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Renewable energy for rural development in Turkey

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Abstract

In last three decades, Turkey's rural energy development has achieved some success. The average cooking efficiencies increased from 25% in 1980 to 60% in 2010, more than 99% of townships and villages have electric connection, remarkable progress in biomass, hydropower and other renewable energy also has been made. Since the late 1980s, both the rural economy and rural energy consumption have changed dramatically. In order to reduce dependency on imported expensive fossil fuels, Turkey should be used the renewable energy sources, because they are domestic and abundant. However considering the total cost of renewable energy production, these sources can be used not to replace the fossil fuels, but to supply energy requirement in the country. Renewable energy is being pointed as a potentially significant new source of jobs and climate change mitigation. This paper discusses the status, features, and trends, as well as technical potentials of renewable energy for rural development in Turkey. The present study also shows that there is enough renewable potential for meeting the country energy and electricity demand.

Keywords: energy demand, renewable sources; rural energy; sustainable development.

1. Introduction

The rise of renewable energy is driven by dramatically falling renewable energy costs across the technology spectrum. Since 2009, solar PV module costs have fallen by more than 80%. The power generated by solar PV declined by 73% between 2010 and 2017. Onshore wind costs have also fallen sharply. The global weighted average cost of electricity from onshore wind fell by 22% between 2010 and 2017, making it one of the most competitive sources of electricity available today. The cost declines do not end there. By 2020, the average cost of power generation from all commercially available renewable energy technologies will be competitive with fossil fuels [1-4].

Renewable energy needs to be scaled up at least six times faster for the world to meet the decarbonisation and climate mitigation goals set out in the Paris Agreement. The historic 2015 climate accord seeks, at minimum, to limit average global temperature rise to "well below 2°C" in the present century, compared to pre-industrial levels [1]. Renewable energy and energy efficiency can, in combination, provide over 90% of the necessary energy-related CO_2 emission reductions. Furthermore, this can happen using technologies that are safe, reliable, affordable and widely available. While different paths can mitigate climate change, renewables and energy efficiency provide the optimal pathway to deliver most of the emission cuts needed at the necessary speed [1]. Actual carbon dioxide (CO_2) emission trends are not yet on track. Under current and planned policies, the world would exhaust its energy-related carbon budget in less than 20 years. Even then, fossil fuels such as oil, natural gas and coal would continue to dominate the global energy mix for decades to come [1, 2].

The total share of renewable energy must rise from around 20% of total final energy consumption in 2018 to around two-thirds by 2050. Over the same period, the share of renewables in the power sector would increase from around one-quarter to 85%, mostly through growth in solar and wind power generation. The energy intensity of the global economy will have to fall by about two-thirds, lowering energy demand in 2050 to slightly less than 2015 levels. This is achievable, despite significant population and economic growth, by substantially improving energy efficiency, the report finds [1].

Turkey is a poor fossil energy country; 75% of total energy requirement has been supplied by imported fuels as shown in Table 1. As shown in Table 1, Turkey's energy production is only 35 374 kilotons of

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oil equivalent (ktoe) while energy consumption was 136 230 ktoe in 2016. Petroleum, gas and coal have the biggest share in total energy consumption as shown in Table 1. If we look to the Table 1, we saw that only 25% of the total energy consumption supplied by domestic resources. It means that Turkey is an energy imported country and it should pay a lot of money for buying these fuels. Therefore, the governments and private sector companies should use domestic and clean renewable energy sources as soon as possible [5-20].

Table 1. Turkey's energy situation in 2017 (ktoe)

Energy source	Production	Consumption
Coal and Lignite	14 470	38 824
Oil	2 682	44 536
Natural gas	430	45 872
Hydropower	5 112	5 112
Geothermal	7 124	7 124
Bioenergy	2 536	2 536
Solar/Wind/Other	2 754	2 754
Total	35 108	146 758

ktoe: kilo tons of oil equivalent

In Turkey, energy utilization for industry and heating purposes is increasing very fastly in recent years. Thermal power plants are also use commercial fuels such as hard coal, natural gas and coal/biomass co-firing [12]. Diesel engines are widely used for pumping and irrigation in the rural areas instead of renewable energy. Therefore large capital costs are paid for diesel engines [13]. But, substitution of renewable electricity from solar and wind instead of diesel engines appears to be practically possible. Solar energy and biogas may be an alternative energy source for space heating in rural regions [10-20].

2. Status of rural energy development

Provided the background conditions are right, one of the most powerful ways to improve energy supplies is to ensure that the energy market is determined by consumers' choices. In particular that means both that the price of energy should reflect its cost and that regulation of energy industries should encourage competition and choice. Governments should concentrate on ensuring that there is a level playing field for different investors in energy, whether they are public utilities, private firms, or enterprises set up by the local community [3, 20].

The opposite has been true in most developing countries. Rules and regulations have strangled the emergence of firms other than the state-run utility. For example, it is illegal in many countries for local private or cooperative non-grid-connected generation and distribution enterprises to enter the market [1]. Many government programs have attempted to extend energy supplies to rural areas. But too often the result has been unsustainable public institutions promoting technologies that are unsuitable for rural consumers [2].

Subsidies for electricity consumption are a particular problem. In the early 1990s average electricity tariffs in developing countries were less than US¢4 per kilowatt hour (kWh), even though the average cost of supply was around US¢10 per kWh. Such subsidies are harmful in a host of ways. They constitute a huge financial drain. As a result utilities are often economically crippled, unable to finance the extension of services to rural areas [1]. Where supplies have been extended to rural areas, subsidies often undermine the efforts of businesses to provide cheaper ways of generating electricity. In remote rural areas, for example, diesel engines or solar photovoltaic (PV) systems may provide electricity at a lower cost than grid supplies. But consumers will not opt for them if grid supplies are subsidized, nor will investors come forward to develop least-cost options to serve rural consumers [1-3].

Overall subsidies on energy consumption tend to benefit rich people more than the poor. In some poor developing countries showed that high-income households benefit disproportionately, largely because they use more electricity. In Malawi, for example, a poor consumer on average receives a mere US¢4 a year in electricity subsidies, while a rich one gets US$6.60. Some subsidies may be justified–but only if they are limited to specific and affordable goals, such as providing cheaper rates for very poor households for a fixed maximum consumption per month [1, 2, 3, 20].

Hefty subsidies for modern cooking fuels, such as kerosene and LPG, are also common in a number of developing countries [1]. As with electricity, the results are often counterproductive. In Indonesia, for example, kerosene used for cooking and lighting is subsidized. But richer households reap a disproportionate share of the benefits because they can afford to buy more energy than the poor [2]. The government of Ecuador also subsidized kerosene until recently. But the poor received little of the fuel because retailers could make more money selling it for use in vehicles. Even if subsidies reach the poor they often become unsustainable financial burdens on the state budget. Senegal's annual subsidies for LPG, for example, rose from US$2 million to US$10 million between 2000 and 2014 an increase that could have paid for thousands of desperately needed teachers [1-3, 6-10, 20].

Market-opening reforms can be dramatically effective, as shown by the experience of Diyarbakır, Urfa, Maraş, Van, Siirt and Hakkari in Turkey. In 2010, for example only the richest 10% of households in these provinces used LPG. The proportion has since risen to over 60%. Meanwhile fewer households are using fuelwood even though the city's population has doubled since 2000. The main cause of the change was the liberalization of energy markets. In particular, the Turkish government relaxed restrictions on the production and import of LPG. As a result more middle-class households could buy LPG, a more efficient fuel than kerosene. That in turn allowed the poor to graduate up the fuel ladder from wood to kerosene [6, 13, 18].

In last three decades, Turkey’s rural energy development has achieved some success. The average cooking efficiencies increased from 25% in 1980 to 60% in 2010, more than 99% of townships and villages have electric connection, remarkable progress in biomass, hydropower and other renewable energy also has been made. Since the late 1980s, both the rural economy and rural energy consumption have changed dramatically. The amount of energy consumption for production increased from 30% of total rural energy consumption in 2000 to 65% in 2010 while the amount of biomass energy consumption decreased from 20% in 2000 to 12% in 2012. Because the share of Liquified Petroleum Gases (LPG) for household cooking purposes is increasing continuously in rural region of Turkey. According to the researchers, the fossil fuel should be a main energy source for rural energy consumption in 2030, the share of biomass energy and renewable energy should be less than 10% of total rural energy consumption [3, 6, 10, 12, 13, 18].

Turkey has experienced remarkable rates of industrial and economic growth over the past several decades. After the establishment of the Republic of Turkey, the Turkish governments took significant steps focused on the industrial development of the country. These continue today with Turkey averaging 6% economic growth rates per year. Recognizing the successes of other developing countries, the Turkish government focused on rural electrification programs as a means of stimulating industrial growth and movement towards further modernization. Since the inception of efforts at rural electrification, Turkey has been successful in electrifying 100% of its population. This was accomplished while maintaining high rates of growth and improved human development indicators, like literacy and infant mortality rates, as well as per capita income. Because of Turkey’s electrification programs, it has achieved incredible success in moving towards its own development goal, as well as those of the United Nations Millennium; however, there is plenty of room for improvement. As a result of its high reliance on coal to generate electricity, Turkey has some polluted cities. In these cities, air and water quality have suffered significantly. In order to maintain the economic growth that electrification has brought and to establish sustainable development, Turkey must take stronger initiatives to increase the development of renewable energy sources like wind, hydroelectric, geothermal and solar/photovoltaic power. As well, legislation must be introduced that limits pollution and limits the initial costs of renewable development [3, 4, 7, 12, 13, 17, 18].

3. Renewable energy in rural region of Turkey

3.1. Energy and renewables

Energy is central to human development [1]. It accelerates social progress and enhances productivity. Without the provision of and access to clean, reliable, and affordable energy services, other economic and social development goals cannot be achieved. Energy directly affects people, communities and countries in terms of economic growth, health, security, environment, education, and employment [2]. Although most countries in Europe and Turkey provide access to the electricity grid and gas distribution networks for most citizens and businesses, the challenges they face related to sustainability, efficiency and reliability of modern energy services are complex [3]. The challenges associated with sustainable energy are not primarily about physical access to the electricity grid or gas distribution network. They are mostly related to the inefficient use of energy, frequent power cuts, increasing energy costs, sustainable and affordable heating in winter, and the slow uptake of renewable energy. As the 17th largest economy in the world and 6th largest in Europe, Turkey is experiencing an increase in its energy demand. Turkey has become one of the fastest growing energy markets among the OECD countries in the world, in parallel to its economic growth registered over the last ten years. Also, Turkey has been second largest economy on demand for electricity and gas after China. Projections performed by Ministry of Energy and Natural Resources confirm that this situation will continue to be valid for medium and long term [4].

Turkey's energy policies and strategies are based on energy supply security, alternative energy resources, diversity of energy resources, utilization of domestic energy resources to create additional value to economy, liberalization of energy markets, and energy efficiency. Due to this perspective, special emphasis has been made to maximum utilization of local and renewable energy resources as highest priority. On the other hand, the rapid pace of urbanization, the positive demographic trends, the economic expansion and rising per capita income are the main drivers of the energy demand. The energy demand is estimated to increase around 4 – 6% per annum until 2023 [11-13].

The Turkish government has made it a priority to increase the share of renewable sources in the country's total installed power to 30 percent by 2023. Renewable energy has been one of the important topics on Turkey's energy agenda. The Turkish government has made the last decade significant energy reforms. The significant progress that has been made in the field of renewable energy started after the enactment of the Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy (Renewable Energy Law, REL) in 2005. After 2005, the Turkish government kept producing, updating and implementing several laws and regulations. Due to this, Turkey's energy sector turned it into one of the most attractive investment destinations in the world. In line with the implementation of investor-friendly regulations and the high increase in demand, the Turkish energy sector is becoming more vibrant and attracts the attention of more investors for each component of the value chain in all the energy sub-sectors [4, 9, 12, 13]. According to the Ministry of Energy and Natural Recourses, the total amount of investments required to meet the energy demand in Turkey by 2023 is estimated to be around USD 110 billion, more than double the total amount invested in the last decade. Turkey's ambitious vision for 2023, envisages especially interesting targets for the renewable part of the energy sector. These targets include [8-12]:

- 34,000 MW capacity of hydro power plants;
- 20,000 MW capacity of wind power plants;
- Minimum 5000 MW of solar power plants;
- Minimum 1000 MWe geothermal energy; and
- 1000 MWe installed capacity for Biomass energy.

Turkey has enough renewable energy such as hydro, biomass, solar, wind and geothermal energy (Tables 2-5 and Figs. 1-5). In recently, electricity generation from renewable sources is increasing steadily, especially solar and wind has more and more attention, after renewable energy law published by the Turkish government. Table 2 shows Turkey's installed capacity and generation development by sources in 2017. As shown in Table 2, the share of renewables about 43% (84 800 GW_h) and the part of hydropower is highest (20%). Table 3 also shows Turkey's installed capacity targets for renewable power plant from 2017 to 2023. As shown in Table 3, the amount of installed capacity is increasing steadily from 39 960 MW in 2017 to 66 500 MW in 2023 [12, 13, 17, 19].

Table 2.Turkey's installed capacity and generation development in 2017 (GWh)

Resources	Installed Capacity (MW)	Share (%)	Generation (TWh)	Share (%)
Natural gas	26 638	31	108.1	37
Hydropower	27 273	32	58.3	20
Domestic coal	9 872	11	44	15
Import coal	8 794	10	51.1	17
Renewables	11 000	13	26.5	10
Other	1 623	3	7.5	1
Total	85 200	100	295.5	100

Table 3. Installed capacity targets for renewable power plants

	Installed capacity (MW)		
Resource type	2017	2019	2023
Solar power	1 800	3 000	10 000
Geothermal	420	700	1 500
Biomass	540	700	1 000
Wind power	9 500	10 000	20 000
Hydropower	27 700	32 000	34 000
TOTAL	39 960	46 400	66 500

3.1. Hydropower

In Turkey, potential of hydropower is very high and especially small-scale hydropower plants can be used to produce electricity in rural areas. Hydropower is the second largest source to generate electricity after the coal and provide around 40% of the electric energy in Turkey. The theoretical viable hydropower potential of the country has been estimated at 433 TWh/year, but economical potential was only 215 TWh/year. In 2017, the total hydropower installed capacity was 27 274 MW and total generated energy was 58 3000 GWh in Turkey [10-14]. As one of the most suitable and applicable rural energy sources, the small hydropower (SHP) performs a major role in the advance of agricultural modernization and rural electrification in Turkey. It is estimated that, Turkey has 910 GW electricity generation and 4686 MW total installed capacity for SHP. By the end of 2017, the total number of SHP stations in operation throughout the country was 157 with a total installed capacity of 1 360 MW in Turkey. Table 4 shows the small hydropower capacity. In 2017, total hydropower capacity is 29 000 MW and only small hydro power capacity is 4686 MW [17].

Table 4. SHP plants (below 10 MW) by stage of development in 2017

License type	Stage	Capacity (MW)	Number of power plants
Pre-License	Application stage	1064	240
	Evaluation stage	68.3	18
	Granted	389.6	84
	Granted	2687.8	479
Total		4209.7	821

The South-eastern Anatolia Project (GAP) is one of the largest power generating, irrigation, and development projects in the world and covering 3 million ha of agricultural land. The GAP project on the Euphrates and Tigris Rivers encompasses 20 dams and 17 hydroelectric plants. Once completed, 55 billion kwh of electricity will be generated annually which is 45% of the total economically exploitable hydroelectric potential [5-9]. The rate of physical realization in GAP energy projects is 74%. The total installed capacity of 10 HPPs now in operation is 5,530 MW and annual electricity production potential is 20.6 billion kWh. The total energy output of HPPs under GAP from their first operation up to the end of 2013 is 392.1 billion kWh which means 23.5 billion $ in monetary terms. Hydraulic plants in the region account for half of annual energy production in Turkey and the GAP contributes directly to national economy with its energy projects (Table 5).

3.2. Biomass

Turkey has a sufficient bioenergy potential, but plant and animal wastes sometimes will be required to minimize collection and supply chain risks in rural Turkey [4, 13]. Turkey's current installed biomass capacity is 130 MW_e. Turkish biomass market has a good chance of reaching several hundred MW_e installed capacity in the near future [11-13]. Figure 1 shows electricity generation capacity from crop residues in Turkey [10]. Turkey has about 21,7 million hectares of forest area (about 27,2% of country's land area) [18]. A similar share is occupied by pastures and grasslands. The consumption of woody biomass has decreased from 22 to 10% because the consumption of liquefied petroleum gases (LPG) is increasing continuously. It is easy to transport and ignite, and in addition it is a clean fuel [18]. The annual biomass energy potential of Turkey has been estimated to be 33 Mtoe and the yearly biomass consumption was 2.54 Mtoe (Table 1).

Table 5.Electricity production by dams in the GAP region since their first operation to 2012

Hydraulic Power Plant (HPP)	Plant Type	Installed capacity (MW)	Operating Since	Total Electricity Production (kWh)
Atatürk Dam and HPP	Reservoir	2 400	1992	157 642 587 790
Karkamış Dam and HPP	Reservoir	190	2000	5 561 000 275
Şanlıurfa HPP	Canal	50	2006	932 839 611
Karakaya Dam and HPP	Reservoir	1 800	1987	190 909 871 299
Kralkızı Dam and HPP	Reservoir	94	1999	1 672 316 722
Dicle Dam and HPP	Reservoir	110	2000	2 777 925 211
Batman Dam and HPP	Reservoir	200	2003	3 885 089 279
Cağcağ HPP	Canal	15	1968	1 476 129 990
Erkenek HPP	Canal	12	1972	15 410 355
Birecik Dam and HPP	Reservoir	672	2000	27 220 970 225
GAP Total		5 540		392 094 140 757

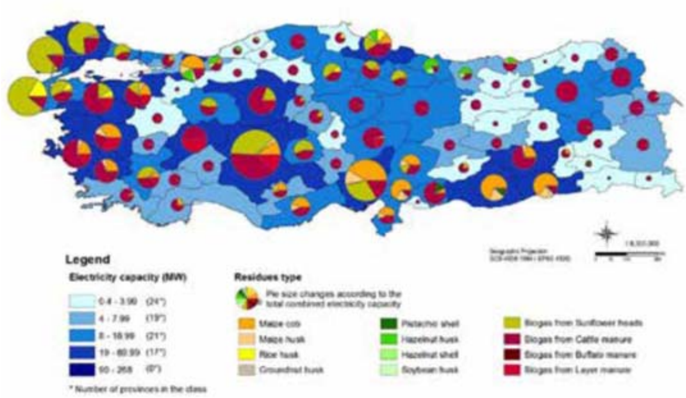

Figure 1. Electricity capacity generation (MW) from crop residues in Turkey.

3.3. Solar energy

Turkey has significant renewable energy (RE) potential, including solar, mainly as a result of its geographic location. Taking advantage of this potential will decrease the country's dependence on imported fossil fuels as well as reduce greenhouse gas (GHG) emissions. Recognizing this, the government has established a target of at least 30% (or 127.3 TWh) of the total electricity generation from RE by 2023. In addition, it has set targets of 3 GW of installed solar power by 2019 and 5 GW by 2023. As a result, the solar market in Turkey has grown exponentially over the last few years, with installed solar capacity growing from 40 MW in 2014 to 3,421 MW at the end of 2017 [13, 17, 19].

Solar energy potential of Turkey is well since it located geographically in a region called the "solar band". The government's general directorate of renewable energy (YEKA) estimates that Turkey receives, on average, 1.02 million TWh/year of solar radiation each year. Turkey's average annual total sunshine duration is calculated as 2640 h (daily total is 7.2 h), and average total irradiation as 1311 kWh/m².year (daily total is 3.6 kWh/m²) as shown in Figure 2. As shown in Figure 2, Mediterranean and Southeastern regions have the highest solar energy potentials with 1460 kWh/m^2·year and sunshine duration of 2993 hours per year.

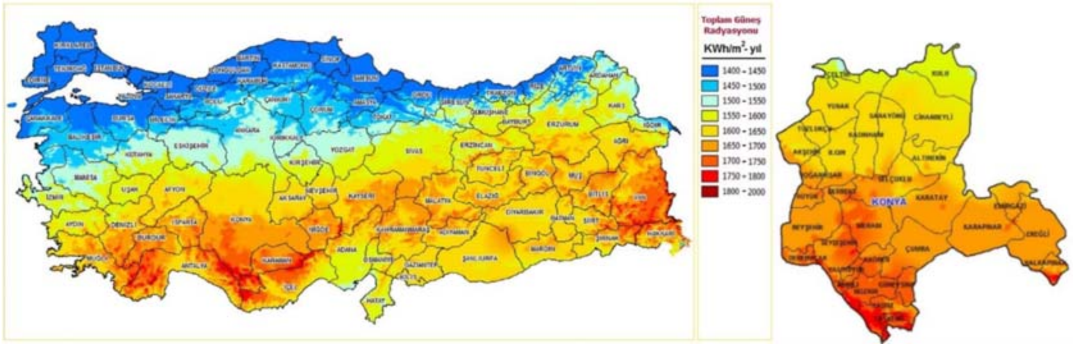

Figure 2. Solar energy potential in both Turkey and Konya provinces.

In Turkey, about 1.9 million m² of collector area is installed in 2014 and country has reached total area of 18 million m^2. Figure 3 shows solar collector market in Turkey as a installed thermal capacity (MW_{th}). As shown in Figure 3, the amount of collector thermal capacity increased from 300 MW_{th} in 2004 to 1300 MW_{th} in 2014 [13, 17]. In Turkey, multi-family houses were considered as the fastest-growing segment in solar thermal market, as stated by 52% of the survey participants. Another 17% considered single-family houses to be the most important segment, 14% opted for the tourism sector, 10% for the public sector and 7% for industrial process heat [13, 17].

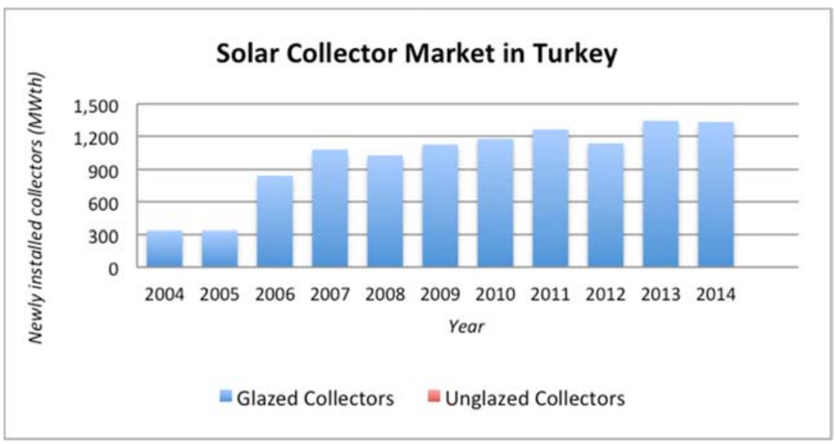

Figure 3. Solar collector market in Turkey

The solar boom in Turkey has been primarily limited to larger projects. Most of them are, however, under 1.0 MW in size in order to take advantage of the unlicensed feed-in-tariff schemes. In contrast, in countries with more developed solar markets, such as Germany, the United States and Japan, a significant portion of solar capacity is produced by rooftop solar photovoltaic (RSPV) applications with 1.0 kW to 10 MW capacities. Given the fast pace of urbanization and corresponding residential, commercial and industrial markets, this study concludes that there is a significant potential for RSPV deployment in Turkey. A first-order assessment of the RSPV market potential has been carried out at by the Directorate General for Renewable Energy (YKA) with financial and technical support [17].

3.4. Wind energy

In 2017, Turkey added 766 MW and bringing the country's total wind power capacity to 6,857 MW. Addition to this situation, marked a turning point for Turkey's wind industry: 2.11 GW were issued preliminary licences for 67 wind projects by Turkish electricity transmission operator TEIAS [18]. This completed a round which had started in June 2017 with the assignment of 710 MW of so called pre-licences projects. In addition, the country's first wind tender was held in August, where 1 GW of onshore wind capacity was allocated under Turkey's Renewable Energy Sources Department (YEKA) renewable program. Recently Turkey's energy and natural resources ministry also announced its plans to start offshore wind development to boost the country's renewable energy capacity. The ministry has identified potential zones for the country's first offshore wind tender. Figure 4 shows Turkey wind energy potential atlas [12-14].

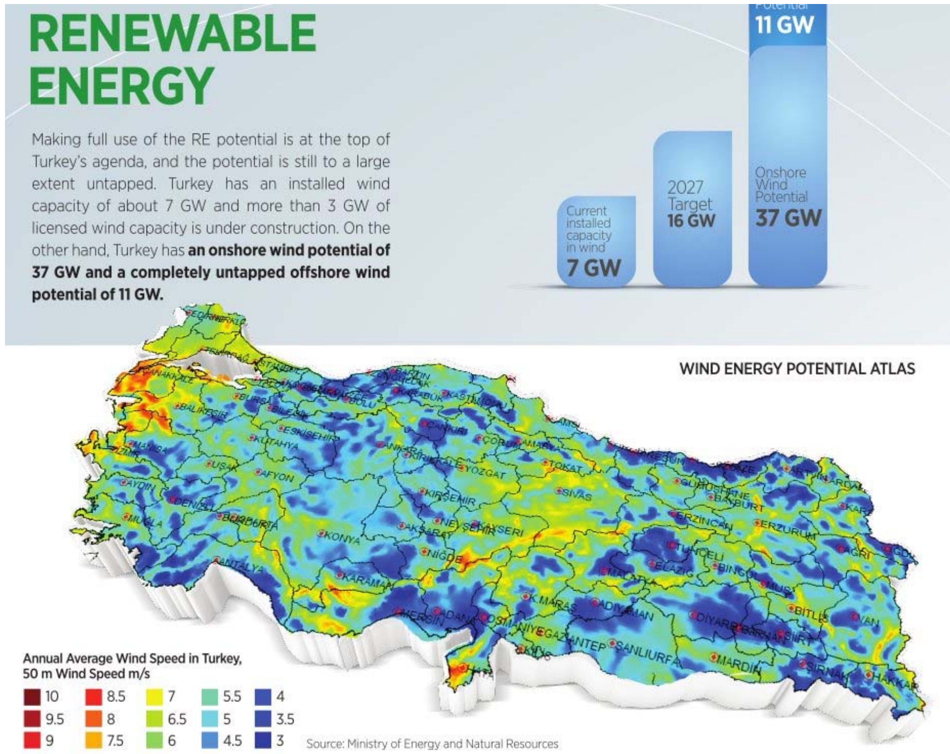

Figure 4. Turkey wind energy potential atlas.

3.5. Geothermal energy

Turkey's geothermal energy potential is well and a significant development was achieved geothermal electricity production and direct uses during last ten years. Geothermal Law published by the government and its regulations accelerated the geothermal activities. So, direct-use applications have reached 2886.3 MW_t and including district heating (805 MWt), 3 million m^2 greenhouse heating (612 MW_t), thermal facilities, hotels heating 420 MW_t, balneological use (1,005 MW_t) and heat pump applications (42,8 MWt). Geothermal electricity production has reached to 400 MW_e with 17 power plants. The geothermal power plants install capacity under construction is 165 MW_e. Figure 5 shows geothermal resources in Turkey [15, 16]. Table 6 also shows the potentials for renewable investment in Turkey.

Table 6. Potentials for investment for renewable energy technologies in Turkey

Sectors	Million $	Remarks
Hydroelectric	120	Economical development potential of 28,400 MW, Corresponding 100,000 GWh/a
Wind power	72	Economical development potential of 48,000 MW With wind speed > 7 m/s
Solar thermal	170	Economical development potential of 131,000 GWh/a, Corresponding to approx. 300 million m^2 collector area
Bioenergy	15	Agricultural residual material and dung, when used for electricity generation, 1,000 MWe and 7,000 GWh/a
Total	377	

Figure 5. Geothermal resources in Turkey

5. Conclusions

Turkey has the challenge to decrease its energy dependency, fulfill the huge growth in the energy demand but at the same time reduce the GHG emissions as mentioned in the Paris Agreement. The current plans for generation are mainly based on the addition of coal and gas power plants and would lead as we can see in the baseline scenarios to a huge increase in the GHG emissions as well as the imports of crude oil and coal.

A shift toward renewable energy technologies is expected with the GHG mitigation scenario. This scenario is quite ambitious in term of added capacity but the investment costs are actually lower than the nuclear scenario. The addition of capacity stops after 2023 since the government plan is only for the period 2013 - 2023 which explain why this scenario has higher GHG emissions than the nuclear scenario but the government should keep on the same pace for additional renewable plants for the period 2023 – 2040 since the plans are currently not enough.

Beside all of this Turkey should of course also focus on reducing its energy intensity to decrease the pressure of energy generation. Turkey should shift to both renewable and nuclear energy in order to lower its GHG emissions, more detailed plans should be set to satisfy the aim the government set for the future. Renewable and nuclear would also lower the imports of Turkey which would benefit the country because they are currently highly dependent on other countries.

Where renewable energy deployment in rural areas is largely incentive-driven, it is unclear if deployment levels can be maintained once current public incentives are phased out. In this context, specialisation in the production of renewable energy responds to the economic opportunities associated with public incentives, rather than a demand for additional energy. It seems that public incentives are not catalysing a regional specialisation, but rather entirely supporting it. There is the risk that rural economies enjoying the “boom” of renewable energy might experience a “bust” once public support expires. In this case, the policy question is how to orient and use public support in a way that can trigger regional specialisation without creating long-term dependence on public money.

Some intensive renewable energy installations can compete with tourism activities. While wind turbines can be compatible with farming activities, their impact on landscape can be intense. In reality it is very difficult to assess the real impact of wind turbines on landscape values in an objective way. To some, they are a symbol of sustainable development – to others, a blot on the landscape. None of the case studies revealed clear damage caused by renewable energy installations to tourism, but this could also depend on the relatively short research period (two years) and on the lack of precise information. One of the problems is that wild, remote, scenic areas often tend to also be windy and sparsely populated. In this context, overly high subsidies to wind energy could shift the balance in favor of wind power, despite local opposition of local communities and the potential damage to tourism activities.

Many rural areas have surplus renewable energy resources, while urban areas lack sufficient space and resources to meet their energy needs through renewable energy. Without sufficient grid capacity to transport electricity from rural regions to urban consumption centers, many projects will struggle to find funding, as their revenue potential is limited to local demand. In some instances, rural areas may prefer to concentrate on meeting local demand before connecting to a grid. Another option would be to use high feed-in tariffs to cover part of the cost of developing a “smart” and diffused grid.

Renewable energy policy is expected to deliver in three areas: energy security, climate change mitigation, and economic development. However, this is not always the case and there can be significant trade-offs among them. For instance, large biomass heat and power plants can generate new employment opportunities in rural communities, but may have a negative CO_2 balance due to land-use change and transportation of feedstock over relatively long distances. Similarly RE is in most instances a capital-intensive activity, and energy as a whole represents a small share of employment in regional economies. Small-scale installations typically source labor and equipment from suppliers, and some of the factors helping renewable energy in achieving its three goals. Focusing on ensuring the supportive ingredients are present will be a step forward in putting renewable energy to work in rural communities.

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