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Towards a Cleaner and Developed World: A Birds Eye view on Renewables Distribution and Strategy Around the World

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Abstract: *This paper gives a bird's eye view on the allocation of renewable resources across the world using the data from IRENA (International Renewable Energy Agency) from 2000 to 2019. It depicts many graphs for major countries and regions on how to develop renewables and thus address policy suggestions with a focus on renewables and so fossil fuels can exit the market.*

Keywords: *Renewables, Energy Structure, Panel Data Studies*

As is mentioned by Jevgenijs Steinbuks and Thomas W. Hertal (2014), the Energy Information Administration (EIA) has high fossil fuel price changes projected for 2035 and the Annual Energy Outlook they published in 2021 has stated that by 2035, climate change will impact many countries and thus make the human beings realize the importance of developing cleaner resources. Renewables are not depletable and can be put in industrial use in this matter. Major forms of renewables include Hydro Power, Marine, Wind, Solar, Bioenergy and Geothermal, each enjoys certain lab features or natural application advantages or disadvantages.

For example, hydropower is expensive to prepare in lab but in reality, faces possibility of explosion, if not pure. Marine power is also expensive to capture through tidal power stations, compare to the current existence of fossil fuel power plants and the current electricity prices based on it. Wind power station has established in vast areas of the U.S., Germany, China, India, Spain, Britain, France, Brazil, Canada, and Italy and has received good commercial prospects. Solar requires the construction of solar photovoltaic board (namely certain plastic) and has also been commercialized in certain countries with climate feasibility infrastructure especially in Germany, U.S.A., China, South Asia and so forth. Bioenergy requires good technology on wood so the organic materials including wood, straw, sugarcane, can be converted to LC methanol and be used as fuels. It is believed that the insitu of bioenergy is 2 times larger than the current consumption of it. Geothermal, despite its existing minor application on underground water and the hot springs, also faces the hardship to capture as its existence is often close to where volcanoes and earthquakes happen. According to the Geothermal Resources Council (GRC), only 18 countries have geothermal electricity generation infrastructure with total capacity of 5827.55 gigawatts. Major countries whose capacity exceeds 100 gigawatts are the U.S.A, Philippines, Mexico, Italy, New Zealand, Japan, and Indonesia. Other major countries and regions developing geothermal are Turkey, Iceland, Kenya, and Taiwan.

This paper gives a bids eye view on the allocation of renewable resources across the world using the data from IRENA (International Renewable Energy Agency) from 2000 to 2019. It depicts many graphs for major countries and regions on how to develop renewables and thus address policy suggestions with a focus on renewables and so fossil fuels can exit the market.

1. Background: From Fossil Fuel to Renewables: 25% to 65%

The world will witness a transition from fossil fuels to renewables taking place right now. With both planned and the transforming energy scenarios, renewables will take 27% and 65% of the entire energy supply side. This is saying that we need to transform to a cleaner environment faster with the R&D and the commercialization of renewables. Two scenarios planned and transforming scenarios are introduced by the IRENA as the projection methods.

For transforming scenario, renewables need to take place of the whole energy supply from 17% to 65%, this is saying that the application of renewables has a long way to go in every applicable country.

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On demand side, renewables can be applied onto industries, buildings, transportation, and other sectors. They are mostly used for infrastructure building, industrial application, and transportation fuel. As is depicted in figure 1, the broad application prospect of renewables, is just around the corner.

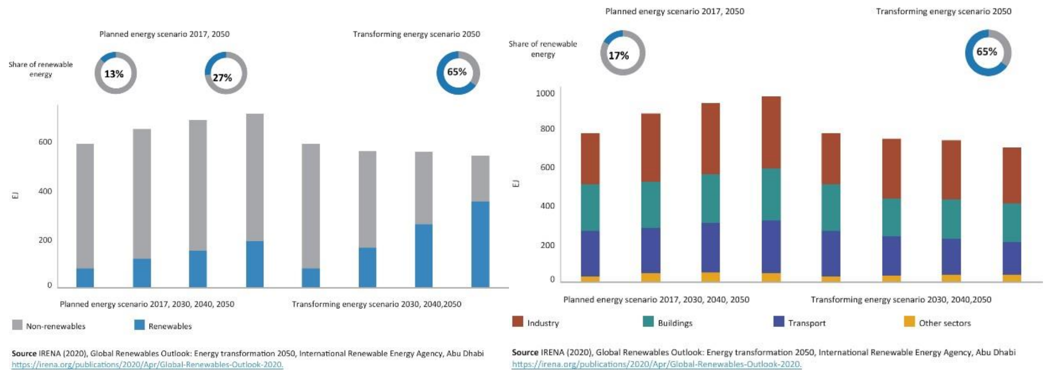

Figure 1. Energy Supply and Demand of the World with Transition Scenarios of 2017, 2030, 2040, 2050

Current electricity capacity and electricity generation is an important application of renewables. Transforming the renewables to electricity powers the human beings. For existing capacities (i.e., the infrastructure built within certain forms of renewable), fossil fuels still have more than 60% but for planned scenarios, we need more wind energy infrastructure and solar PVs and also hydropower plants to make the transition happen. Currently fossil fuels, with 4415 gigawatts in 2017, take 67% of the total 6466 gigawatts of the electricity generation. Similar is for the electricity generation, 19224 TWh out of 35935 TWh electricity current is generated by the fossil fuels, taking 75%. How to lower the use of fossil fuels become a critical topic worldwide. Solar PV, Onshore wind and hydropower thus become the main drive forces of increasing the application of renewables.

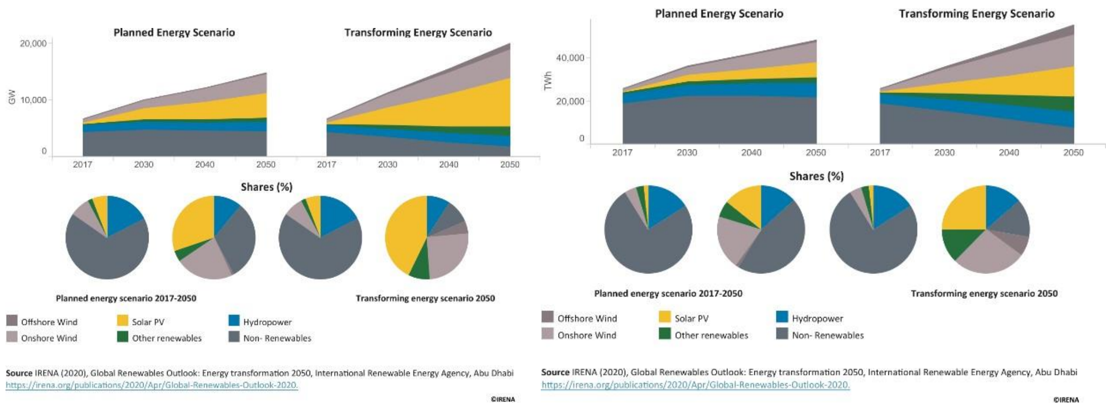

Figure 2. Electricity Capacity and Generation by Renewable Types under Planned and Transforming Scenario

Money can be spent on increasing the application of renewables. However, each country/region has different status quo which binds their investment on each forms of renewables. This is deeply rooted in each country's culture, history, and the path dependence. Take the investment need for example, from 2017 to 2050, the world needs not supply-side investment but more on the renewables, energy efficiency and electrification of heat and transport. In contrast, grid build and power generation from fossil and nuclear should be reduced. For North America, this is similar as the need for renewable and air conditioning and transportation investment is booming. North America needs better electricity efficiency too.

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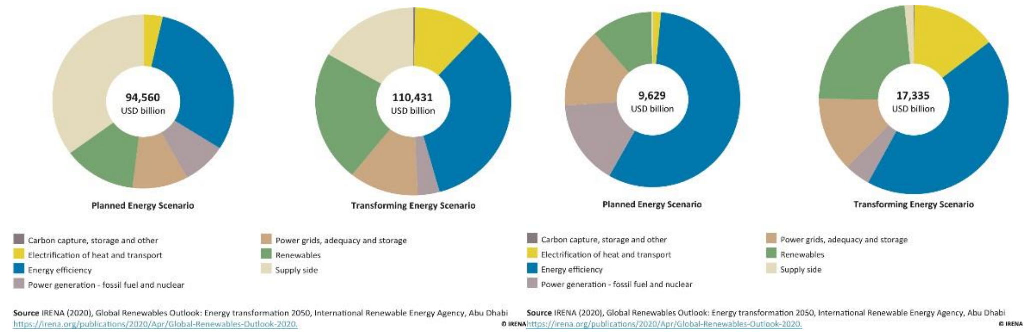

Figure 3. World and North America: Cumulative Investment Need from 2017 to 2050 under planned and transforming energy scenario.

For CO2 emissions of each terminal sector, we can also see the planned and transforming energy scenario. With transformation from fossil fuels to renewables, the CO2 emission clearly goes down.

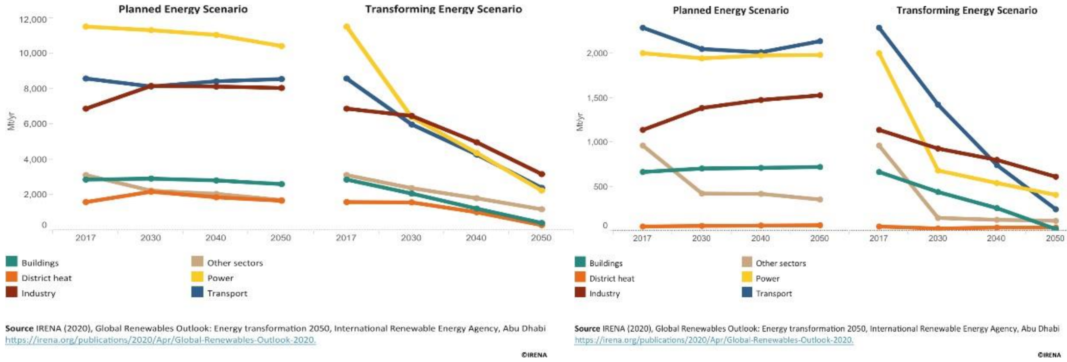

Figure 4. World and North America: Sectoral CO2 Emissions 2017 to 2050 under planned and transforming energy scenario.

For 2018: Total Energy by cap globally, is about 9424060MW to 15707100MW, approximately, and 7065195MW to 13351035MW are from Fossil Fuels. In this case, we have a long way to go to transit to renewables.

2. Heterogeneity of Renewables: Capacity & Generation with a focus on Capacity

We have seen an urgent transition between the fossil fuels to the renewables, as mentioned previously. However, as each country has different status quo on infrastructure, it is relatively different to find a one-size-fits-all solution for policy makers to see the different structures when developing renewables. For example, although development correlates firmly with the income- level and technological advantage, (as we see in the following graphs, EU, U.S. and Russia, China are mostly leading R&D roles in renewables), Brazil, Pakistan, and Mexico, along with the already developed Oceania countries, are notably specialized in bagasse biofuels. Meanwhile, Japan, Chile, Malaysia, and Kenya are particularly excellent in capturing geothermal energies within the only 18 cohorts who are able to research in this realm. However, for hydrogen energy, almost every country that has some technology is interested in its R&D, not to speak of the developed ones, but in middle Asia we can see Mongolia, India, Kazakhstan, almost all coastal Africa, all most all south America, south Asia have some capacity of developing hydrogen. This gives us a thought on capturing the heterogeneity as well as the homogeneity of each country's step-in leaping towards the electrification of renewables, in replacement of the fossil fuels.

By using the geographical illustration of the data provided by IRENA from 2000 to 2018, we could depict the capacity and generation of different forms of renewables by its absolute number. Here capacity means the infrastructure built to generation electricity, so the unit measurement is MW (megawatt), and the generation is the quantity of the electric current flow, so the unit measurement is kilowatt times hour (kw ħ) . Roughly, we can draw based on the data using Microsoft Navinfo with our data to get an intuitive view on the capacity and generation from the renewable resources:

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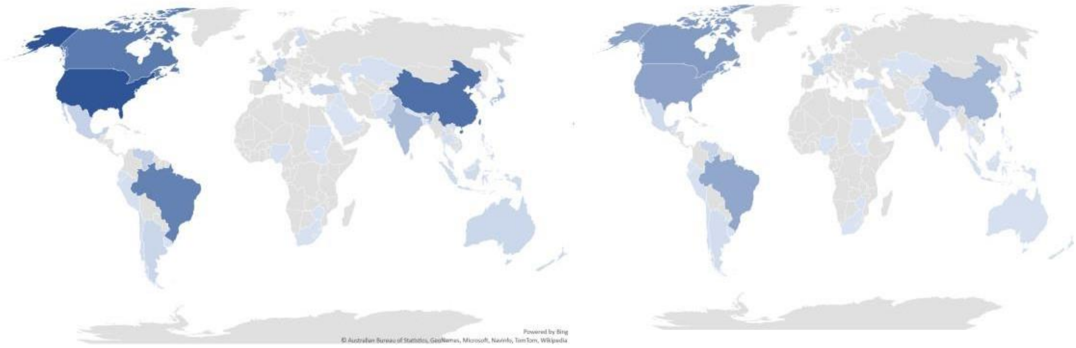

Figure 5. Electricity cap and generation by renewable resources in 2018 (world, 17%-27% of the total: 2356065MW)

2.1 Hydro power: 50.38%, Attention-attractive, easy to Explode.

Hydro power is considered cleanest and idealistic power as after combustion the only left-out is water. The world is attracted by finding good pure H2 source while reducing the carbon emissions or furthermore, completely drop out the C-atom in fossil fuels. 1295019MW are produced from Hydro power in 2018 globally, taking more than half of the renewables. The R&D of hydrogen power is also of great importance globally.

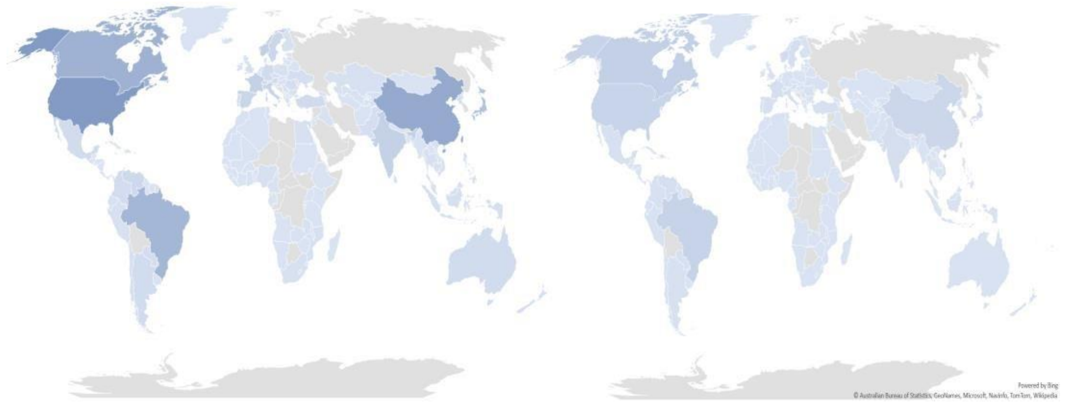

Figure 6. Electricity cap and generation by Hydropower in 2018 (world, 50.38% of the total: 1295019MW)

The distribution of hydropower consists along with the homogeneity of our common sense on income distribution and many other indicators of assessing the successfulness of different economies. The power of hydrogen is usually categorized into renewable hydrogen and pumped storage hydrogen.

The difference between renewable hydrogen and Pumped Storage Hydrogen (PSH) is that the renewable is usually lab-based and connects jointly with another form of resource so electrolysis could happen continuously and H2 can be created renewably. This form of producing H2 requires strict lab and field safety. The common knowledge is that the mixture of H2 and the air with a H2 density of between 4% to 74%, will cause serious damage by explosion. Although current lab and industrial facilities can already collect the pure H2 using drainage gas collection method, it still requires good lab and industrial management. However, once industrialized, it is the cleanest and greenest form of hydrogen energy.

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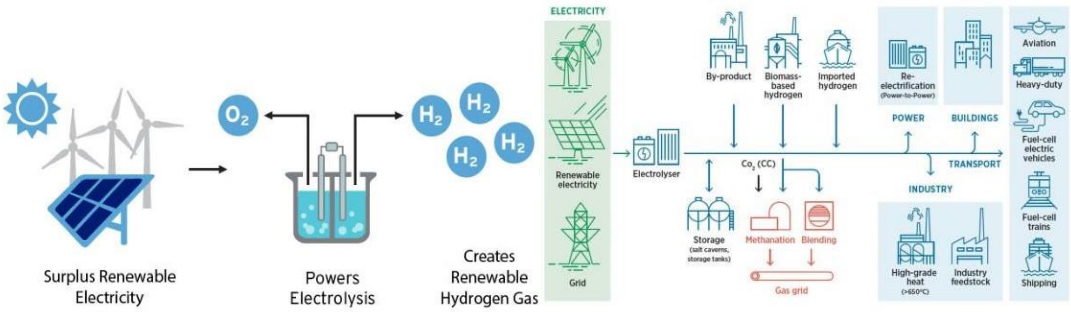

Figure 7. Renewable Hydrogen and PSH

Pumped storage H2 is a different story. It is considered not as green but greyish to blue because it improves based on fossil fuels. While pumping oil and gas and other fossil fuels, H2 could come out so if plants could pump the hydrogen out and store the H2 gas, it becomes usable. This form of H2 is not expensive in lab and can be applied in larger scale. Although it is grey-ish or blue-ish, whether purified or not, it still reduces the carbon emission compared to the direct use of fossil fuels and thus is considered renewables.

2.1.1 Renewable Hydrogen

This type of lab-based hydrogen takes the majority portion of hydrogen power capacity around the world. As hydrogen is always an attractive source of renewables in its efficiency of combustion, in derivation and relationship with the fossil fuels, it has been researched abundantly throughout the world. What's notable is that in this graph, despite the notable R&D and infrastructure construction initiated by the U.S(83743MW). and China(322271MW), Canada(80830MW), Brazil (104463MW), and India (9965MW) are remarkable countries having comparative advantage in hydropower derivation. On December 17th, 2020, the government of Canada has just announced the national strategy of hydrogen production in British Columbia, Quebec, Alberta, Ontario, Saskatchewan, Manitoba, and the rest marine provinces. In 2018, Canada's renewable hydropower production by capacity is 80830MW, slightly less than USA's 83743MW.

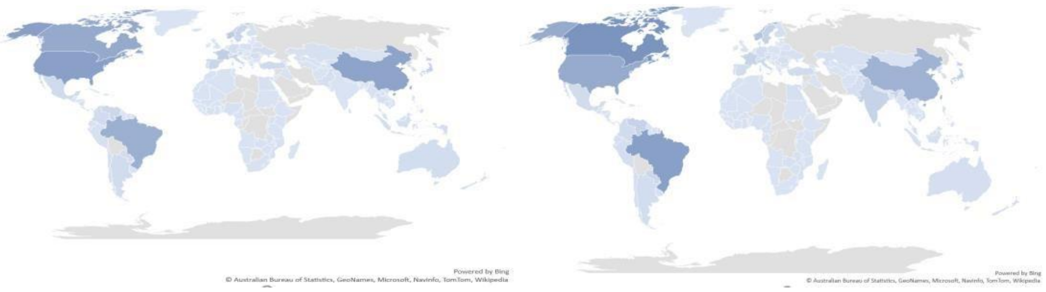

Figure 8. Electricity cap and generation by Renewable Hydropower in 2018 (world, 90.71% of hydrogen: 1174664MW)

Brazil is another hydropower giant. Although always a target country for foreign energy giant investments, Brazil keeps providing strong raw materials for power all the time and thus maintains its occupation on global energy market. Many mixed-equity energy giants operate in Brazil and the well-known projects include Enegix (Australian Company), Base One and many others. This makes Brazil very appealing to foreign energy sector investors. Brazil's 2018 capacity is 104463MW.

Another (usually underestimated) hydropower giant is India. The well-known TERI (The Energies and Resource Institute) located in New Delhi oversights India's determination of transiting to a cleaner powered large-scale economy. India also has been spending enormous effort in transitioning to H2. At the top, governmental orgs hire consulting firms such as FTI to give solutions on the strategic solutions on H2 Bharat tracking, H2 logistic clusters, steel and fertilizers powered by H2, municipal biogas-H2 projects and goal gasification H2 production. India's 2018 capacity is (9965MW)

2.1.2 Pumped Storage Hydrogen (PSH)

The world has 120356MW capacity on PSH in 2018. This only takes 9.29% of the whole hydropower capacity. Part of the reason is due to the technological difficulty. The storage of H2 is always an applied hassle, although solved by scientists, the high cost is still the constraint. The storage, along with the R&D of the batteries is always highly-technologically intensified. In contemporary society, H2 is usually liquified and stored, by 1960. American Air Product Inc. for the first time stored 27000L liquified H2 for the U.S. Air Force. Right now, in 2018, the PSH able economies are as follows:

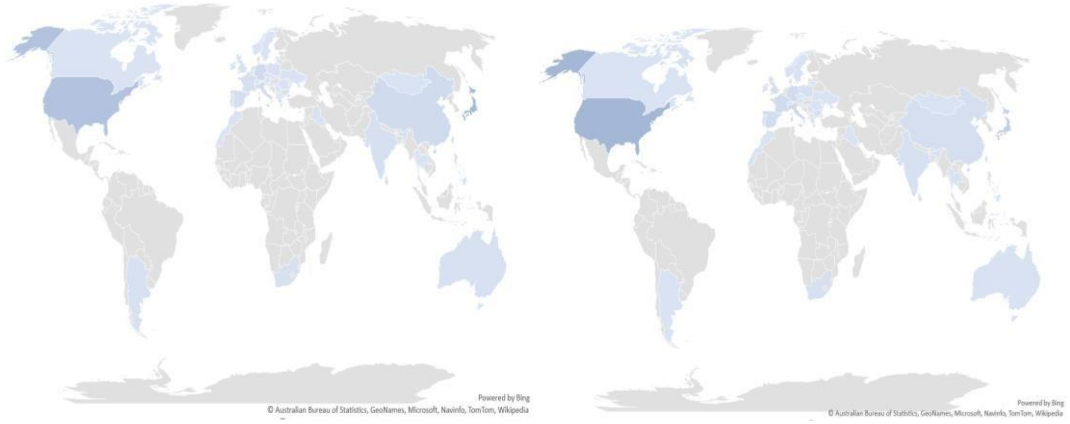

Figure 9. Electricity cap and generation by PSH in 2018 (world, 9.29% of hydrogen: 120356MW)

The PSH is still mostly used for airspace navigation and rocket science. In this case, traditional technologically intensified and powerful military economies such as the U.S.(19104)., EU(Germany(5355), France(1728), Belgium(1310)), South Africa(2732), Australia(810), Canada(174), Japan(21894), India(4789), China(29990), Korea(4700), Russia(1216), Argentina(974), Iran(1040), Iraq(240), Ukraine(1509), Poland(1423), Czech(1172), Luxemburg(1296), and some Spain-dominated northern Africa (Morocco (464) and Western Sahara, as Spain does marine and H2 R&D there) are leading the way.

2.2 Wind: 23.90%, the Commonest

We can look at the electricity cap and generation by each specific form of renewables in 2018. The world has 2356065 MW capacity in total. Leading countries and regions include the U.S.246569MW (North America: 368956MW), China (695488MW), Brazil (136156MW, South America: 212666MW, Venezuela: 16596MW, Chile: 10855MW), Canada (100140MW), EU (537428MW, Germany: 119296MW), India (118079MW), Oceania (30969MW, Australia: 22884MW), India (90579MW), Russia (52150MW).

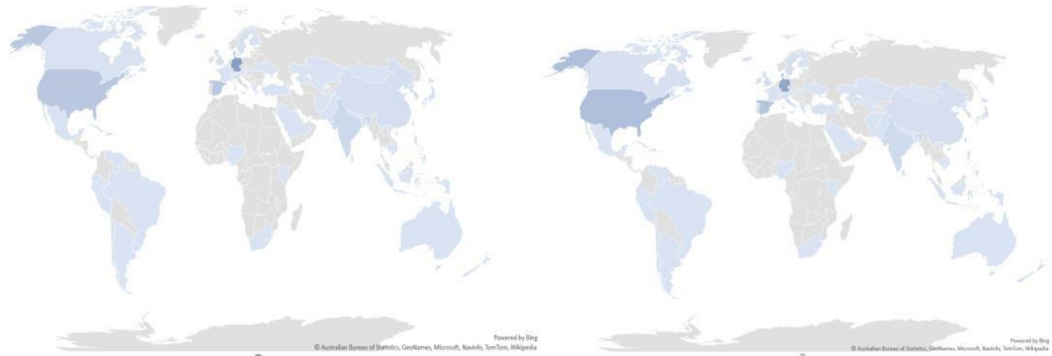

Figure 10. Electricity cap and generation by wind in 2018 (world, 23.9% of the total renewables: 563186MW)

As we can directly see from the figure 10 that wind energy can be depicted. In 2018, the world is capable of 563186MW (539557MWonshore, 95.80%) in total for wind electrification (23.9% of the total renewable cap). Major countries with good wind capacities include Germany: 58843MW, 52447MW onshore, 89.13% (EU: 181385MW), USA: (94417MW, 94388onshore, 99.97%) (North America: 112109MW), France (14900MW, 14898MW onshore, 99.98%), Spain(23405, 23400onshore, 99.98%), Canada(12816MW, 100% onshore) China (184665MW, 180077onshore, 97.5%), Brazil(14833MW, 100% onshore, South America: 19135MW, 100% onshore), Mexico(4855 MW, 100% onshore) South Africa(2094MW, 100% are onshore), Kenya(336MW), (Africa in total 5470MW) , Oceania(6421MW, Canada 5679MW), Chile(1524MW), India(35288MW 100% onshore), UK (21770MW, 13554MW onshore, 62.25%) Sweden (7300MW, 7097MWonshore, 97.22%), Japan (3667MW, 3602MW onshore, 98.22%), Pakistan (1186MW, 100% onshore), Chile (1516MW, 100%

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onshore), Chile (1524MW, 100% onshore)

2.2.1 Onshore (95.80%) and Offshore (4.2%)

Wind resource can be decomposed to onshore wind and offshore wind, onshore specifically means the coastal wind that can be applied using a wind turbine and a conductor to convert the mechanical energy to the electricity. Offshore wind means non-coastal wind, such wind can be from continental, latitude change or just temperature change. Broadly speaking, offshore wind resource refers to any kinds of random wind resource. If we look at the onshore and offshore decomposition of the allocation of on grid wind electrification by capacity of each major economy, we can get the following graphs:

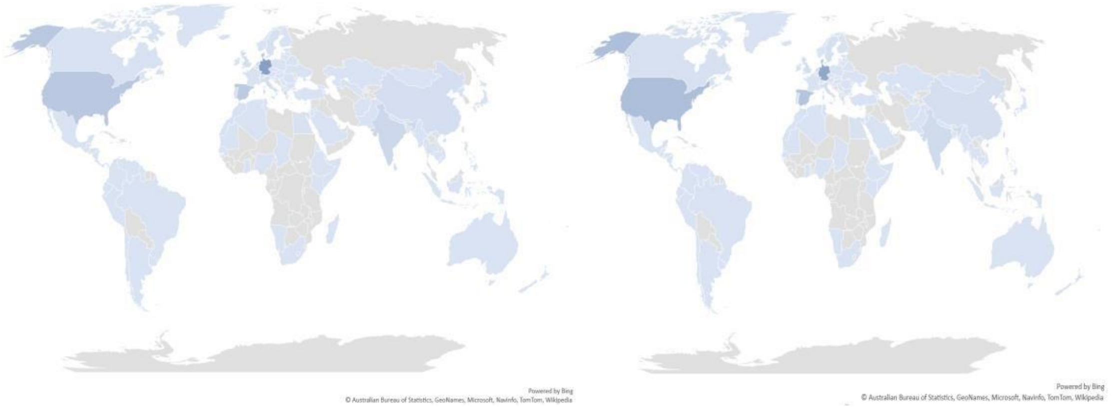

Figure 11. Electricity cap and generation by onshore wind in 2018 (world: 539557MW)

Many coastal countries research and build on the capacity of onshore wind. The world, by 2018, has 539557 MW capacity of using onshore wind for electrification, taking 95.80% of the total wind electrification. Despite the previous major economies using large portion of onshore wind mentioned in earlier text, offshore wind requires much advanced R&D capability. Only 16 countries report they have offshore wind electrification capability in 2018, they are: Germany(6396MW), UK (8217MW), China(4588MW), Belgium(1186MW), Denmark(1701MW), Netherlands(957MW) Sweden(203MW), Viet Nam(99MW), Finland(73MW), Korea(73MW), Japan(65MW), USA (29MW), Ireland(25MW), Spain (5MW), Norway(5MW), France(2MW).

Figure 12. Electricity cap and generation by offshore wind in 2018 (world: 23629MW)

Why there are few offshore wind capacities for countries? This paper comes up with several explanations:

Technology threshold: many countries do not have the ability to research on offshore wind.

Political system differences: many countries have no incentive to enhance the reliability of current grid system and adding renewables can be costly.

Geographical reasons: many countries do not have enough wind resource or culturally they do not think wind can be researched as a form of resource.

Path dependence. Most countries apply onshore wind as the technology is mature, but not offshore wind, because many R&D other than windmill type of generators, are still in lab.

Similar heterogeneity issue happens for bioenergy and geothermal. By brainstorming and some middle school geography common sense, we might guess that Brazil can be very agriculturally resourced, and geothermal resource is abundant where there's hot spring. These guesses are intuitive and correct. Now we look at the bioenergy.

2.3 20.66% Solar: Second Commonest, but not the Thermal Power CSP

The sun shines everywhere, so the application of solar photovoltaic spreads out everywhere. However, the concentrated thermal power is more expensive to install and requires more maintenance. This session talks on the solar energy. World's electricity produced by solar is 486721MW in 2018, taking 20.66% of the total renewables' capacity for electrification.

2.3.1 Solar PV: 98.82% of Solar Energy

Solar PV is the simplest material converting sun heat to electron using single crystalline silicon. It is usually a plastic-like board installed on rooftop and applicable areas to collect the sunshine. As it is easy to install, its application is wide range. In 2018, 480984MW capacity is installed worldwide, taking 98.82% of the electrification of solar energy.

The easy-to-use feature makes the distribution of solar PV very well-suited for mid-income to low-income countries. Unless extremely poor or because solar energy is not abundant (such as high latitude area in Russia), solar PV is always easy to install to collect solar energy.

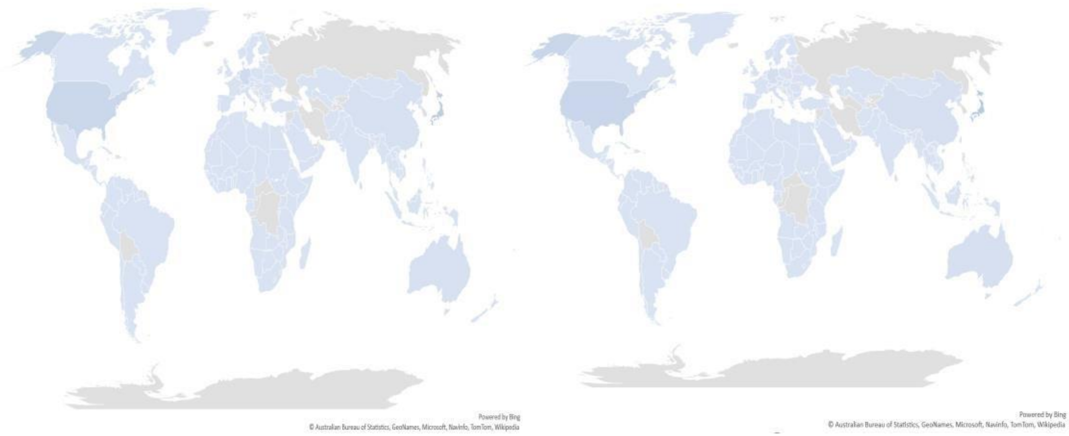

Figure 13. Electricity cap and generation by Solar PV in 2018 (world: 480984MW)

2.3.2 Concentrated Solar Thermal Power (CSP): 1.18% of Solar

Concentrated solar is another story. It theoretically uses convex lens to concentrate solar energy into one point, so the energy is high enough to combust. The reduction of the cost is a major issue in R&D of the industrial use of CSP. The allocation of CSP can be depicted as follows:

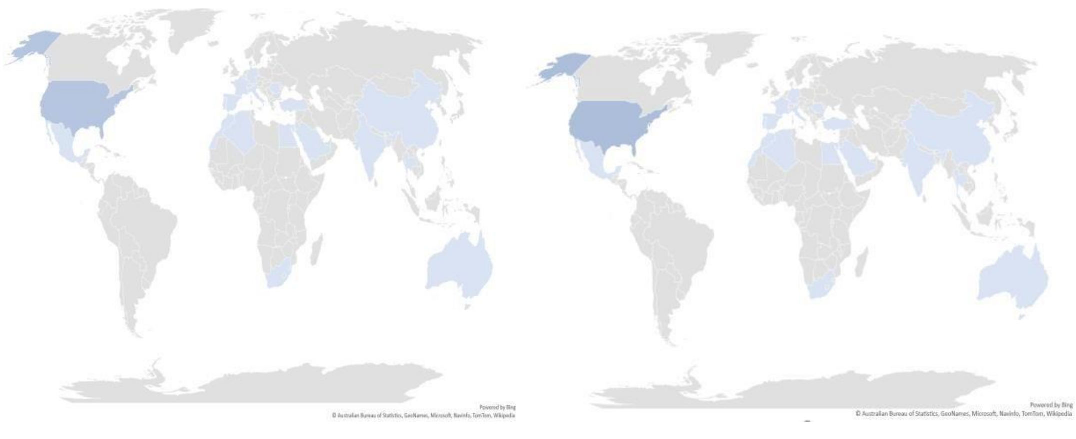

Figure 14. Electricity cap and generation by CSP in 2018 (world: 5738MW)

We could see that CSP electrification still has a long way to go, and it is still within the exploration of the scientists. As CSP is far less cost-efficient than solar PV, countries with strong R&D capability

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and enough sunshine resources can produce few megawatts, they include Spain (2304MW), USA (1758MW), Morocco (530MW), South Africa (400MW), China (271MW), India(229MW), the rest scatters around a few comparatively advantageous countries in middle east, Africa, and southern Europe.

In general, solar PV has a huge market and CSP, because of its high cost, remains in lab for most countries.

2.4 Bioenergy: Only 4.99% of the Renewables but most Potential

2.4.1 Bagasse

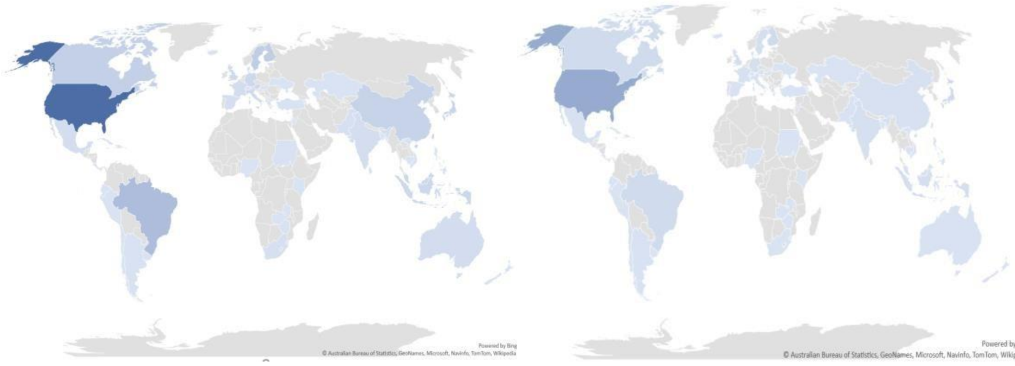

Figure 15. Electricity cap and generation by all forms of bioenergy in 2018 (world)

The distribution of bioenergy is relatively abundant. The key matter is how to put them in electrification. The world in 2018 has the capacity of 117738MW (96221MW solid) Countries with good agricultural heritage may invest in the R&D of bioenergy.

For electrification cap of bagasse, Brazil drives the first ranking all along. The ranks are: Brazil (14499MW), China (12605MW), US (10163MW), India (10124MW), UK (5152MW),

Sweden (4484MW), Japan (2746), Canada (2360MW), Central America and Caribbean (2626MW), Africa in total (1621MW). The source is just bagasse.

Bagasse electrification in Brazil has always been very mature since the survey year. As the world's largest sugarcane manufacturing country, Brazil has developed very abundant source and infrastructure particularly for the sugarcane industry. In Brazil, sugarcane electrification has already been as important as the construction of waterpower plants. Brazil has been highly experienced in producing both first generation and second-generation biofuels using sugarcane extracts such as industrial sugar, sugarcane residues(bagasse) and lignocelluloses. Although liquified biofuel has not been in the market in Brazil, it still takes the first largest solid biofuel market without any doubt.

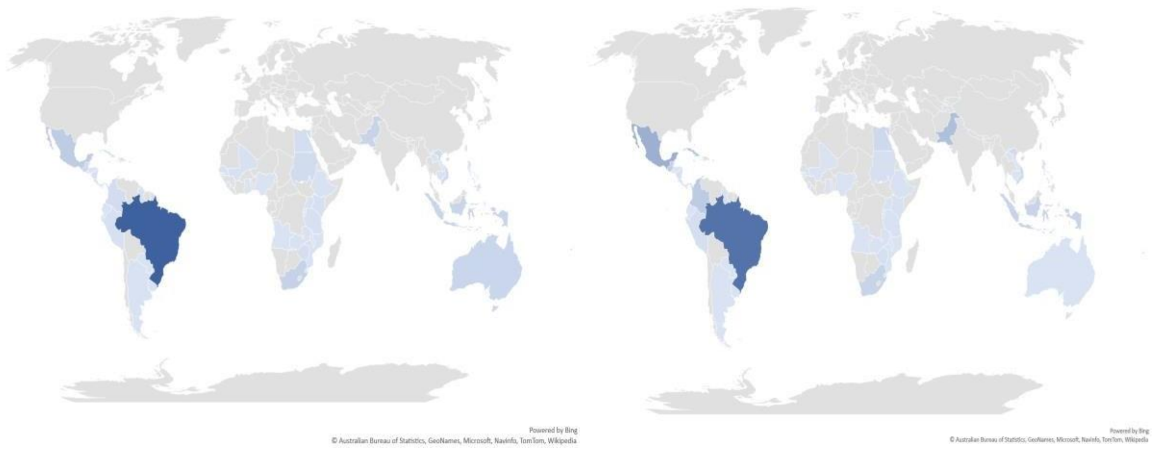

Figure 16. Electricity cap and generation by bagasse only in 2018 (world)

2.4.2 Municipal waste

Municipal waste is another story. It reflects the general ability of a country to purify, recycle, reuse,

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and reduce the externality of pollutants. By drawing the density map, we can get the description of municipal waste:

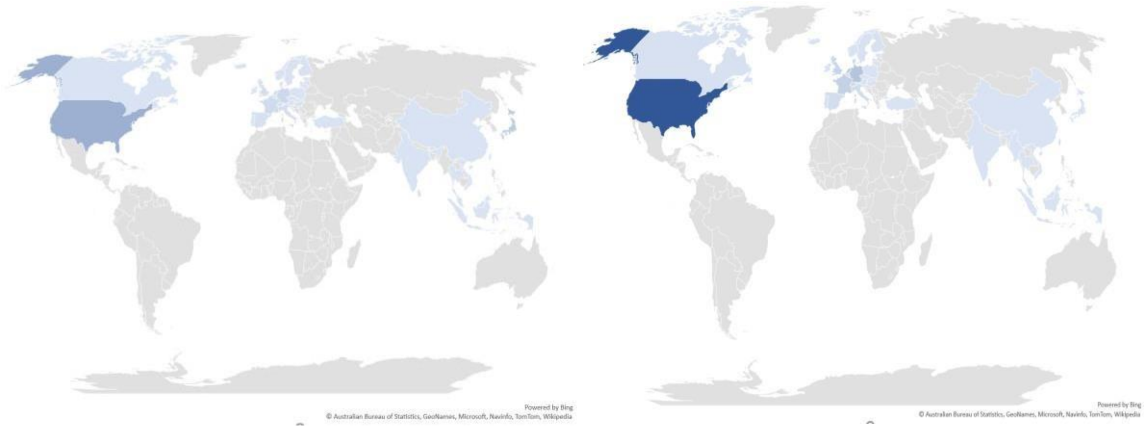

Figure 17. Electricity cap and generation by municipal waste only in 2018 (world:13083MW)

There is not much doubt that the U.S. is leading the way in this type of renewables. What is also notable that Africa, South America and Australia, Russia, and most part of the central Asia, except for China, is entirely left behind. Processing of this pollutant requires delicate lab work and high R&D ability. Except for US, Canada, India, China, Japan, southern Asia (typically Singapore), we can see that EU and Turkey are particularly strong in this realm.

What is notable here is that when we plot the graph for this one, the density of generation is a lot thicker than the capacity graph. This implies that the world has not built enough municipal waste electrification for use. The facilities might need further investments.

2.5 Geothermal Energy: less than 0.56%, not fully known, but huge potential.

Whether using geothermal for human power generation is always debatable as from the ancient times human beings have witness the massive power of earthquake and volcano explosion. However, whether and how to use such energy is always a “measurement” for environmental economists and the ecological economists. Countries with such geological features might not be afraid, little by little, and they even develop touristy places such as Japanese and Iceland hot springs near the volcano and earthquake active regions. However, the energy used for electricity is still rare in this form.

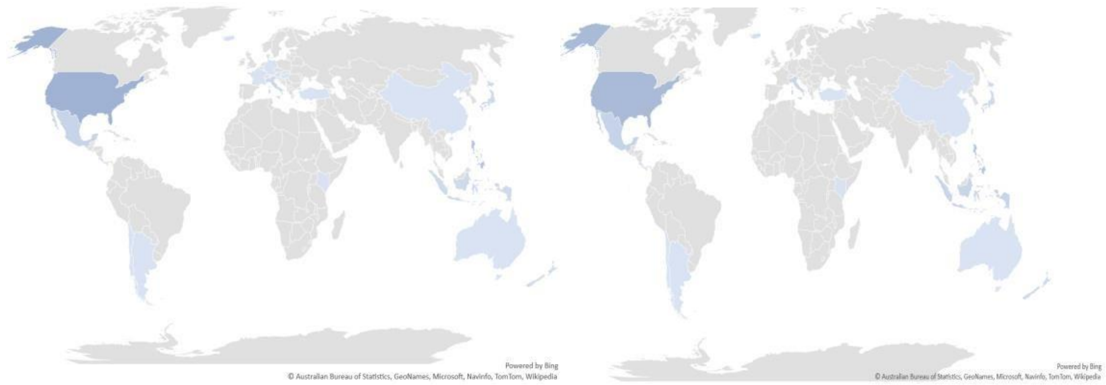

Figure 18. Electricity cap and generation by geothermal only in 2018 (world:13227MW)

Leading countries with well-developed geothermal capacities are: USA (2541MW), Indonesia (1946MW), Philippines (1928MW), Turkey (1283MW), Mexico (951MW), New Zealand (941MW), Iceland (156MW), Italy (767MW). All have certain geological advantage in applying geothermal.

3. Modelling the Comparative Advantage

With long description of each country’s heterogeneity in developing renewables including hydrogen, solar, wind, bioenergy and geothermal energy, this paper develops a linear-regressional model on evaluating whatever country with the data from IRENA provided.

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3.1 Data from IRENA

As a profoundly well-known intergovernmental organization supporting countries to transit from fossil fuels to renewables, IRENA itself collaborates with more than 270 countries/regions/sovereigns to enhance the greener transition. Their database is abundant and detail oriented. The data used for this research can be found at: (https://www.irena.org/Statistics/Download-Data), for consistency of statistics, this paper uses the 2010 to 2018 cross-sectional data for each country. The tool for analyze is the Microsoft Plug-in for Office called StatPlus.

3.2 Modelling the Energy Structure: The world is not flat.

The model is a single regression model written as:

$$Total\ Renewable\ Supply = \alpha wind(onshore\ \&\ offshore) + \beta solar(PV\ \&\ concentrated) + \gamma bioenergy(S, L, G) + \delta Geothermal + \theta hydro(renewable \& pumped) + \varepsilon$$

This is basically regressing the 2000 to 2018 renewable energy-specific data to get each country's unique coefficients for that country. After regression, we can get the following table of major economies:

Table 1 Capturing the Heterogeneity using Linear Regression of Major economies, 2018

	Cap in 2018 (MW)	Hydro	Wind	Solar	Bio	Geothermal	Error Term	R-squared
World	2356065	1295019	563186	486721	188	13227	-2276	
World Coeff. (2010-2018)	.	0.9890	1.0427	1.0143	0.7530	-7.2044	233.9877	1.00
USA	246596.30	1.1060	1.0623	0.9718	0.2881	4.0126	- 32,464.6051	0.9997
Canada	100140.20	0.7394	2.8469	-4.6629	3.9682	.	62913.1695	0.9860
Mexico	22128.37	2.9032	1.9830	0.8885	-2.9225	7.6315	6130.1709	0.9825
Germany	119296.00	0.2781	1.0011	1.0220	0.9745	- 11.5638	4,820.6446	1.0000
France	50526.90	0.8323	0.9948	1.0074	1.1656	2.7571	2524.89	1.0000
Finland	7697.53	1	1	1	1	.	0	1.0000
Denmark	8924.7320	0.9842	1	0.9997	1.0003	.	0.0642	1.0000
Iceland								
Japan	90579	0.7755	3.2310	1.0592	-1.8163	17.0040	55418.6340	0.9968
China	695488.17	0.9046	0.9975	0.9211	2.4035	- 676.9078	16,457.8959	1.0000
Korea	12050.0770	0.1901	0.3030	1.1527	0.9769	.	827.2653	0.9992
Philippines	6576.6310	0.5785	0.2927	0.9876	1.5178	4.2537	-5279.6205	0.9952
DPRK	4942.45	1	1	1	.	.	0	1.0000
Russia Fed	52149.52	0.9978	1.9425	0.9172	1.0691	0.5746	-1167.3322	1.0000
Turkey	42230.393	1	1	1	1	1	0	1.0000
Armenia	1356.6450	1	1	1	1	.	0	1.0000
India	118079.40	0.7368	1.1090	1.0234	0.9003	.	5,093.6832	0.9999
Iran	12678.938	1.0234	- 2.7232	0.0920	- 16.7944	.	57.6349	0.9951
Nepal	1114.7260	.	1646.7075	6.4203	.	.	557.9020	0.7365
Brazil	136155.93	19.9499	-0.4546	5.5838	1.2142	.	49533.1866	0.9852
Argentina	11510.2140	1	1	1	1	1	-974.0000	1.0000
Venezuela	16596.59	.	1.9189	472.35	.	.	13833.06	0.6216
Chile	10855.286	-10.7654	1.7271	1.0574	12.3774	-8.0248	4947.68	0.9791
Saudi Arabia	87.138	.	1.0000	1.0000	.	.	0	1.0000
Jordan	1154.323	1	1	1	1	.	0	1.0000
South Africa	6064.64	0.4728	0.8853	1.0412	-27.6804	.	6774.06	0.9957
Nigeria	2143.31	1	1	1	1	.	0	1.0000
Australia	22884.00	0.3789	1.0240	0.9913	1.0549	-496.9554	4305.0731	1.0000
New Zealand	7218.89	1.0001	1.0001	0.9999	0.9994	0.9999	-0.3933	1.0000

The above table, although methodology is simple, reveals many interesting facts. Many countries

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coefficients are just 1, however, their income level and capacity vary, this convergence to 1, means either they are too well-developed (Finland), they are of an especially close economy (DPRK), or they are too poor to develop anything big (Nigeria), or they are mid-income, and they do not care (Turkey). Such 1 can be seen as a state of convergence, while some other countries show apparent advantages or disadvantages in the capacity of each form of renewable energy use. (Japan, Mexico, high in geothermal). This can lead to the discussion and policy implications.

4. Discussion and Implications

Although the algorithm is simple, this paper provides new and reliable data analysis onto the transition to renewables and it sums up all the features, either heterogeneous or homogenous, of the structural renewable resource allocations for one representative economy. It surely has limitations in the following aspects:

First, although the paper tries to minimize the selection bias due to data insufficiency and reporting bias, when soliciting the data, although minor, we inevitably find some economies with reporting issues typically on biofuels and geothermal, such as Cuba.

Second, this paper entirely put the income out of its research scope since the research believes that electricity capacity and generation can eliminate the political system bias using certain monetary values. For example, DPRK has more electricity generation compared to Nigeria although its political system is closed and unknown to many non-DPRK brains.

Third, when considering electricity production, this paper focuses more on capacity than generation because we believe that once the infrastructure, or the capacity is installed, it can be of no difficulty to operate and start to generate streams of the electricity current, whether DC or AC. This is not always true for some forms of renewables, typically biofuels since it does not require much capacity or infrastructure to generate current. For example, the production of LC methanol, electrification of bagasse and the reprocessing of municipal waste, although require some basic facilities, does not need complex capacity-able infrastructures. On the other hand, hydropower, especially PSH requires much more technology so the cap is usually much greater than the generation. In this regard, we take electricity capacity, rather than generation, as an evaluation of the ability to use renewables.

All in all, this paper uses simple linear regression method with variables representing hydropower, wind, solar, bioenergy and geothermal energies to assess each major economy's capability and the results vary according to the country's energy structure. Although variations exist due to economic development stage, historical path dependence and so forth, this paper provides an eye view on how renewables are applied in each country and may serve also for investors and other stakeholders.

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