GLOBAL ENERGY TRANSFORMATION

In order to limit climate change and enable sustainable growth, global energy transformation driven by renewable energy, energy efficiency, electrification, and digitalization must be accelerated. In addition to mitigating climate change, reducing local air pollution, and improving energy security, socio-economic benefits are among the key drivers for this transformation. While system-wide innovation is necessary to continue the power system transformation with cost-effective renewable energy solutions, energy efficiency, renewable energy, and electrification solutions must jointly be pursued in the heating and transport sectors. Early action will be crucial to reap the economic benefits of this transformation and to limit its costs. Countries should start planning today to limit the potential risks that could arise from geopolitical shifts and the changing structure of economies due to global energy transformation.

Değer Saygın & Dolf Gielen*

TURKISH POLICY QUARTERLY
Summer 2019

*Değer Saygın is the Director of the Istanbul-based SHURA Energy Transition Center. Dolf Gielen is the Director of the Innovation and Technology Centre at the International Renewable Energy Agency (IRENA). The authors would like to acknowledge Selahattin Hakman, Chair of the Steering Committee at SHURA Energy Transition Center, for his valuable contributions.

Monitoring the Current Progress in Global Energy Transformation

The Paris Climate Agreement aims to limit the average global temperature rise to below 2°C by the end of this century. Around two-thirds of global greenhouse gas (GHG) emissions stem from energy production and use − making the current dynamics of global energy the main reason behind climate change.[1] The energy sector's transformation is of paramount importance to limit global temperature increase.

The rapid decline in renewable energy costs, progress in energy efficiency, widespread electrification of heating and transport sectors, and technological breakthroughs have so far been the leading results of efforts to transform the global energy sector. In addition, renewables have been globally recognized as a mainstream energy source. Enabling solutions are also becoming economically viable, thus allowing renewables to be integrated into the grid.

According to the International Renewable Energy Agency's (IRENA) statistics, 2018 was a year with record high additions of renewable generation to the global capacity. At the end of 2018, a total of 2,351 gigawatts (GW) capacity was installed. Solar photovoltaic (PV) installations took first place with a capacity increase of 94 GW, higher than any other resource.[2] With these developments, renewable energy's share in total global electricity generation exceeded 25 percent.[3] The wind and solar PV's shares represented around 11 percent.

There are several factors that contribute to the ongoing transformation of energy dynamics, one being the drop in generation costs. While the average generation cost of the majority of onshore wind projects that came online in 2018 were at 0.056 dollars per kilowatt-hour (kWh), solar PV's average dropped to 0.085 dollars/kWh in 2018, with costs of many projects falling well below this average. Compared to 2017, this was 13 percent lower, indicating that the global costs were continuing to decline. The policy framework has been shifting from support mechanisms, like feed-in tariffs, to competitive tender mechanisms−which have been used by 48 countries in 2018. According to the most recent auction and power purchase agreement data, onshore wind and solar PV will be cheaper than the lowest cost fossil fuel-equivalent by 2020. In fact, the total cost will drop below the operating cost of coal and gas plants in most

[1] "Fossil CO2 emissions of all world countries," *Joint Research Centre (European Commission)*, 2018, https://publications.europa.eu/en/publication-detail/-/publication/41811494-f131-11e8-9982-01aa75ed71a1/language-en

[2] "Renewable Energy Capacity Statistics 2019," *International Renewable Energy Agency (IRENA)*, 2019, https://www.irena.org/media/Files/IRENA/Agency/Publication/2019/Mar/IRENA_RE_Capacity_Statistics_2019.pdf

[3] "Renewables 2019 Global Status Report," *Ren21*, 2019, https://www.ren21.net/wp-content/uploads/2019/05/gsr_2019_full_report_en.pdf

countries, which may lead to a massive number of stranded assets.[4] Nearly all countries have renewable energy targets either in generation share, total output or installed capacity − and 65 of them are targeting to supply all demand from renewables.[5]

In heating and transport, the progress remains limited. Direct use of modern renewable energy sources (excluding renewable electricity and district heat) accounts for one-tenth of the total demand for heating and cooling. The share is much less in transportation−just above three percent of the sector's total energy demand. This stagnation is problematic as these sectors represent 80 percent of the total final energy consumption worldwide.[6] Less than 50 countries have renewable heating and cooling energy targets and only half of them has a regulatory framework in place to realize these targets.[7]

"The energy sector's transformation is of paramount importance to limit global temperature increase."

One promising trend is electric mobility−with a rapidly growing electric vehicle (EV) market. Countries have realized EV's various benefits, such as their contribution to a cleaner urban landscape, electricity load management, and better efficiency overall. As a result, EV and charging infrastructure policies are expanding. Furthermore, many car manufacturers have targets to increase the number of EV production and invest in new models.[8] By the end of 2018, the total number of EV's on the road had reached 5.1 million. A similar number of chargers serve the EV stock with around 5.2 million in use worldwide.[9] EV uptake is also driven by the promising developments in storage technologies.

According to the recent estimates on energy efficiency, the energy intensity has decreased by 1.3 percent in 2018−down from 1.9 percent in 2017.[10] The average im-

[4] "Renewable Power Generation Costs in 2018," *IRENA*, 2018, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf

[5] "Renewables 2019 Global Status Report," *Ren21*, 2019, https://www.ren21.net/wp-content/uploads/2019/05/gsr_2019_full_report_en.pdf

[6] "World Energy Balances," *International Energy Agency (IEA)*, 2019, https://www.iea.org/statistics/balances/

[7] "Renewables 2019 Global Status Report," *Ren21*, 2019, https://www.ren21.net/wp-content/uploads/2019/05/gsr_2019_full_report_en.pdf

[8] "Global EV Outlook 2018," *IEA*, 2018, https://www.iea.org/gevo2018/

[9] "Global EV Outlook 2019," *IEA*, 27 May 2019, https://www.iea.org/publications/reports/globalevoutlook2019/

[10] "Tracking SDG 7: The Energy Progress Report 2019," *World Bank*, https://www.worldbank.org/en/topic/energy/publication/tracking-sdg7-the-energy-progress-report-2019

provement over the 2011–16 period amounted to 2.1 percent.[11] A significant gap remains in order to reach the seventh Sustainable Development Goal (SDG) target of 2.6 percent by 2030. Outpacing the progress on energy efficiency, demand for energy has grown by 1.9 percent in 2017−the highest growth since 2010. The global market of Energy Service Companies (ESCO) has grown eight percent but new business models, private financing sources, and innovative financing models are needed.[12]

Energy Sector Decarbonization Pathways: What they Imply in Terms of Investment, Cost, and Benefit

The energy sector must transform faster to limit the increase in global GHG emissions. More than 90 percent of all the emissions reductions to curb climate change by 2050 will need to come from renewable energy, energy efficiency, and electrification solutions.

According to IRENA's third edition of Global Energy Transformation Roadmap to 2050,[13] the share of renewables in the electricity sector was 25 percent in 2017. This share needs to increase to 85 percent, mostly through the development of solar and wind sources, by 2050. This transformation would require system-wide planning and innovation that would link the power system with end use sectors, new system and market operations, and regulations.[14]

The current share of renewable energy in the total global energy supply is below 20 percent−even lower than in the electricity sector. This share must increase to cover two-thirds of the total demand by 2050. A six-fold acceleration of renewables deployment is needed to meet this target, which requires a significant increase in renewable energy use in industrial process heating and space/water heating in buildings. The electrification of heating in buildings and in the industrial sector, as well as electric mobility, will also be crucial. The share of electricity in total energy demand will need to increase from today's 20 percent to 50 percent by 2050. Moreover, improvements in energy intensity needs to increase to 3.2 percent per year until 2050.[15]

Energy sector investments have stabilized at around 1.8 trillion dollars per year in the past three years, representing around 10 percent of the total global investments

[11] Energy efficiency improvement is measured by energy intensity which represents primary energy supply per unit of purchasing power parity. For more: "Market Report Series: Energy Efficiency 2018," *IEA*, 19 October 2018, https://webstore.iea.org/market-report-series-energy-efficiency-2018

[12] IEA (2018).

[13] "Global Energy Transformation: A Roadmap to 2050," *IRENA*, 2019, https://www.irena.org/DigitalArticles/2019/Apr/-/media/652AE07BBAAC407ABD1D45F6BBA8494B.ashx

[14] Değer Saygın and Dolf Gielen et al., "The role of renewable energy in the global energy transformation," *Energy Strategy Reviews*, 2019, https://doi.org/10.1016/j.esr.2019.01.006

[15] IRENA (2019).

in fixed capital, and 2.5 percent of the total global gross domestic product. Around half of all investments are geared to transform the energy sector, including renewables, energy efficiency, and electrification−as well as the infrastructures to manage these transitions.

> *"More than 90 percent of all the emissions reductions to curb climate change by 2050 will need to come from renewable energy, energy efficiency, and electrification solutions."*

Additionally, substantial investments in low-carbon technologies is also crucial in the shift towards a global supply that will be heavily sourced by renewable energy. If the global energy system implements the planned policies regarding the energy transition, cumulative investment between 2015 and 2050 would need to increase by around 20 percent − from 93 trillion dollars to 110 trillion dollars−meaning that more than three trillion dollars would be invested per year on average over the span of 35 years. To achieve this, three distinct challenges need to be overcome: total energy sector investments need to double compared to the level in the past 15-20 years, energy transition's share in total investments would need to increase from 50 percent to more than 80 percent, and new financing resources will be needed to cover the additional demand.

Taking early action is crucial to maximizing the benefits of this energy transition, limiting the planet's temperature rise to 2°C, and reducing the risk of stranded assets. In terms of costs, the most important impact of energy transition is the reduction of harmful external effects, notably for public health and climate. The benefits of energy transition will exceed the cost by 3-7 times in the year 2050, largely in the form of reduced health impacts. With early action, the estimated stranded assets until 2050 could be limited at around 12 trillion dollars.[16]

It is clear that energy transition investments significantly contribute to the growth of global gross product. Needless to say, with growing investments, the socio-economic impacts of energy transition will be stronger as well −the growth in domestic product is estimated to be at 2.5 percent and the growth in employment at 0.2 percent.

[16] Değer Saygın and Dolf Gielen et al., "Power Sector Asset Stranding Effects of Climate Policies," *Energy Sources, Part B: Economics, Planning, and Policy*, 2019, https://www.tandfonline.com/doi/abs/10.1080/15567249.2019.1618421

The Geopolitics of Energy Transition

As a result of the energy transition, urban and rural communities could function differently in the future, and the structure of economies may change, resulting in significant geopolitical shifts. In their recent report, the Global Commission on the Geopolitics of Energy Transformation discusses how the renewable energy transition will reorder the geopolitical impacts of the fossil fuel dominated system. As electricity becomes more decentralized, energy will no longer be in the monopoly of a few countries, which will allow the majority of states to have independent access. Moreover, the current fossil fuel exporting countries, as well as the workers and communities of countries that heavily depend on fossil fuels, will not only need to adapt to the new prevailing energy system but also reinvent themselves in order to minimize the potential risks related to cybersecurity and new dependencies on rare earth metals.[17]

At around 100 million barrels of oil per day, global crude oil production values 2.4 trillion dollars per year, which correlates to more than three percent of the global GDP.[18] Downstream processing, gas, and coal supply triple this amount to around six percent of world GDP. Electricity supply further adds to a total of more than 10 trillion dollars. However, the economic benefits are spread unevenly. A small number of countries provide most of the oil and gas supply, while others largely rely on imports.

It should be noted that the fall of gas and oil prices in recent years is a direct consequence of the rapidly expanding production capacity and new technology, including economic shale gas and shale oil production. Although fossil fuel demand is growing, the energy transition is bound to change the status quo. Since renewable resources are more evenly spread than fossil fuel resources, energy import dependency will diminish for many states−however, new dependencies could emerge. When renewables share increases worldwide, an assessment of seven global energy scenarios identified seven areas where geopolitics of energy may change. These are: critical material supply chains, electric grids, reduced oil and gas demand, new "resource curse," avoided climate change, energy access, and technology and finance.[19]

---

[17] "A New World: The Geopolitics of the Energy Transformation," *IRENA*, 2019, http://geopoliticsofrenewables.org/assets/geopolitics/Reports/wp- content/uploads/2019/01/Global_commission_renewable_energy_2019.pdf

[18] BP, "BP Statistical Review of World Energy," June 2017, https://www.bp.com/content/dam/bp-country/de_ch/PDF/bp-statistical-review-of-world-energy-2017-full-report.pdf

[19] M. O'Sullivan, I. Overland & D. Sandalow, "The Geopolitics of Renewable Energy*," Center on Global Energy Policy, Columbia University*, June 2017, http://energypolicy.columbia.edu/publications/report/geopolitics-renewable-energy.

By avoiding GHG emissions, increased shares of renewable energy use would reduce the risks related to conflicts and instability that may arise from climate change. Likewise, renewable energy sources can provide solutions to similar risks that could arise from lack of access to modern energy.

The main issue concerning material supply stems from technical challenges to extract the rare earth metals and their varying concentration that impact the availability and the end-product quality. For example, lithium is the material of choice for today's car batteries, which is a resource that is concentrated in a few countries. It is difficult to judge if this is an issue, since technologies are continuing to evolve, possibly leading to new forms of electricity storage that could replace lithium-ion batteries. Similar considerations apply for other strategic materials that have been identified as potential issues with geopolitical consequences.[20]

"Taking early action is crucial to maximizing the benefits of this energy transition, limiting the planet's temperature rise to 2°C, and reducing the risk of stranded assets."

To improve system flexibility, national transmission grid systems will be increasingly interconnected with each other. While this is favorable from an operational perspective, its geopolitical implications may not be straightforward. Greater interdependence between countries may result in conflicts, and as in the case for gas and oil, electricity importing countries may be subject to geopolitical vulnerability.

How the economies of oil and gas exporting countries will respond to the reducing demand for fossil fuels is a growing concern. Several countries have started diversifying their economies as a result of the decline in revenues from the drop in fossil fuel exports. However, not all countries can carry the capacity to react in the same way, thus changing trade balances may result in political instability.

Some oil and gas countries have been referred to experiencing a "resource curse," meaning their governance and economic systems suffer from limited development, conflicts, corruption or domination by authoritarian institutions. Such countries that lose their revenue benefits from oil and gas exports may be more vulnerable to economic crises, domestic unrest or conflicts in the future. A resource curse may

[20] Dolf Gielen and Değer Saygın et al., "Climate and Energy Challenges for Materials Science," *Nature Materials*, 22 June 2016, https://www.nature.com/articles/nmat4545?draft=collection

also similarly apply to countries which consume and produce renewable energy. Limiting its potential impacts will require steps to strengthen governance capacity and involve all relevant sectors of the economy in the energy transition.

Production of renewable energy technology, its equipment, the related services, and the respective business models will all be of paramount importance to determine how the geopolitics of our new energy system develops. Dependencies between renewable energy producers and consumers, issues with technology transfer, and how business models in the future will look like may result in an extension of today's geopolitical issues.

Turkey's Role in the Global Energy Transition

As a founding member of the OECD and a G20 country, Turkey represents around one percent of the total global primary energy supply. According to its Intended Nationally Determined Contribution, with current and planned policies, Turkey's GHG emissions are estimated to increase by 2.5 times−which reaffirms its status as a fast growing emitter.[21] By comparison, Turkey's mitigation scenario targets a reduction of 21 percent of the GHG emissions, which will double between 2015 and 2030.[22]

Following the global energy transition trend, Turkey has been focusing on utilizing more of its local renewable energy and energy efficiency resources. An ambitious National Energy Efficiency Action Plan to 2023 has been in place since 2018. The plan primarily targets a reduction in total energy demand by 14 percent compared to 2017. The six-year plan is inclusive of all the six sectors that supply and demand energy, covering a comprehensive list of 55 actions.[23]

By the end of 2018, renewables supplied one-third of Turkey's total electricity demand of more than 300 terawatt-hours (TWh).[24] Approximately one-fifth was supplied by hydro resources. Turkey also has significant solar and wind resources. Therefore, its current policies prioritize increasing the share of electricity that is generated from these resources. As a result of the promising developments in its renewable energy sector, Turkey's 2023 renewable energy target has been revised

[21] "Intended Nationally Determined Contribution," *Republic of Turkey*, 30 September 2015. https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/Turkey/1/The_INDC_of_TURKEY_v.15.19.30.pdf

[22] "Brown to Green 2018: The G20 transition to a low-carbon economy. Turkey Country Facts," *Climate Transparency*, November 2018, https://newclimate.org/wp-content/uploads/2018/11/B2G_2018_Turkey.pdf

[23] "Ulusal Enerji Verimliliği Eylem Planı 2017-2023" [National Energy Efficiency Action Plan], *Resmi Gazete [Legal Gazette]*, 2 January 2018, http://www.resmigazete.gov.tr/eskiler/2018/01/20180201M1-1.htm

[24] [Electricity], *T.C. Enerji ve Tabii Kaynaklar Bakanlığı* [Republic of Turkey Ministry of Energy and Natural Resources], 2019, https://www.enerji.gov.tr/tr-TR/Sayfalar/Elektrik

as 38.8 percent in the 11th Five Year Development proposal to the government. A detailed grid integration analysis shows that by 2026, renewables can actually supply half of Turkey's total electricity demand − with 30 percent being represented by wind and solar energy.[25] This will require a flexible power system enabled by energy storage, demand response, and modernized thermal generators.[26]

In view of the other countries' success stories in energy transition, Turkey needs to consider several issues to accelerate its energy transition. Long-term energy planning, while considering the country's national priorities, is crucial to ensure that Turkey reaches an optimal point. The comprehensive plans on both renewable energy and energy efficiency need to turn into actual investments. As renewable energy's share in the power system increases, grid integration policies and measures will be crucial, thus planning needs to go in hand with the overall energy objectives.[27]

Conclusions

Global energy transformation is imperative in achieving the sustainable development goals and reducing climate change. In that regard, renewable energy technologies are the immediate and most cost-effective solution to mitigate climate change. Therefore, renewables must become the main source of power generation, and the share of electricity use must grow substantially in buildings, industry, and transport. Higher renewable energy shares and energy efficiency go hand in hand. Both solutions should therefore be jointly pursued. Today's geopolitical issues that result from climate change and other environmental impacts of fossil fuel use should be resolved with the introduction of higher shares of renewable energy in the energy system.

[25] Philipp Godron and Mahmut Erkut Cebeci et al., "Increasing the Share of Renewables in Turkey's Power System: Options for Transmission, Expansion and Flexibility," *SHURA Energy Transition Center*, 2018, https://www.shura.org.tr/wp-content/uploads/2018/12/SHURA_Increasing-the-Share-of-Renewables-in-Turkeys-Power-System_Report.pdf

[26] Değer Saygın and Mahmut Erkut Cebeci et al., "On the Way to Efficiently Supplying More Than Half of Turkey's Electricity from Renewables: Cost and Benefits of Options to Increase System Flexibility," *SHURA Energy Transition Center*, 2019, https://www.shura.org.tr/wp-content/uploads/2019/05/SHURA_Costs-and-benefits-of-options-to-increase-system-flexibility.pdf

[27] Değer Saygın and Philipp Godron, "Lessons from global experiences for accelerating energy transition in Turkey through solar and wind power," *SHURA Energy Transition Center*, December 2018, https://www.shura.org.tr/lessons-from-global-experiences-for-accelerating-energy-transition-in-turkey-through-solar-and-wind-power/