE?

Generation Z are famous for their assumption that technology can fix all problems. As part of the Ethics in Schools programme at Ethical Reading, we use a number of routes to explore why technology may not be enough.

We use case studies based on real life, for the students to discuss in groups and then report back; and let them analyse why different groups have come to different conclusions [38]. We also use games such as Terra Nova, [39] which engages children and adults in exploring current trends.

The best guide to toolkits for gaining views of the future to 2040, in use in many organisations, is *Strategic Foresight* [40]. This can be used in conjunction with *Megatrends* [1] which provides the evidence for the trends, to inform the discussion.

REFERENCES

[1] P. Lustig and G. Ringland, *Megatrends and How to Survive Them: Preparing for 2032,* Cambridge Scholars Publishing, 2018, ISBN 978-1-5275-1601-4.
[2] D. Bricker and J. Ibbitson, *Empty Planet: The shock of global population decline,* Little, Brown Book Group, 2019, ISBN 978-1-4721-4295-5.
[3] https://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html
[4] https://www.epa.gov/energy/centralized-generation-electricity-and-its-impacts-environment
[5] https://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-emissions
[6] https://worldmaritimenews.com/archives/261818/port-of-singapore-readies-for-imos-2020-sulphur-cap/
[7] http://www.world-nuclear-news.org/EE-Bloomberg-sees-1-fall-in-nuclear-global-share-by-2040–1507165.html
[8] https://www.chevron.com/operations/natural-gas
[9] https://www.iea.org/weo/china/
[10] https://www.outlookindia.com/newsscroll/renewable-energy-will-reach-49-percent-in-india-by-2040-report/1078399
[11] http://world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx
[12] https://ec.europa.eu/energy/en/topics/renewable-energy
[13] www.renewableenergyworld.com/articles/2012/06/hydro-powers-latin-america.html
[14] https://www.forbes.com/sites/dominicdudley/2018/02/14/can-the-middle-east-make-a-success-of-renewable-energy-it-may-not-have-a-choice/#493887c61da2
[15] https://www.ucsusa.org/clean-energy/energy-water-use
[16] https://cleantechnica.com/2016/03/26/21-solar-pv-learning-curve-to-continue-report-projects/
[17] https://auto.howstuffworks.com/fuel-efficiency/hybrid-technology/hydrogen-cars.htm
[18] https://www.eia.gov/naturalgas/
[19] https://www.bloomberg.com/news/articles/2017–10–22/how-saudi-arabia-is-building-its-2-trillion-fund-quicktake-q-a

[20] http://www.rcinet.ca/eye-on-the-arctic/2019/04/04/russia-rosneft-oil-northern-sea-route-arctic-cluster-shipping/
[21] https://www.cleanenergywire.org/factsheets/german-onshore-wind-power-output-business-and-perspectives
[22] https://economictimes.indiatimes.com/news/economy/foreign-trade/china-is-biggest-exporter-of-solar-equipment-to-india-with-87-per-cent-market-share/articleshow/58450137.cms
[23] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4299844/
[24] https://about.bnef.com/electric-vehicle-outlook/
[25] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[26] https://www.theguardian.com/world/2018/jan/18/norway-aims-for-all-short-haul-flights-to-be-100-electric-by-2040
[27] https://www.hydropower.org/country-profiles/iceland
[28] https://news.stanford.edu/2018/04/30/new-water-based-battery-offers-large-scale-energy-storage/
[29] https://www.tandfonline.com/doi/pdf/10.3402/ijch.v72i0.21520
[30] H. Rosling, O. Rosling and A. R. Ronnlund. *Factfulness*, Sceptre, 2018, ISBN 978-1-473-63746-7.
[31] https://www.energycentral.com/c/ec/desalination-and-energy-consumption
[32] https://estore.enerdata.net/ukraine-energy.html
[33] http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-accident.aspx
[34] http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/three-mile-island-accident.aspx
[35] http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/chernobyl-accident.aspx
[36] https://www.theguardian.com/environment/2018/mar/09/nuclear-fusion-on-brink-of-being-realised-say-mit-scientists
[37] A. Toffler, *Future Shock,* Turtleback Books, 1970, ISBN 0-553-13264-4.
[38] www.ethicalreading.org.uk
[39] www.terra-nova.nl
[40] P. Lustig, *Strategic Foresight: Learning from the Future,* Triarchy Press, 2017, ISBN 978-1-909470-668.