100% Renewable Energy Scenario for Nepal, 2050

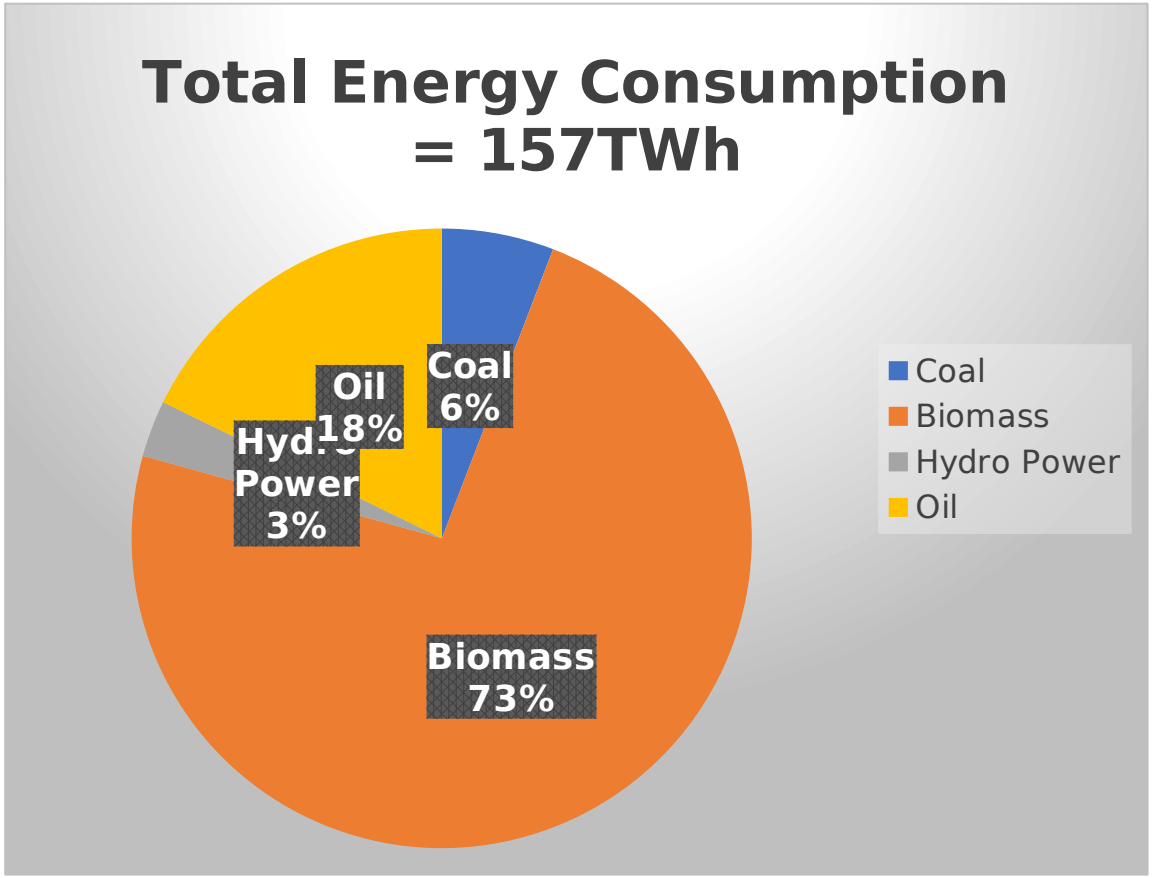
[redacted]

Nepal

- Land are of 147,181 sq. km
- Population 29.3 Million (2017)
- Altitude ranging from 450m-8848
- Land area divided into flat lands, Hills and Mountains on a roughly equal proportion.
- Population growth rate of 1.1% (growth rate declining)

[1]

Energy Consumption (2017)



Biomass Primary Used for heating and cooking

Import Fuels used in transportation, Industry and households (for cooking)

Almost 100% of electricity produced from River-Hydro

Electrical demands met by Electricity Imports from India

Biomass and Petroleum

- Biomass sourced from forest, mostly as firewood and agricultural waste.

- Petroleum imported from India. Mostly for transport and for cooking as LPG

thehimalayantimes

https://markonthemap.wordpress.com/2011/08/06/big-shots-jomsom-trek-tatopani-to-kalapani/

Heating and Cooking

- Biomass is a major source for cooing and heating in most of Rural Nepal.

- A household in Rural Nepal were seen to use between 20-40kg of firewood per day [2]

Image: Shutterstock, RIDS Nepal

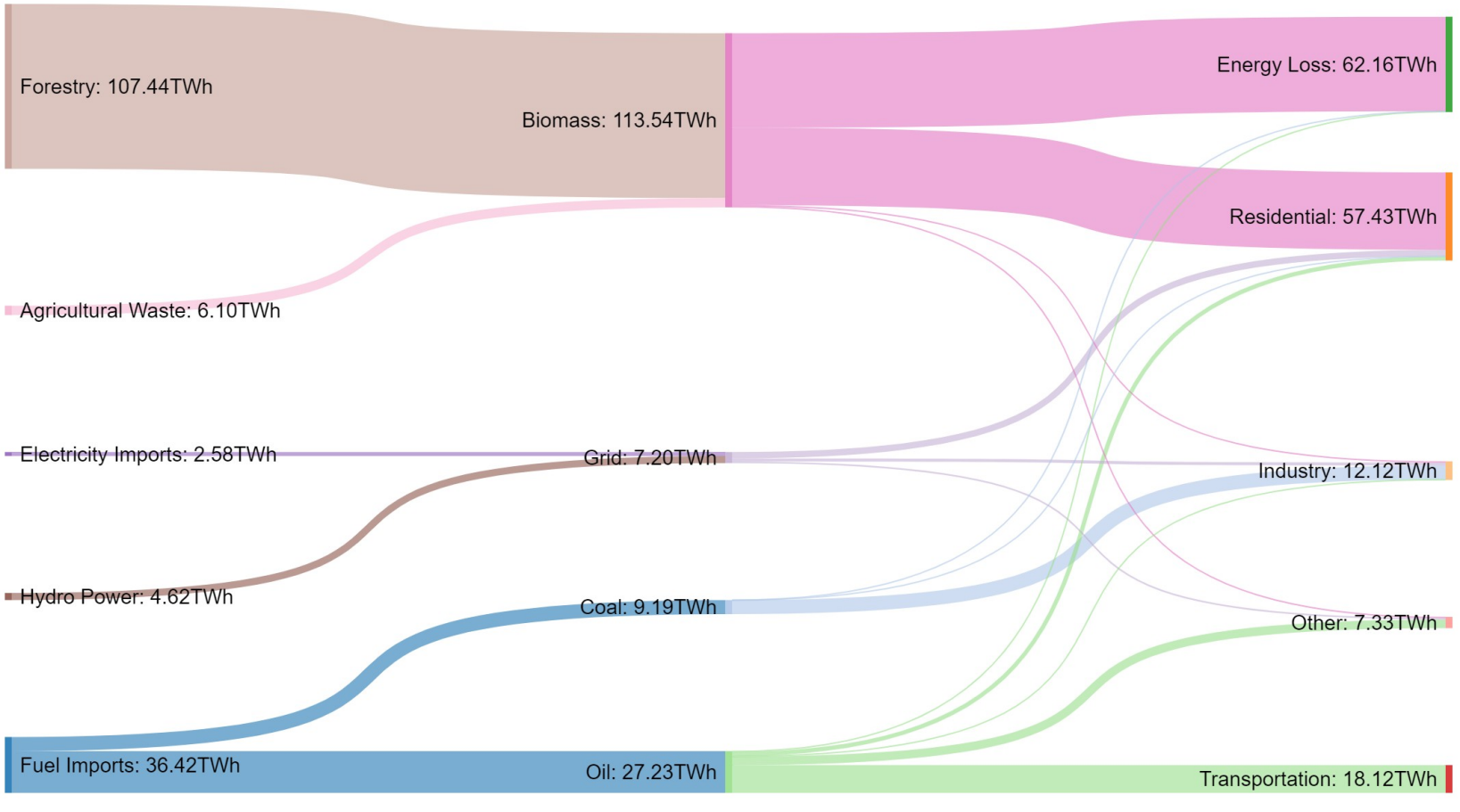
Electricity

- Almost all electricity Generated through Hydro Power Plants
- Current Installed Capacity as of Dec 2019 (1016MW) [3]
- Capacity in 2017 reported between 713-787MW [4]
- 4.6TWh produced locally,2.66TWh imported from India [5]
- Up to 70% of electricity at peak load imported from India

Onlinekhabar,
thehimalayanntimes

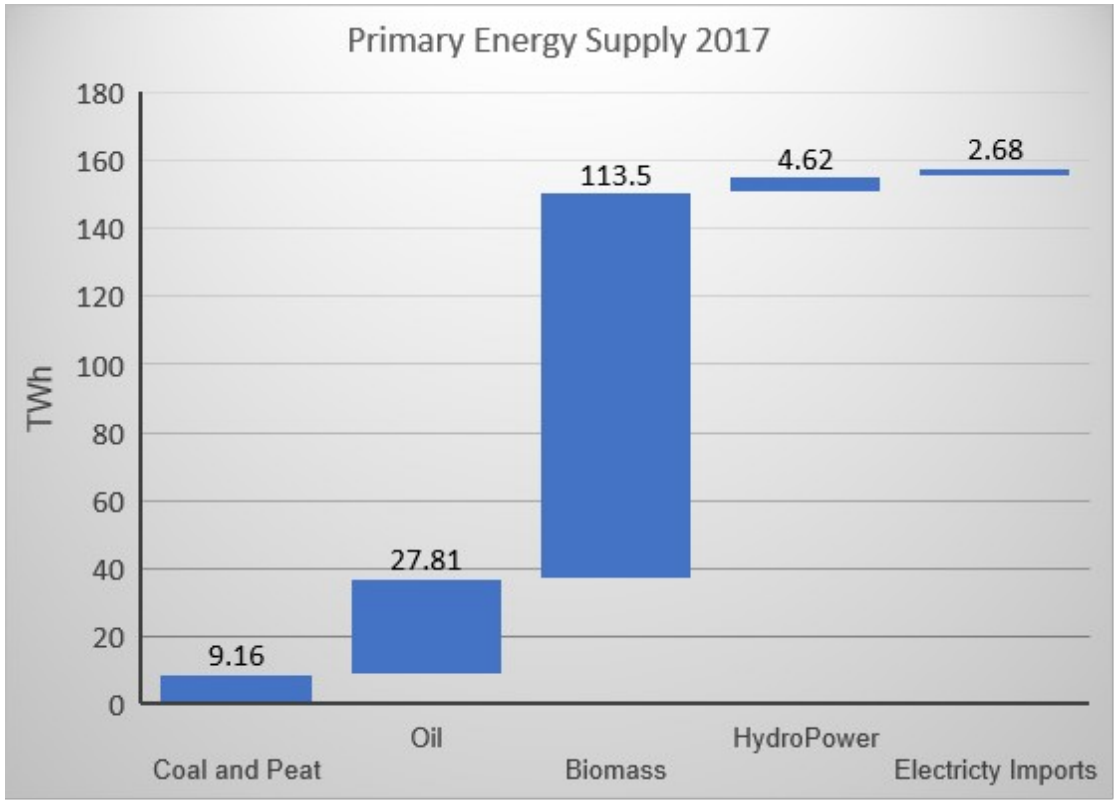
Energy Balance 2017

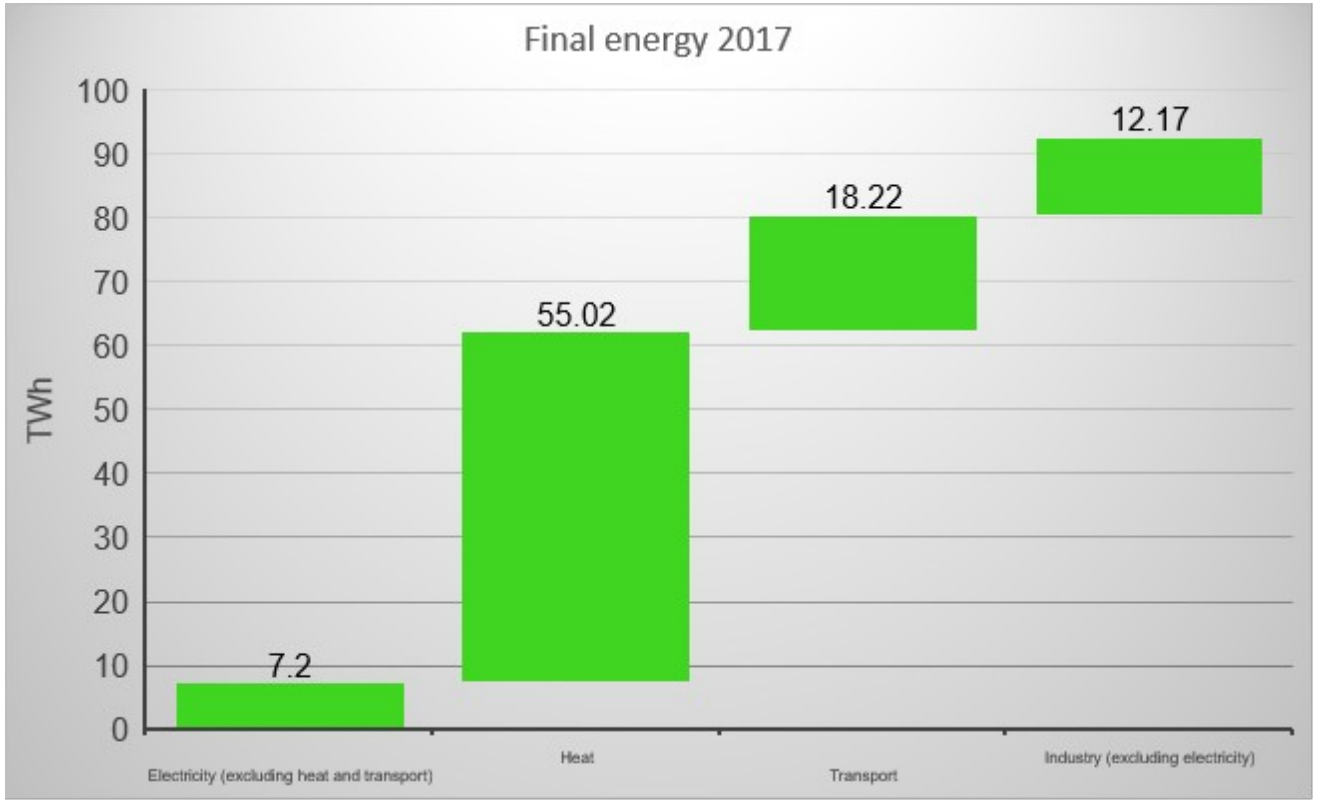
Total Production and import: 157.17TWh



Final Consumption : 95 TWh

Scenario Synopsis (2017) : Energy





Cost Breakdown 2017

COSTS (M EUR): 2017	Total Inv. Costs	Annual Inv. Costs	Fixed O&M
River of hydro	2353	170	47
Oil Storage	302	22	2
Interconnection	600	45	6
Total Investment	**3255**	**237**	**55**
Electricity Imports		155	
Fuel Oil Imports		252	
Gasoil/Diesel Imports		1070	
Petrol/JP imports		262	
Coal Imports		262	
Biomass		3748	
CO2 Emission Cost		297	
Variable Cost		6046	
Total		6283	
Total Annual Cost		**6338**	

Annual cost for energy for 2017 was calculated to be **6.4** Billion Euros

237M Euros annual investment costs and 6.1B Euros in Variable costs, mostly as Fuel imports

Biomass cost alone is 3.75 Billion Euros

Potentials

- Nepal has a theoretical hydroelectricity capacity of 83000MW of which 44000MW is economically feasible [6]
- Investment bans on Energy lifted in 2015 and permits for powerplants of additional 11000MW Capacity have been granted to be completed by 2030.
- Wind power of 5MW/km2 average estimated output for land area with above 300w/m^2 potential (6074km^2 of total 147,181km^2 land area). [7] Total theoretical Capacity of 30370MW.
- Average solar Irradiation of 4.66kWh/m^2day with 300 sunny days per year [8].
- Alleged solid Biomass potential of 66TWh/a through sustainable forestry programs. [9,p51]
- 14.9 million tons of animal dung available (80% available for biogas production) [9,p12]

Electricity Generation Capacity Used for 2050

- 5700MW of River-Hydro Capacity. 29.36TWh$_{el}$/year production estimated in Energy Plan
- 800 MW capacity of On-Shore wind turbines. 7.03Wh$_{el}$/year production estimated in Energy Plan
- 1000 MW of Solar PV with an output of 1.79TWh$_{el}$/y calculated from Energy Plan. Solar PV would be suited mostly for building tops.
- Condensing Powerplant capacity of 3250MW included to use available bio resource as biogas.

Biomass

- Current supply of biomass in Nepal is maintained through communal forests.
- A subscription fee is used which gives access to forest for firewood. Most forest only allow twigs and branches and prohibits cutting of trees.
- Solid biomass potential is reported to be somewhere between 60-85TWh/year
- Animal dung and Agricultural waste are also available as Nepal is predominantly an agricultural country

- 39.57TWh of biomass used in 2050 scenario. 27 TWh as biomass from forestry, 7TWh as agricultural waste and 5.1TWh as wet biomass
- Biomass used as solid biomass in Industry.
- Used to produce biodiesel and biogas used for transportation and electricity production when required.

Energy Usage 2050: Residential

- Total Electric demand expected to grow drastically assuming 100% of the population will have access to electricity, a population growth rate of 1.1% and an average economic growth rate of 6.5% p.a. (high economic growth rate scenario). Demand increase from 7.2Twh/y(2017) to 33Twh/y(2050)
- Residential Energy demand met by Electricity Production.
- Energy used for household appliance. Energy for cooking supplied through electricity.
- A small amount of biomass (3.5TWh of primary energy) used to represent traditional method of cooking and heating.
- Space heating and water heating supplied through individual solar water heater which are trending since the 2000s in Nepal.

From Osmo Solar Water heater facebook page

Energy Usage 2050: Industry

- Energy demand for Industry will be met mostly by biomass.
- 15TWh equivalent of biomass is allocated for industries
- Industry will also use electricity which will consume a maximum of 10% of total electricity demand (3TWh)

Energy Usage 2050: Transportation

- 27 billion km calculated in 2017 with reported 3million vehicles for about 30million people
- A 288% import tax on vehicle is currently imposed by the government to deter new vehicles as 100% of fuel is imported. Also due to lack of roads to support vehicle population.
- 100% Renewable energy-based transportation could drastically increase total vehicle population
- A 1.17% per annum growth rate of vehicle taken to estimate 5million total vehicles in 2050

Energy Usage 2050: Transportation

- 70% electrical vehicle and 30% gas and biodiesel vehicles expected
- Total distance estimated as 32 billion km.
- Distance share shared equally between electrical and non-electric vehicle.
- Electric vehicle mostly used for short commune and non-electric vehicle for cargo and long-range transportation
- 50% dump charge and 50% smart charge vehicles estimated with an average of 60kwh capacity.

Flexibility and Storage

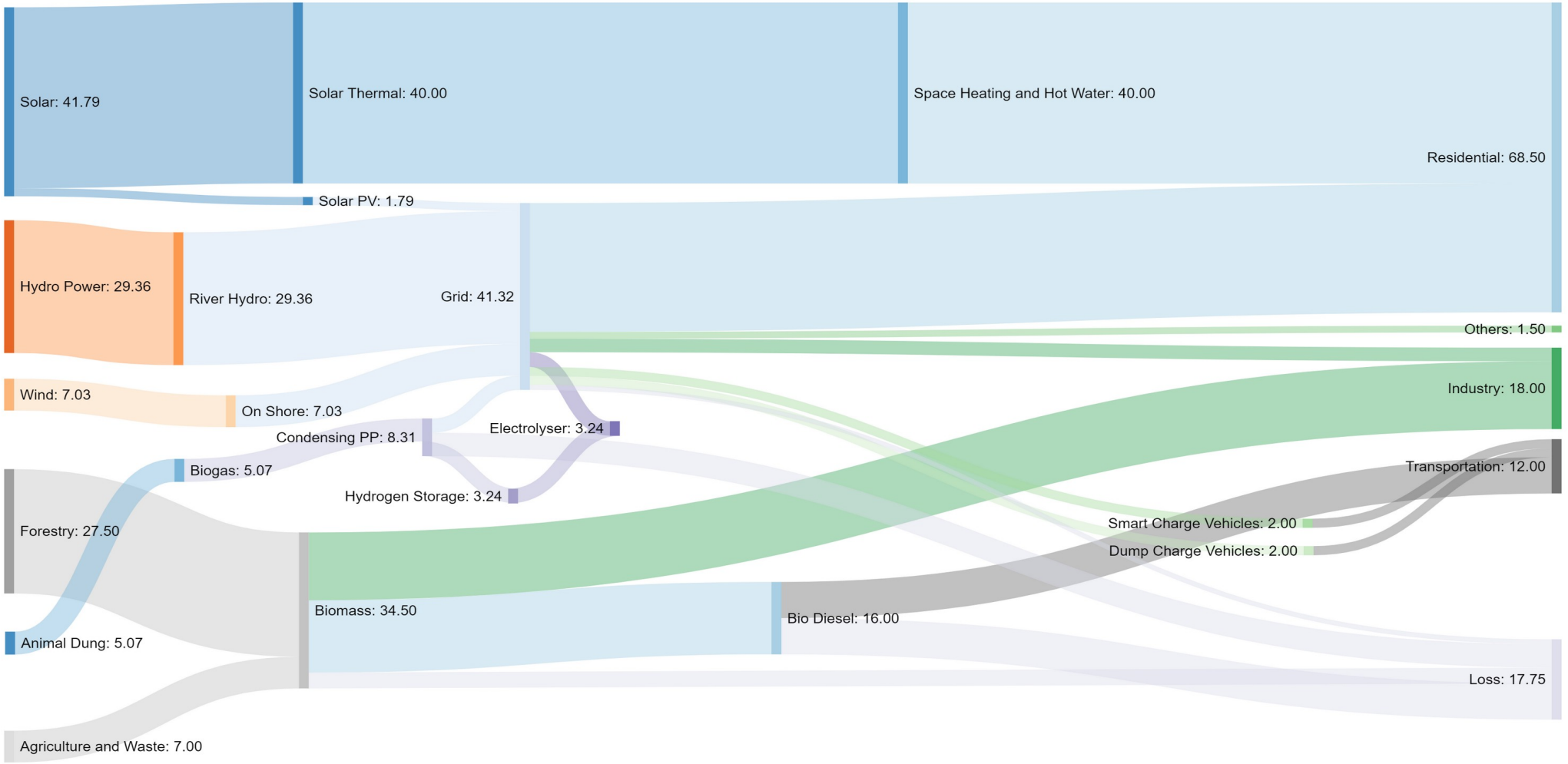
- Flexibility added with a condensing powerplant 3250MW total capacity using Biogas/H_2gas

- 4443MW from smart charge vehicles (assuming half of the smart charge vehicle population opted in)

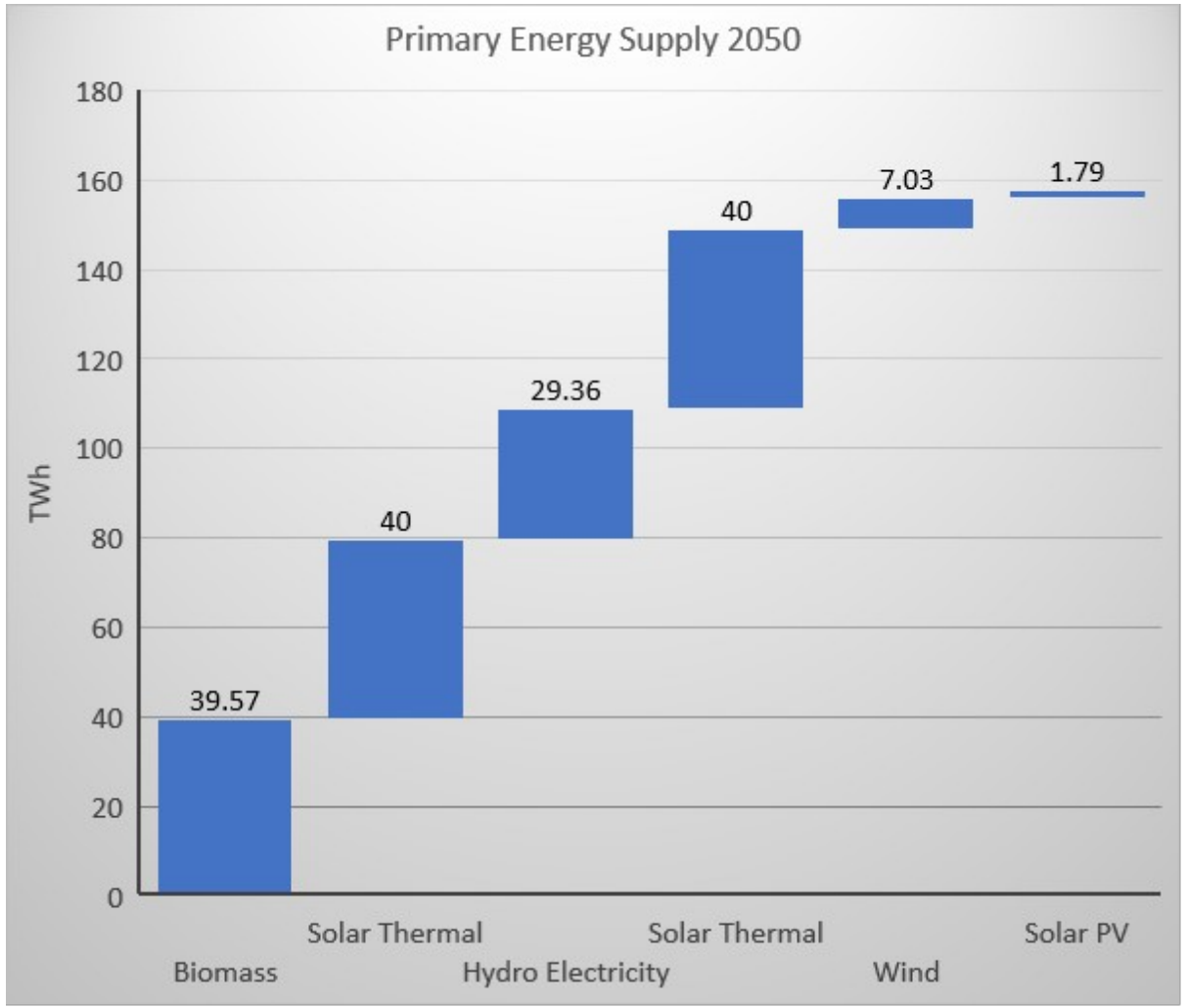
- A 10% of total electrical demand set as 24 hours flex amount. Achieved by scheduling industries and implementing peak demand electricity tariffs.

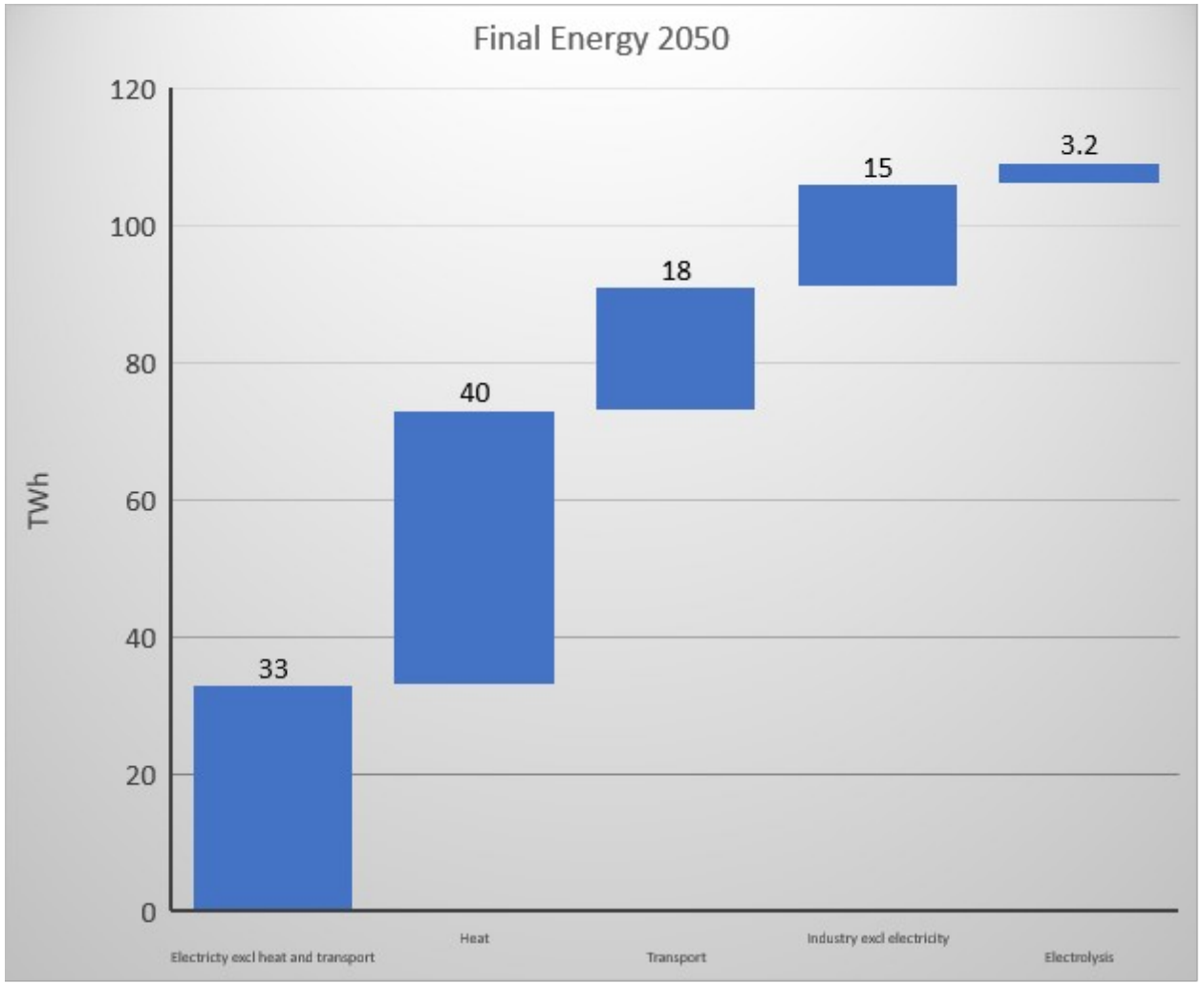
- A gas storage of 3750GWh used to store Hydrogen gas produced during low demands specially in summertime.

Energy Balance 2050 (TWh)

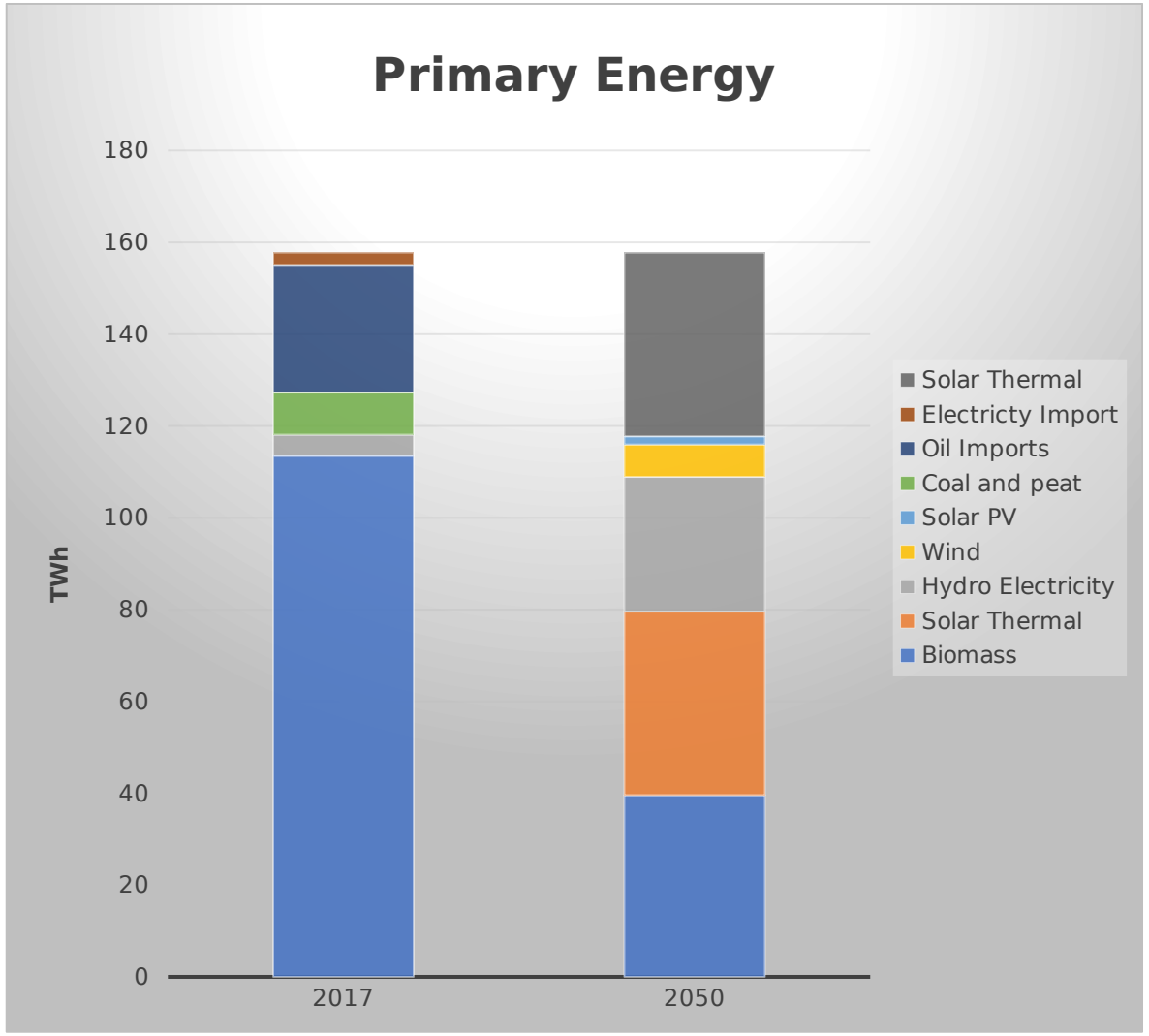


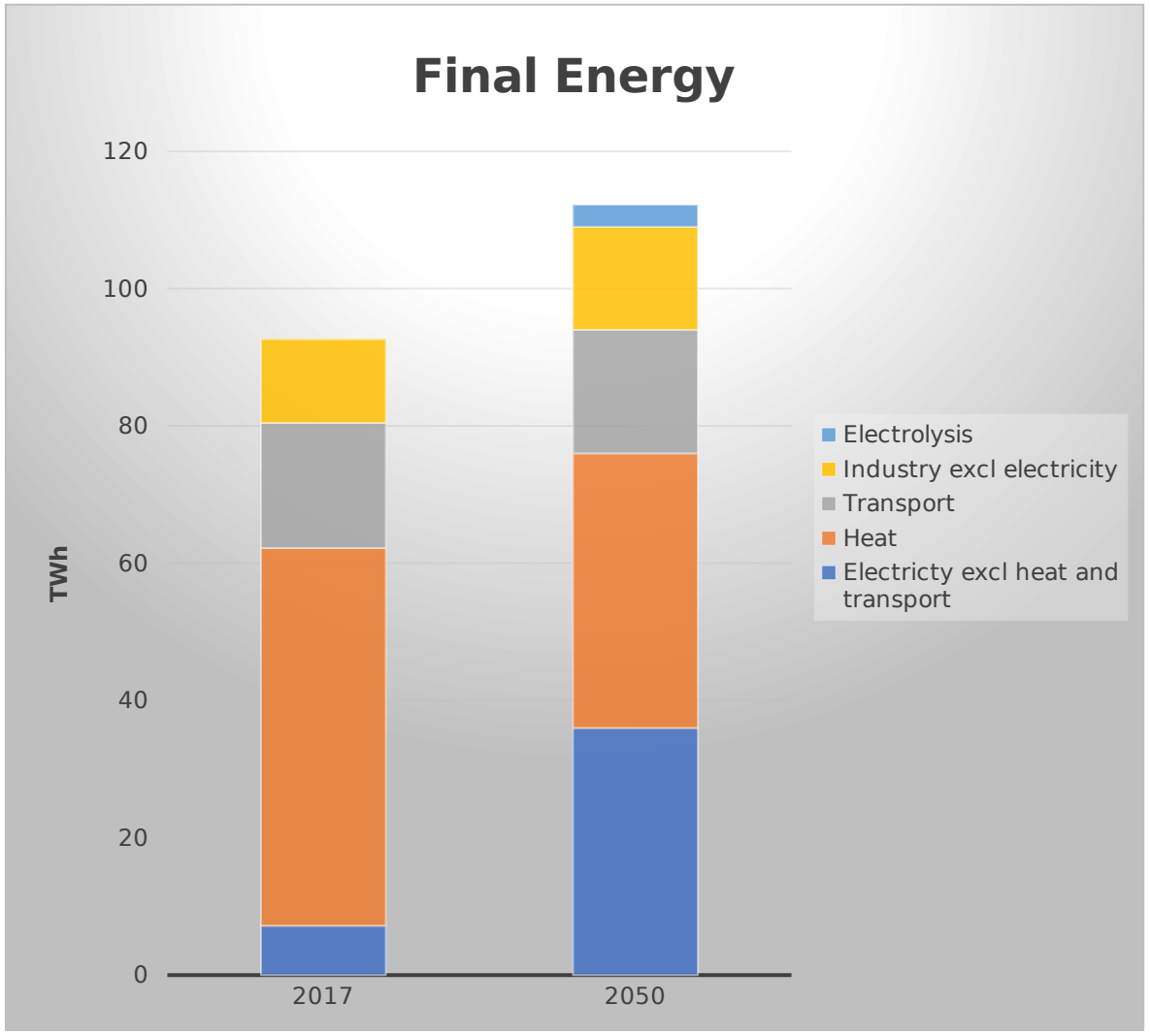
Scenario Synopsis 2050 : Energy





Scenario comparisons





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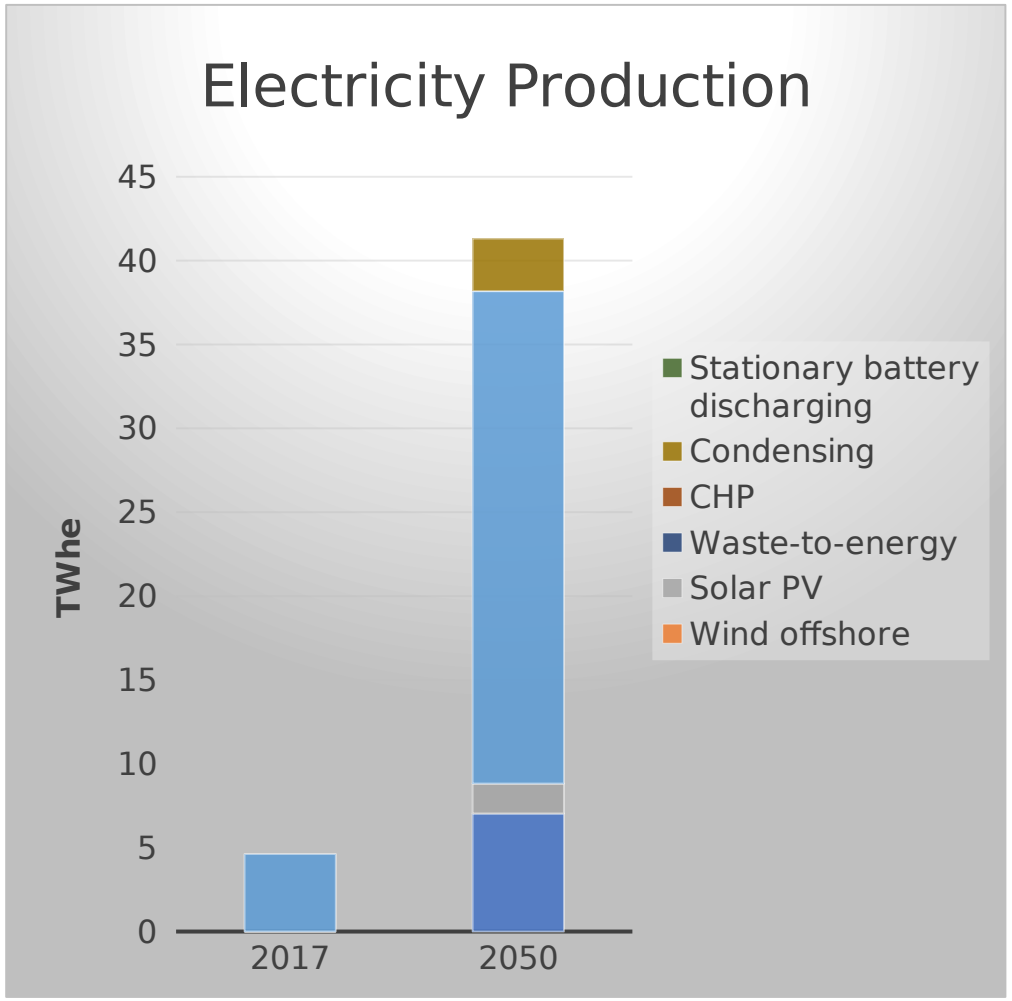

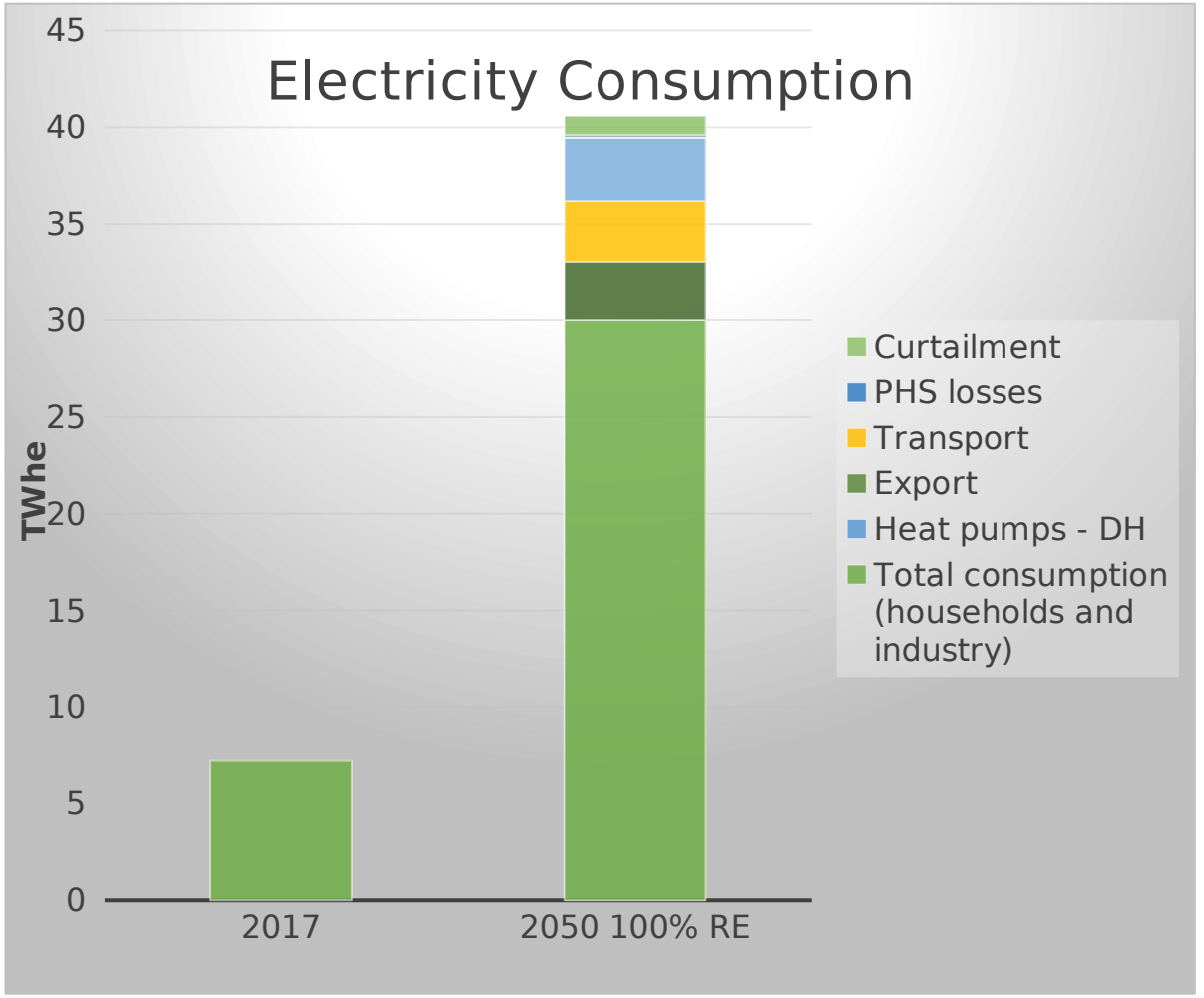

Cost Breakdown 2050

COSTS (M EUR): 2050	Total Inv. Costs	Annual Inv. Costs	Fixed O&M
River of hydro	18810	1363	376
Large Power Plants	3088	258	102
Wind	720	58	21
Solar PV	690	52	7
Biodiesel Plant	3443	325	103
Biogas Plant	1217	115	85
Biogas Upgrade	173	19	33
Electrolysers	351	28	11
CO2Hydrogenation	773	62	23
Individual Solar Thermal	18800	1515	229
Gas Storage	304	22	3
Total Investment	48369	3817	993
Adjusted Annual Investment Cost		**3893**	
Biodiesel /Handling		70	
Biomass		1063	
Other operation cost		9	21
Variable Cost		**1141**	
Total	28141	5034	1014
Total Annual Cost		**6049**	

Annual Cost of 2050 Scenario is 6.05 Billion Euros

Cost Analysis

- Annual costs in 2050 (~6.40B) is 350 Million Euros lower that 2017(~6.05B)
- Annual investment cost increase from 237M Euros in 2017 to 3.90B Euros in 2050
- Variable Cost decrease from 6.05B Euros in 2017 to 1.15B Euros in 2050
- Yearly Variable cost decrease by almost 1/6th in 2050 due to decrease in fuel imports/usage.
- This redirection of funds from fuel purchase to investment will likely create jobs which can greatly help increase Nepal’s Economic growth.

Energy Plan Notes: Base Scenario

- Heat demand on the base Scenario denotes heating and cooking value. Firewood and LPG based cooking (45% efficiency) are included in heating values.
  Individual Biomass and oil Boiler price set to 0.

- National Coal Production, Available PV, Wind capacity and Diesel Powerplants were omitted from the Scenario as the values were very small

- 500MW Transmission line capacity for electricity export used which was roughly enough to facilitate reported electricity imports. Although the reported values vary between 400-950MW[10].

- 7% interest rate used. Although, ADB's WACC estimate for Nepal is 0.75% (for energy related investments)[13]. Interest for newer technologies could be higher hence 7% was considered.

Energy Plan Notes: 2050 Scenario

- Biomass from municipal solid waste, agricultural waste and forestry all incorporated together as solid biomass.
- Losses in Industry (biomass as fuel) not estimated
- Individual space and water heating cost calculated separately according to energy plan data. The system was not simulated in Energy Plan due to complication in simulation
- The Capacity and technologies chosen provided the cheapest option. Hydrogen production and storage was cheaper compared to pumped hydro, which was other scenario options.
- 0.98TWh of electricity was excess. Export electricity (215M Euros) was omitted from cost calculation.

Current path to the Future

- Nepal has commissioned additional 11000MW (as of Dec 2019) Hydro Electricity Projects to be complete by 2030 bringing the national total to 12000MW. 61.81TWh/year production according to Energy Plan estimates.

- Also, Two Pump hydro projects Sunkoshi II (1110MW) and III (536MW) with reported Total Energy Generation of 4760GWh or Firm Energy Generation of 2761GWh are soon to be commissioned [11]. Project is currently in bidding process.

- Nepal's current main source of revenue is Agriculture, Remittance and Tourism. With additional generation capacity, Nepal aims to decrease annual trade deficit with energy trade.

- The energy trade is mostly targeted for Bangladesh as some powerplants are built with cooperation from Bangladeshi Government. [11]

- Nepal has many high-altitude lakes which are sought to be converted to pump hydro storages for South-Asian countries as they are claimed to require minimum investments for conversion. Although additional research is needed and most of the claims come from election campaigns rather than scientific study.

- 1.Google Maps
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  http://www.rids-nepal.org/index.php/Smokeless_Metal_Stove_SMS.html
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  ii.[550-950MW] https://powermin.nic.in/en/content/interconnection-neighbouring-countries
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