Lecture - 26

Energy Resources, Economics and Environment

Future Energy Systems

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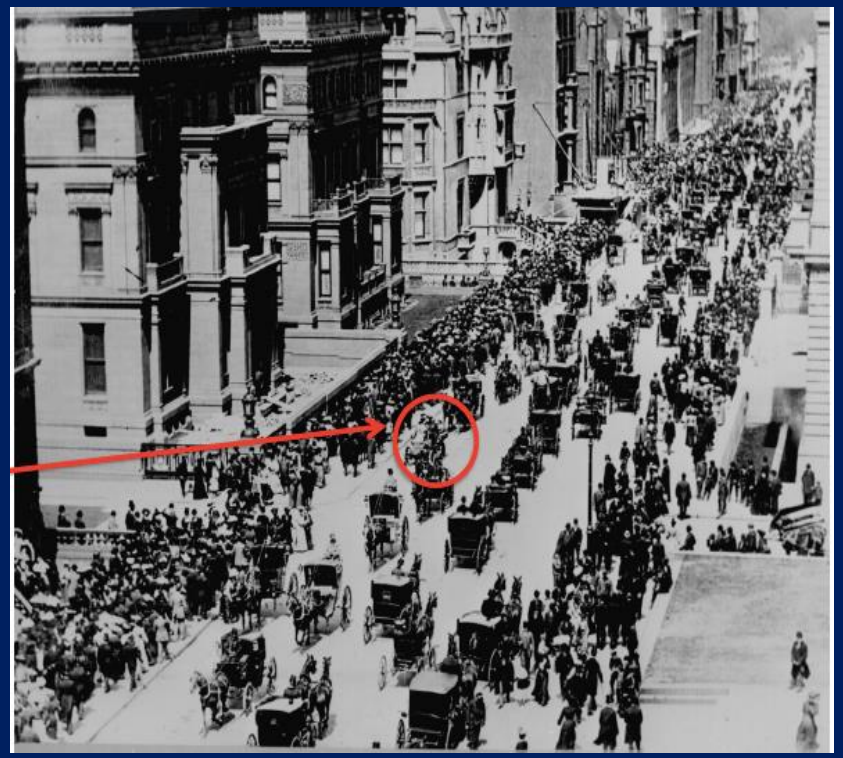
Transport Transitions

5th Avenue New York

15th April 1900



March 23, 1913

https://therationalpessimist.com/2015/03/22/charts-du-jour-21-march-2015-battery-banter/

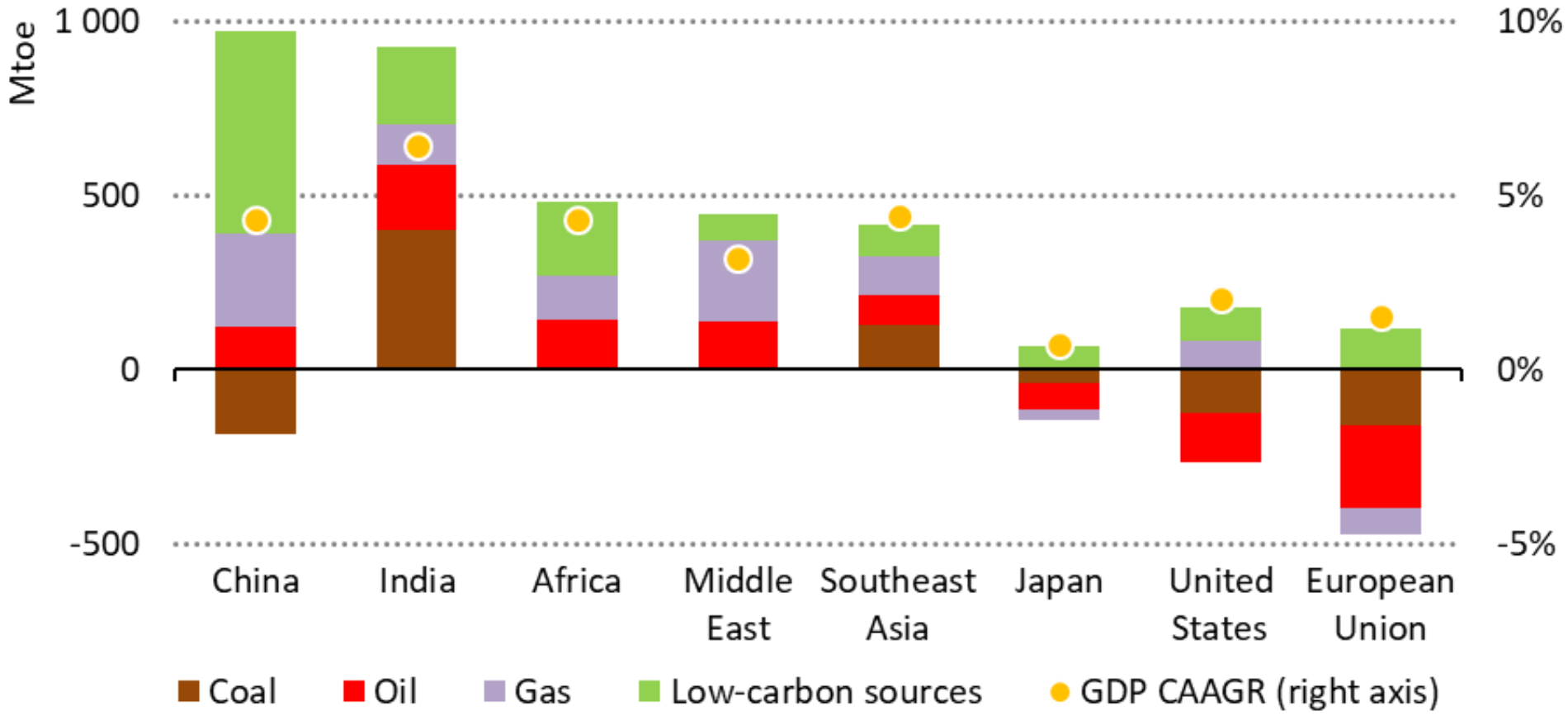
Energy Transitions in the past

- Transition from traditional fuels to modern, commercial fuels (mainly fossil)
- Investment in centralized energy supply and distribution infrastructure
- Centralised inter- connected electricity grid
- Large hydro and coal based thermal power plants
- Focus on supply growth
- Public sector and government investments

Drivers for Energy Transitions

- Climate Change – Paris commitments – global move away from fossil
- Significant drop in prices of Solar PV and wind
- Reduction in prices of shale oil and natural gas
- Success in public procurement of LEDs – rapid decline in prices
- Internet of Things – Technology developments, Intelligent sensors, control

Change in energy demand and average annual GDP growth rate by region in the Stated Policies Scenario, 2018-2040



Faster economic growth in developing economies is accompanied almost everywhere by rising demand for all fuels and technologies

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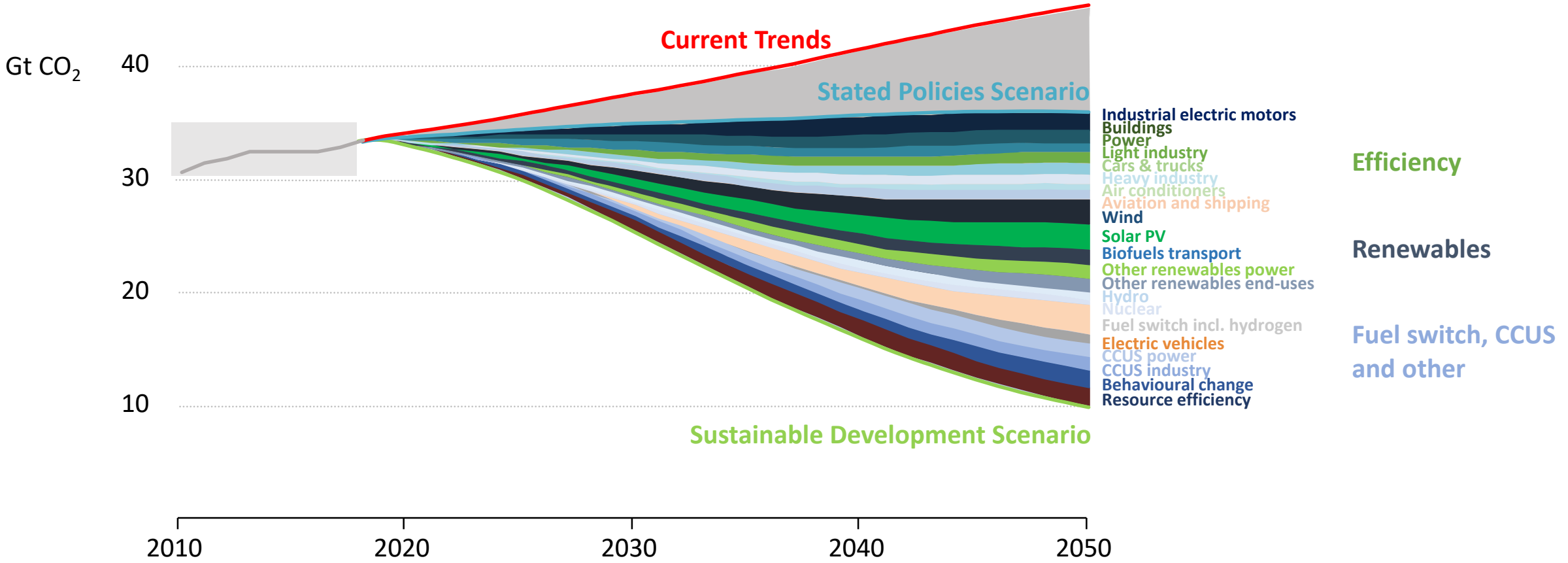
No single or simple solutions to reach sustainable energy goals

Energy-related CO_2 emissions and reductions in the Sustainable Development Scenario by source



A host of policies and technologies will be needed across every sector to keep climate targets within reach, and further technology innovation will be essential to aid the pursuit of a 1.5°C stabilisation

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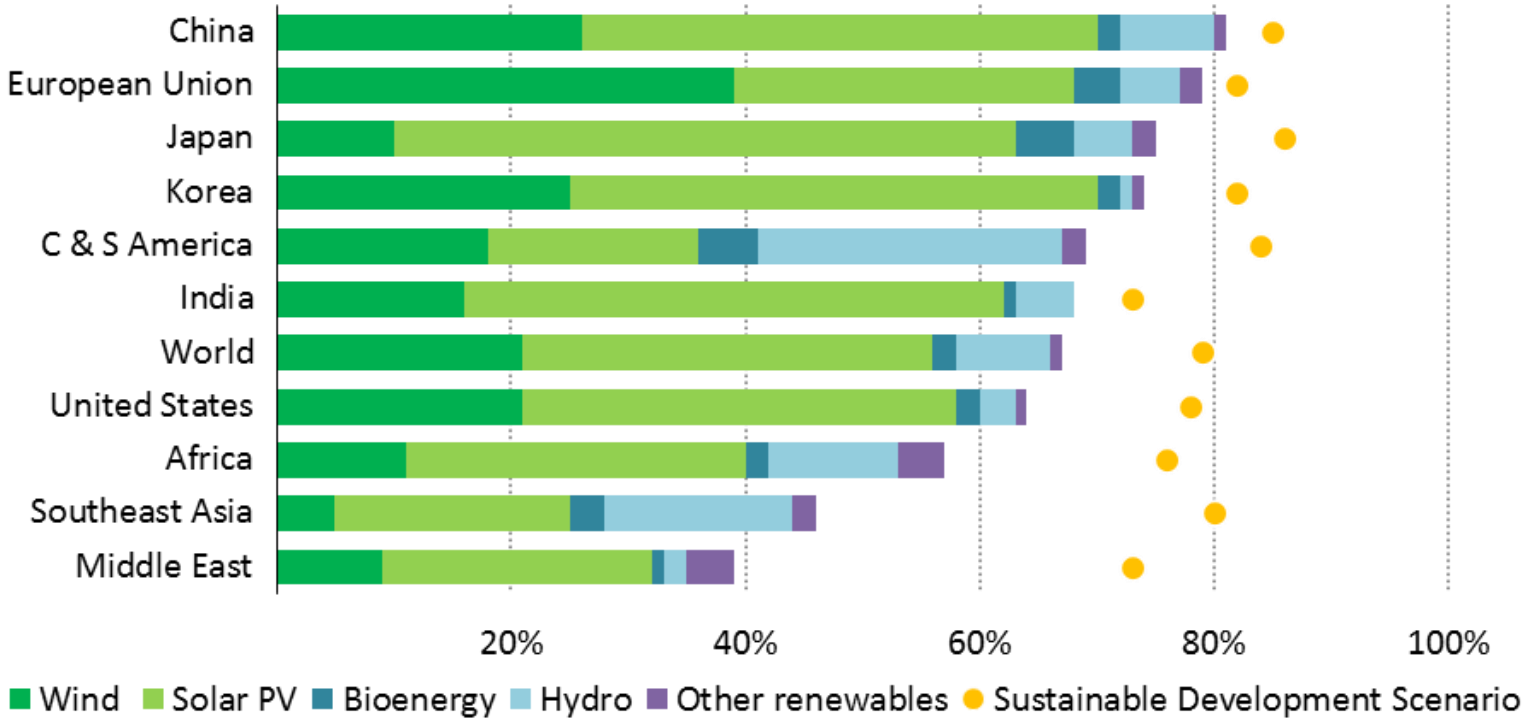
Renewables share in capacity additions by region in the Stated Policies and Sustainable Development scenarios, 2019-2040



Renewables account for the majority of new capacity built to 2040 in most regions in the Stated Policies Scenario and rise to higher shares in the Sustainable Development Scenario

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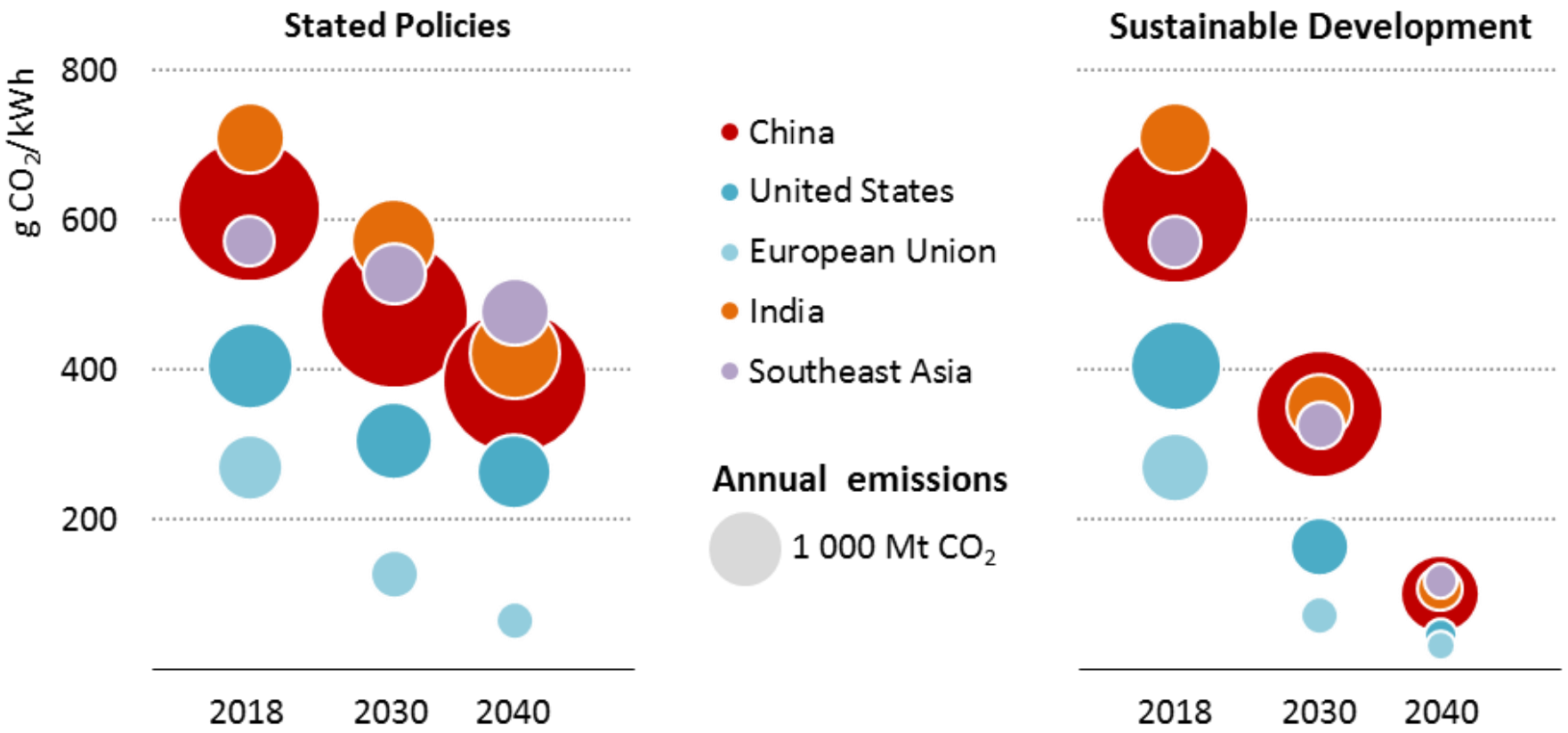
CO_2 intensity of electricity generation by region and scenario



Carbon intensity of electricity generation declines in each region and scenario, though to a much greater extent in the Sustainable Development Scenario

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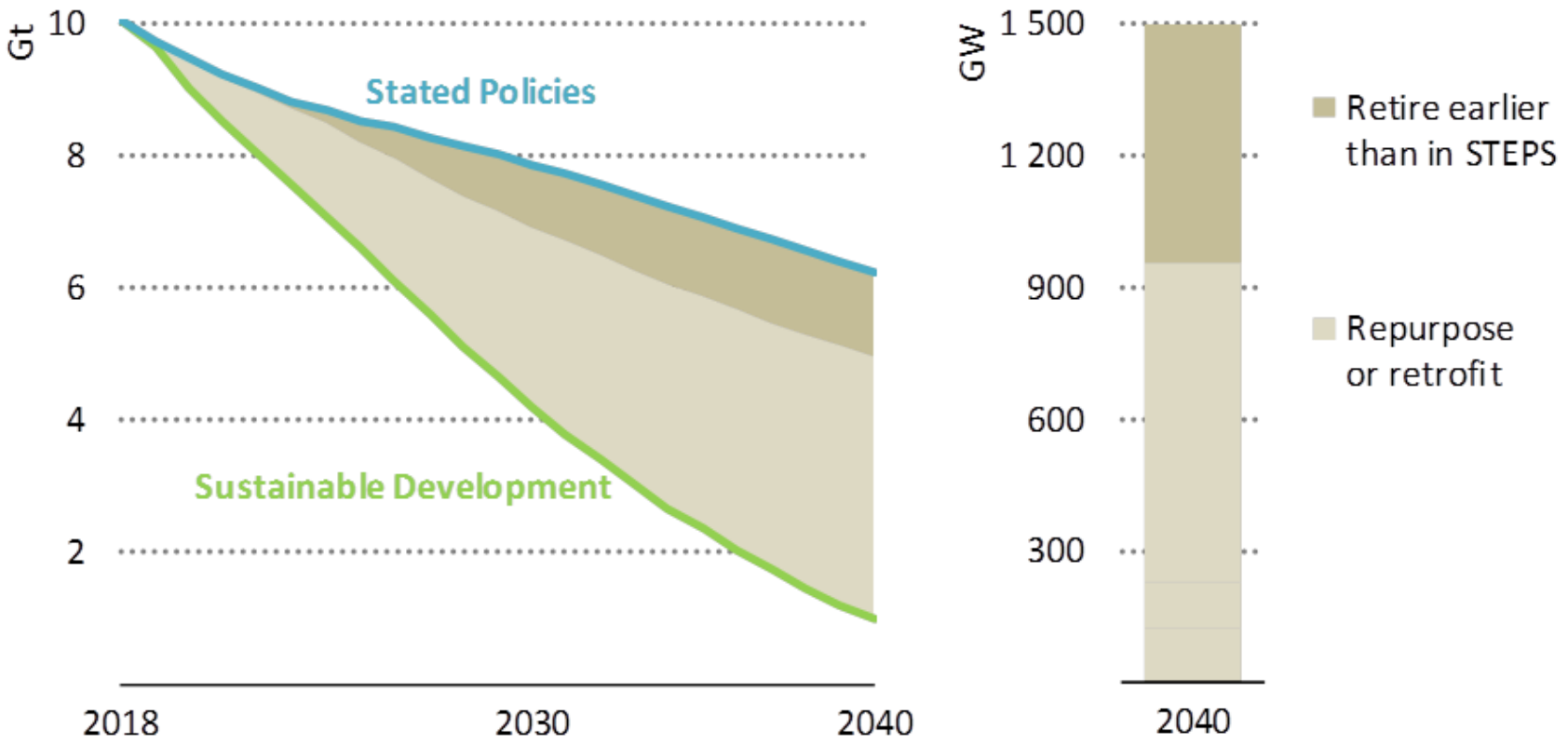
Reducing CO_2 emissions from existing coal-fired power capacity by measure



Curbing CO_2 emissions from coal-fired power plants can be done cost effectively by retrofitting, repurposing and retiring the existing fleet

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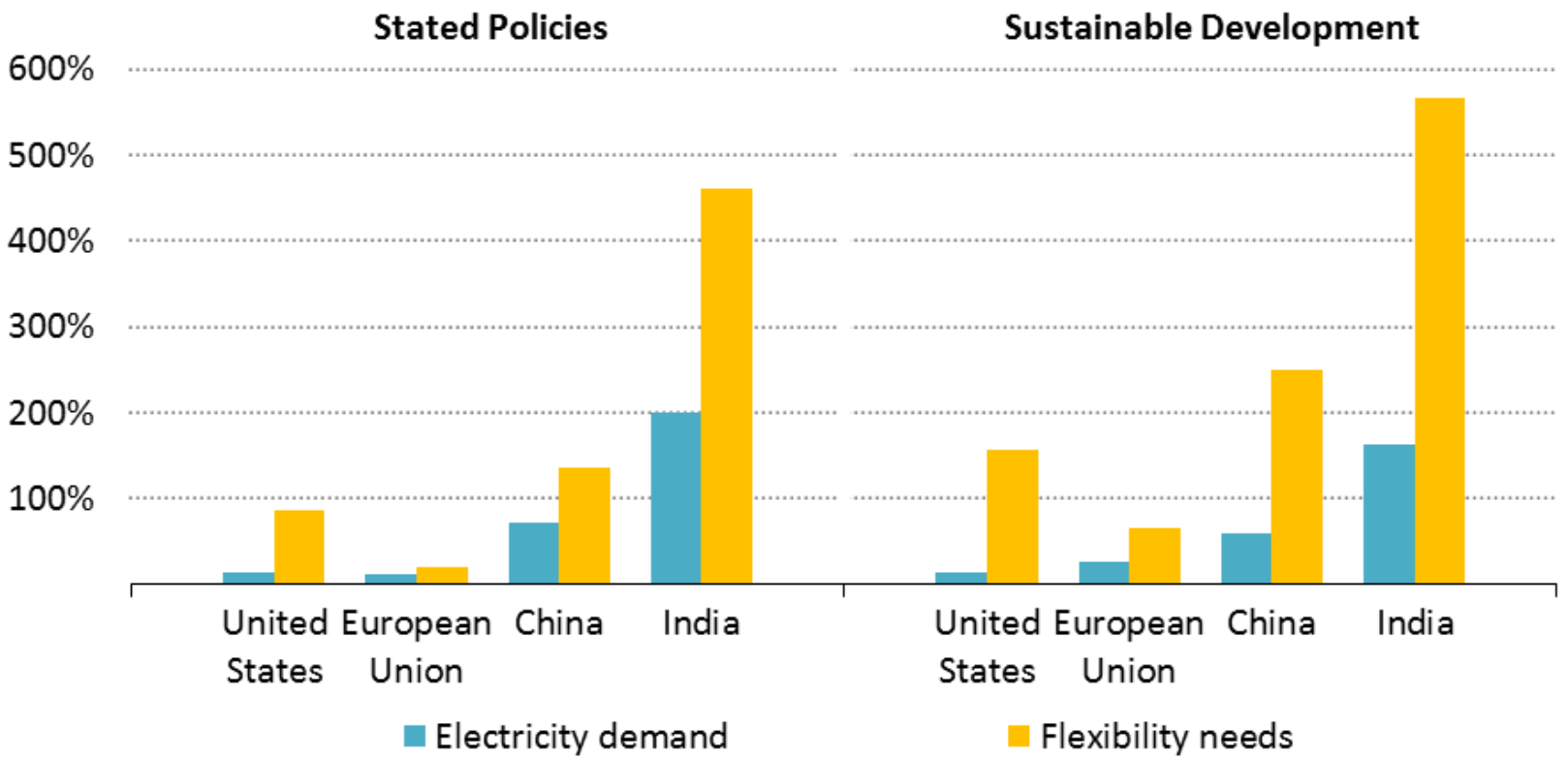
Growth in electricity demand and flexibility needs by selected region and scenario, 2018-2040



Flexibility needs increase much faster than electricity demand, driven by rising shares of variable renewables, more electric vehicles and higher demand for cooling

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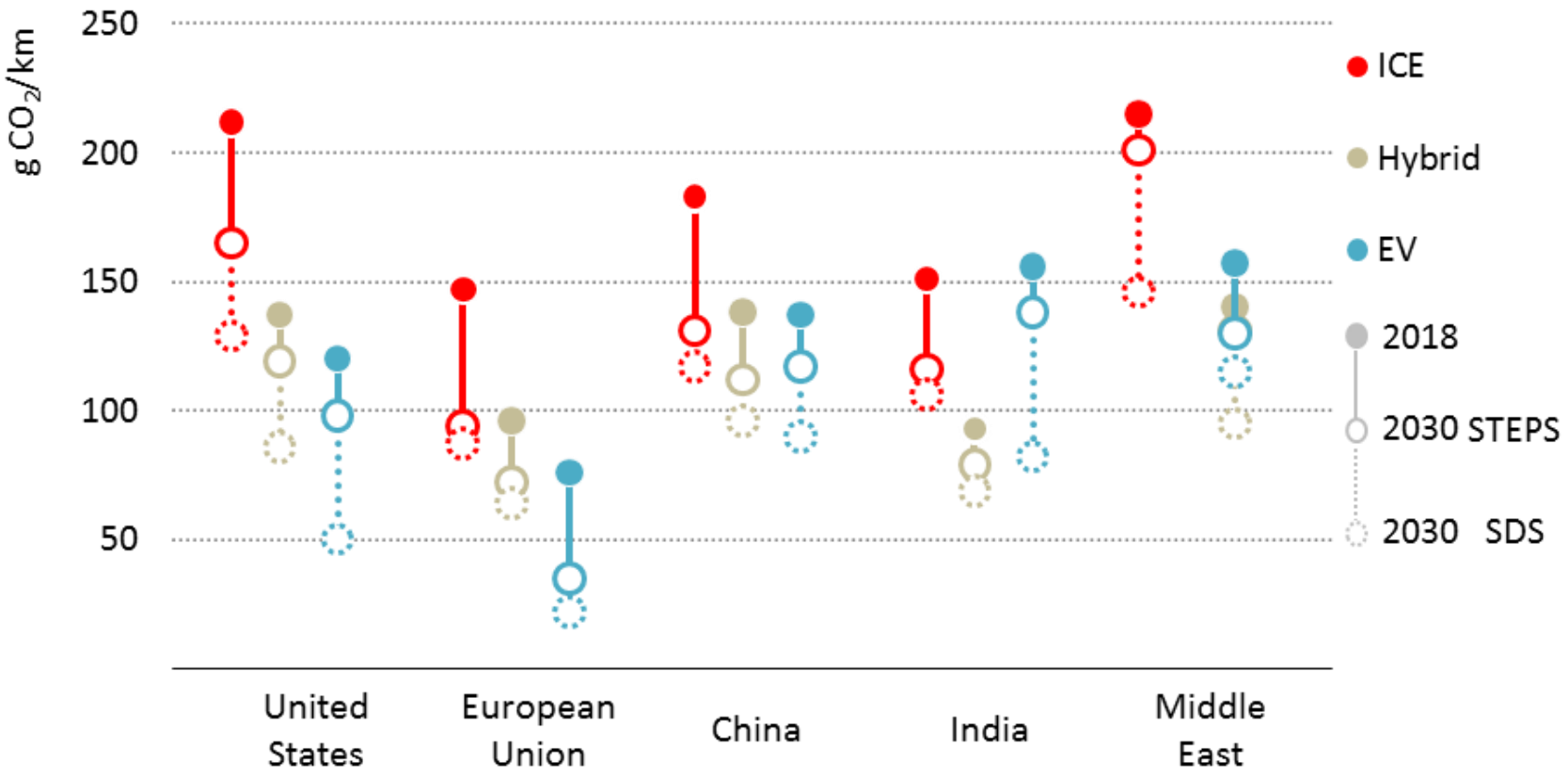
Carbon emissions of different car powertrains by region



The relative carbon footprint of ICE versus electric cars strongly depends on the power sector mix

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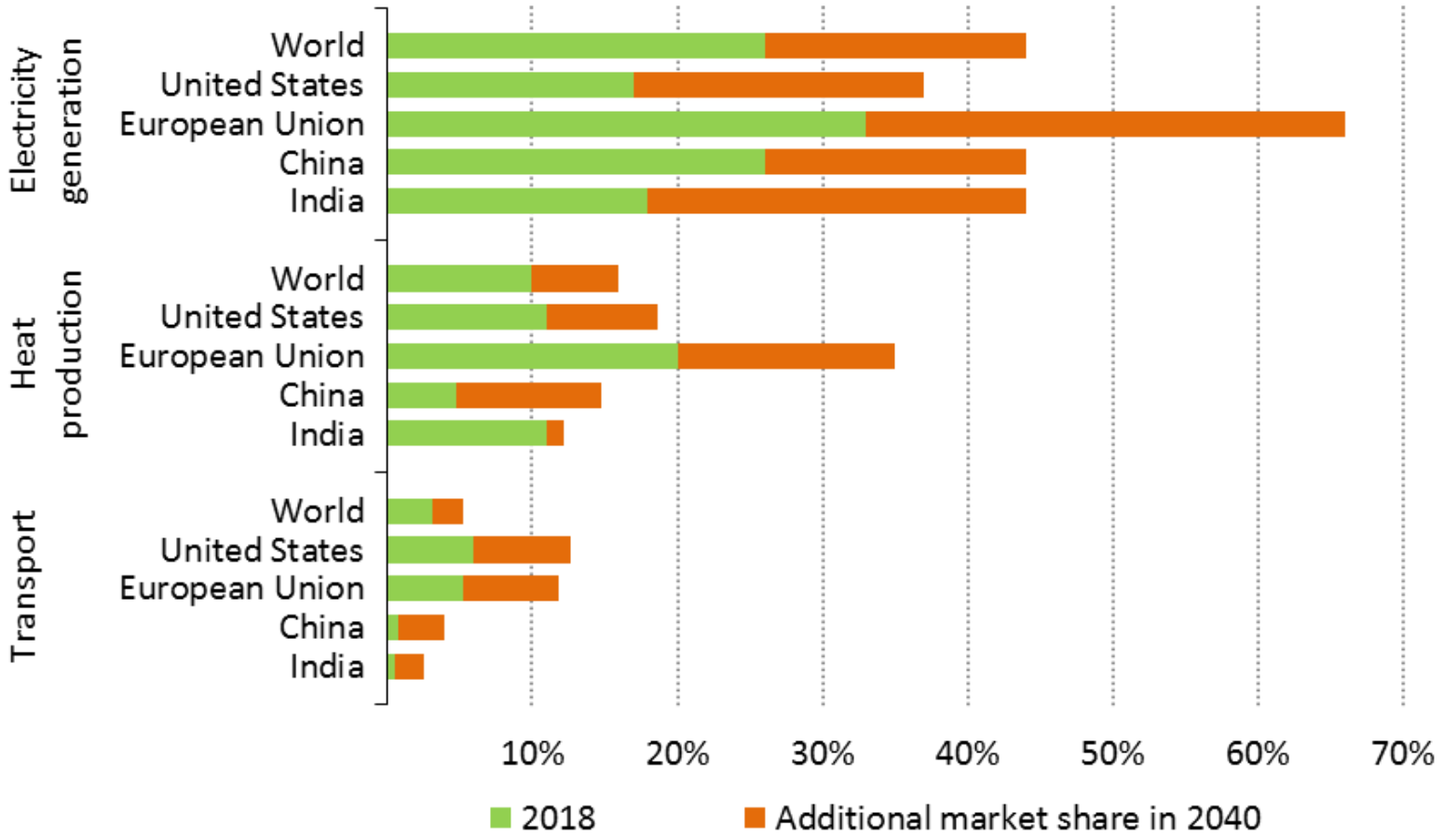
Renewable energy in total primary energy demand by category and region in the Stated Policies Scenario, 2018 and 2040



Strong support policies for renewable-based electricity are boosting their penetration, but more policy action is needed in other sectors

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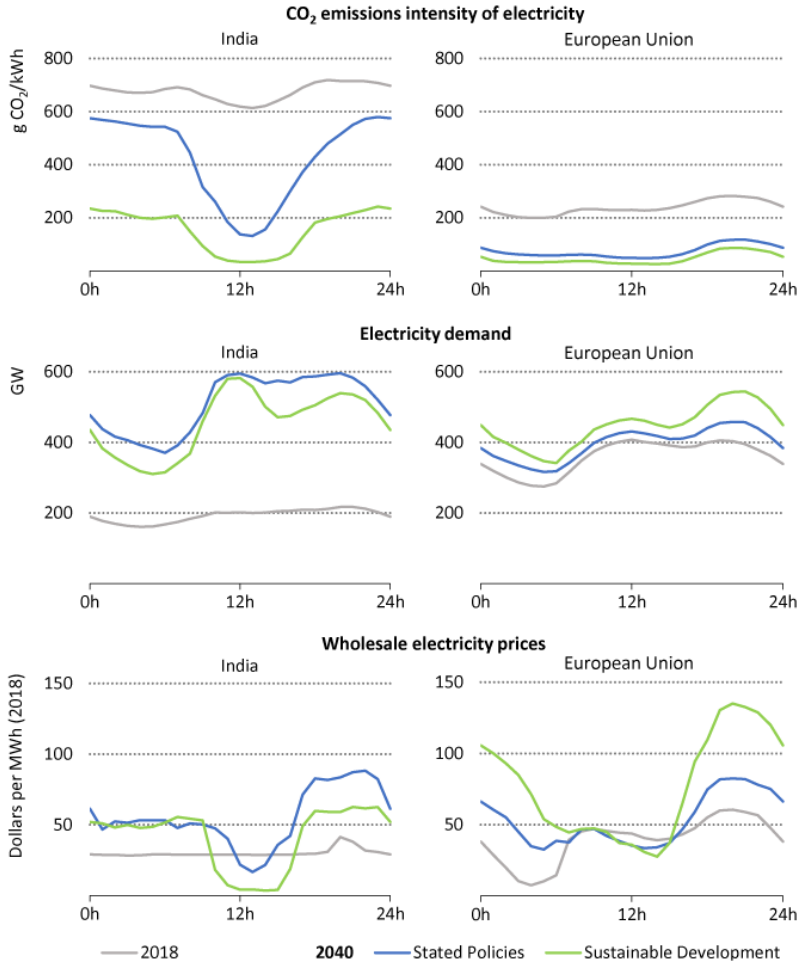
Average hourly CO_2 emissions intensity, electricity demand and wholesale electricity prices in India and the European Union



Daily variation in the average CO_2 intensity of electricity increases to a factor of seven in India, with generation oscillating between solar PV and gas or coal. The European Union, with higher shares of wind generation, reaches a factor of three.

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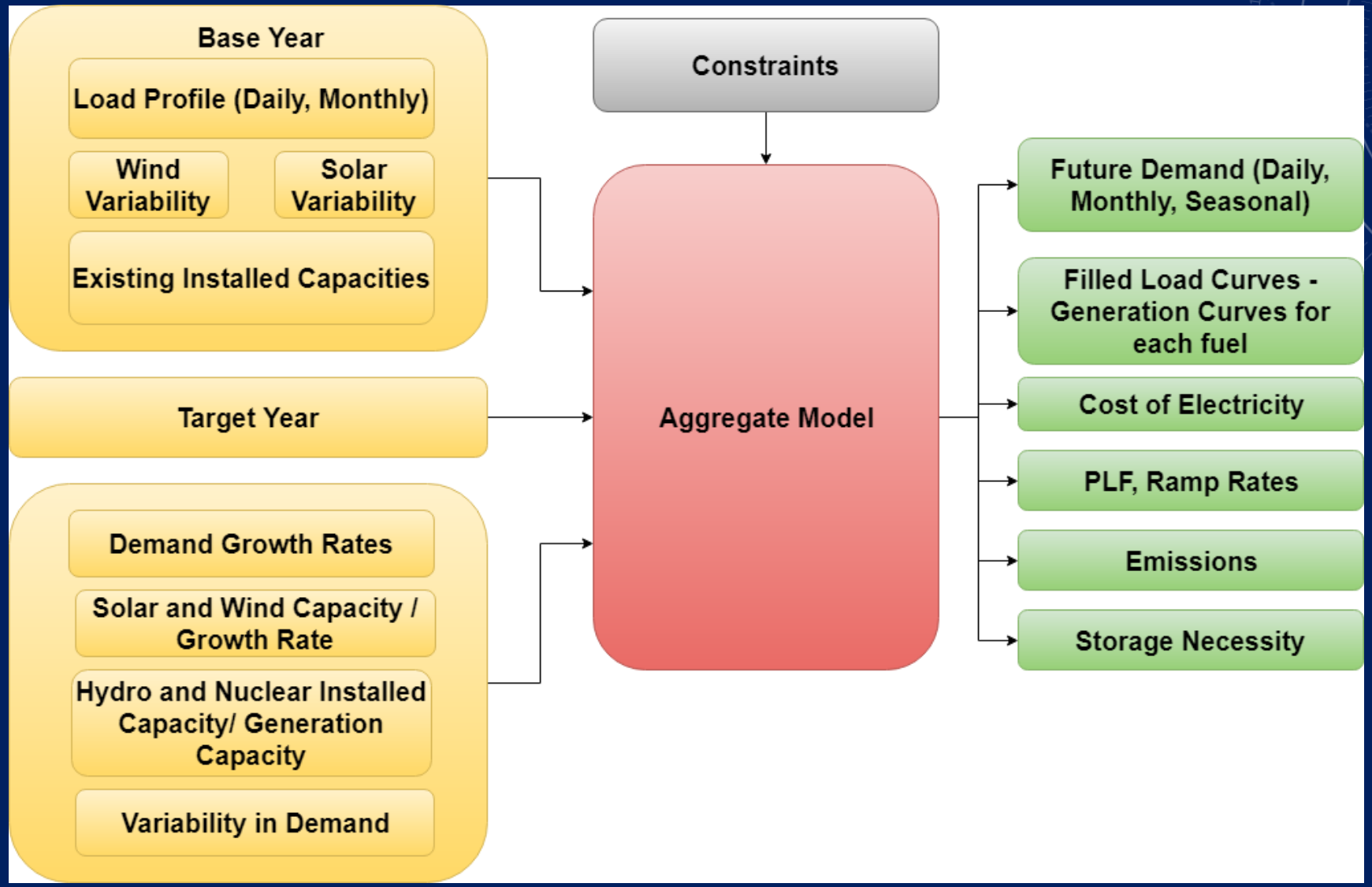
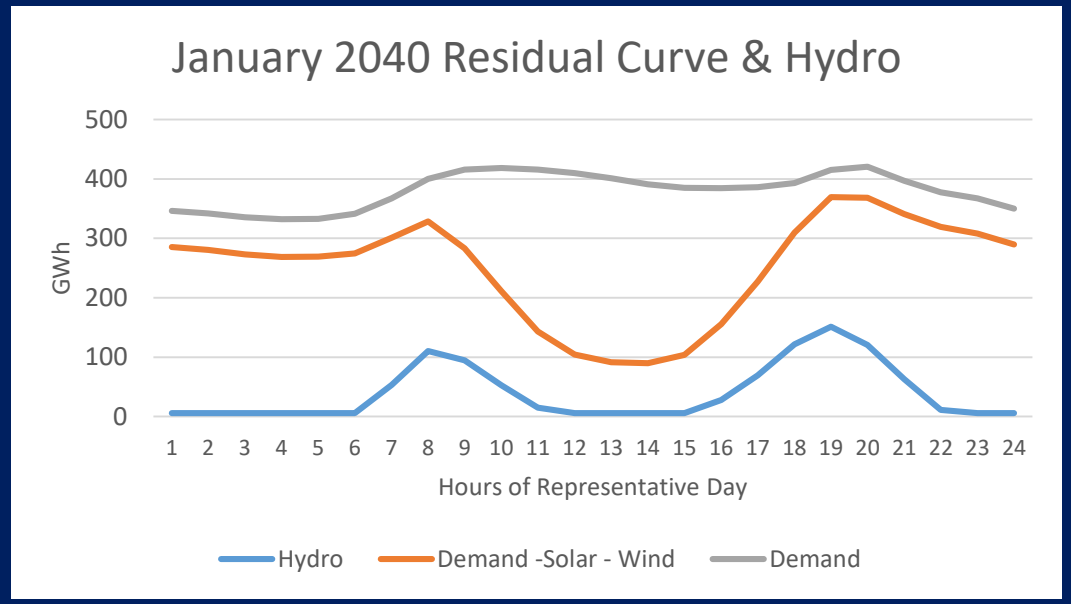
Electricity Generation (Source: Niti Aayog Energy Plan)

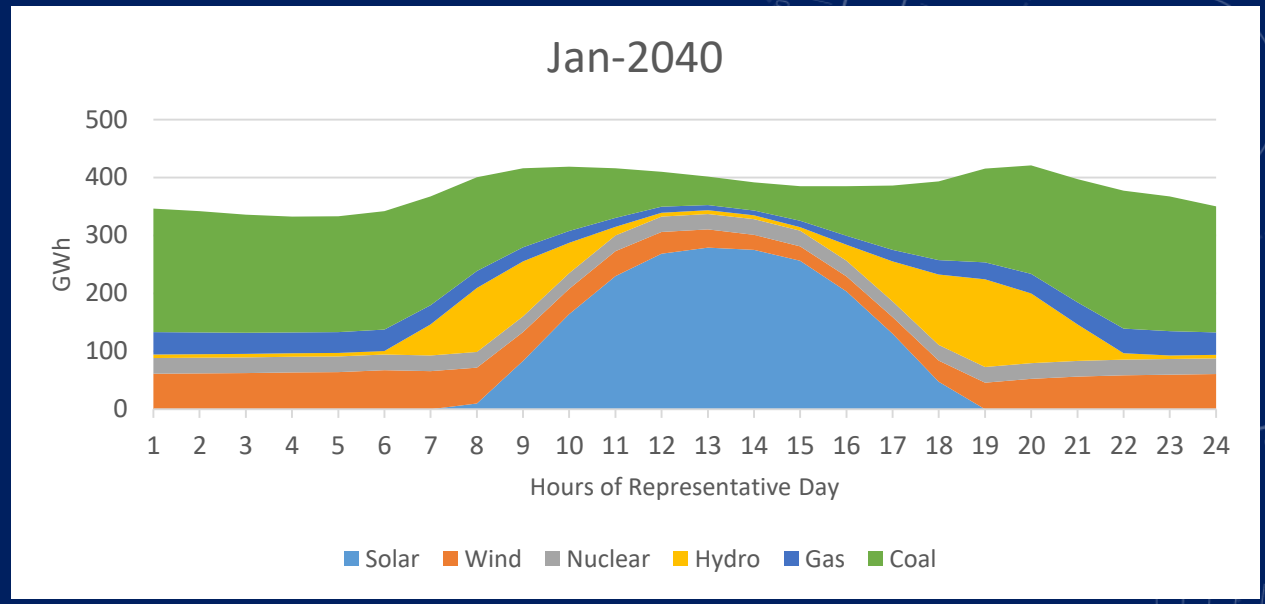
TWh	2012	2022		2040	
		BAU	Ambitious	BAU	Ambitious
Gas Power Stations	115	128	154	181	302
Coal power stations	708	1526	1482	2606	1984
Carbon Capture Storage (CCS)	0	5	5	137	137
Fossil Fuel Based Electricity	824	1659	1641	2924	2423
Nuclear power	27	82	87	164	237
Hydro Power Generation	144	214	214	248	324
Hydro and Nuclear	170	296	301	412	561
Solar PV	2	99	99	422	489
Solar CSP	0	11	14	105	185
Onshore Wind	32	129	129	390	423
Offshore Wind	0	6	6	62	92
Distributed Solar PV	0	55	55	164	193
Other Renewable Sources	46	86	101	203	281
Renewable Based Electricity	80	386	404	1346	1663
Electricity imports	5	15	25	71	126
Total	**1078**	**2356**	**2371**	**4753**	**4773**

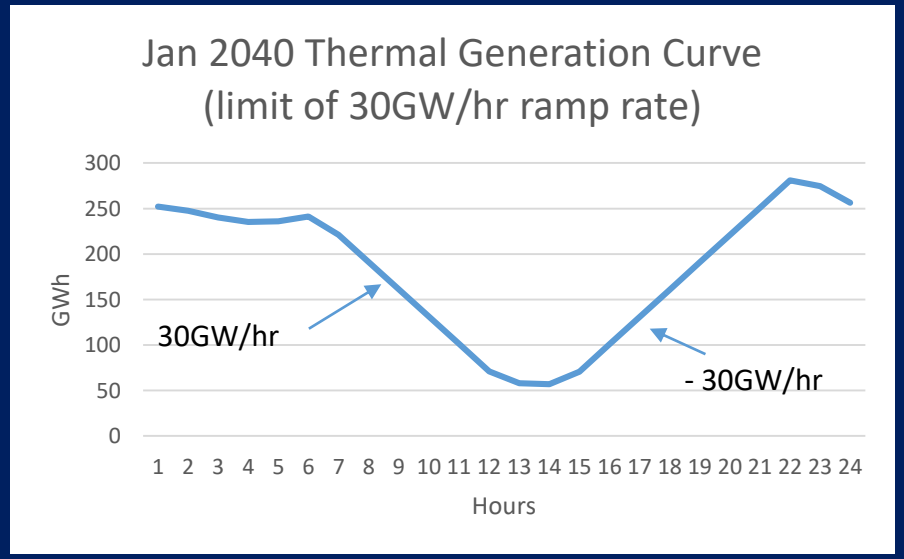
Aggregate - Methodology



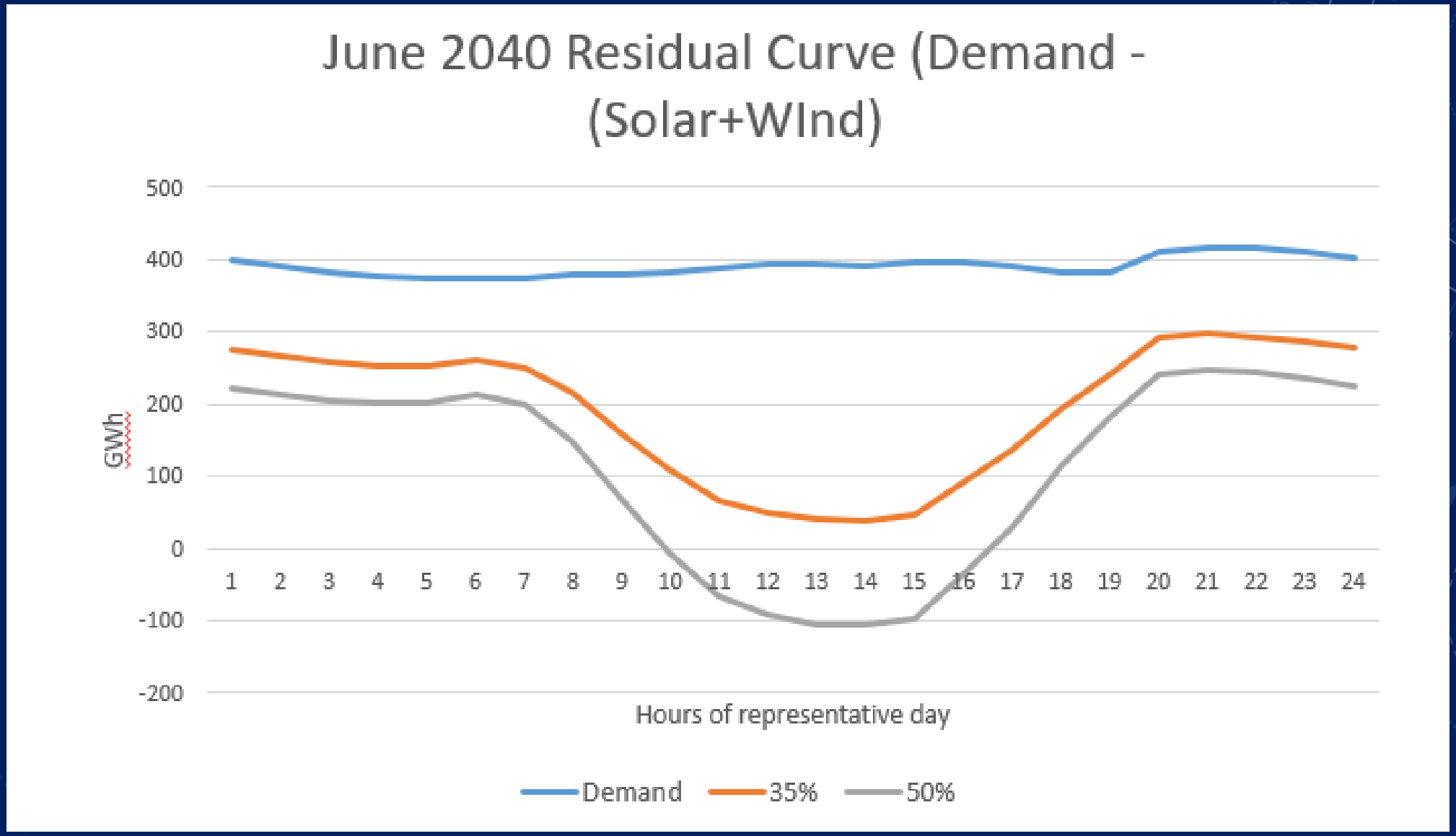
Filling of Curve



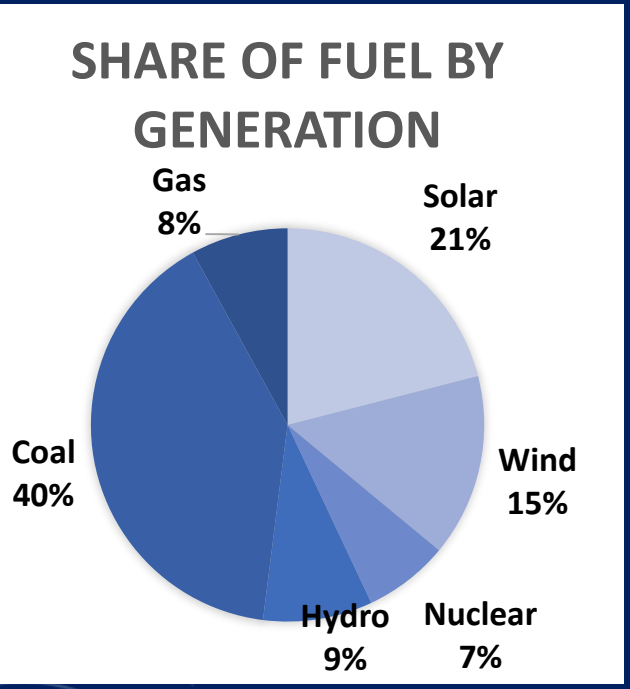


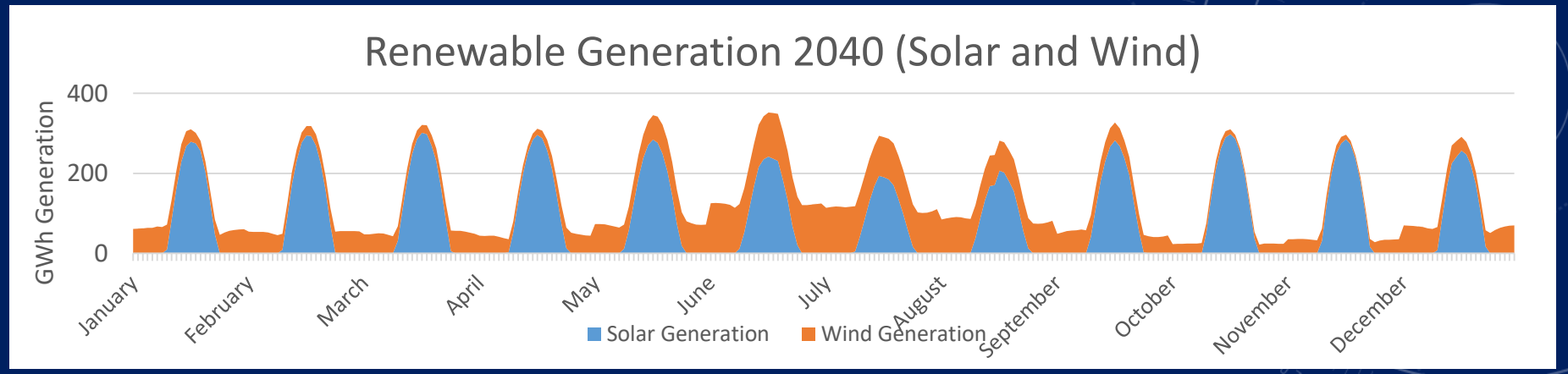


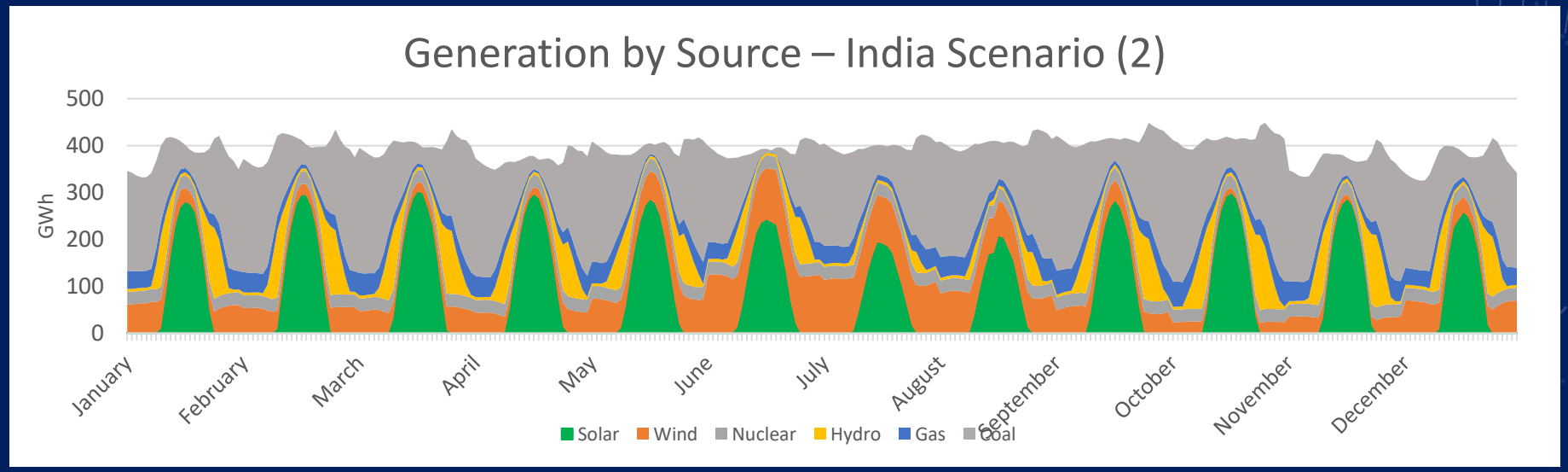
Projected Residual Curve



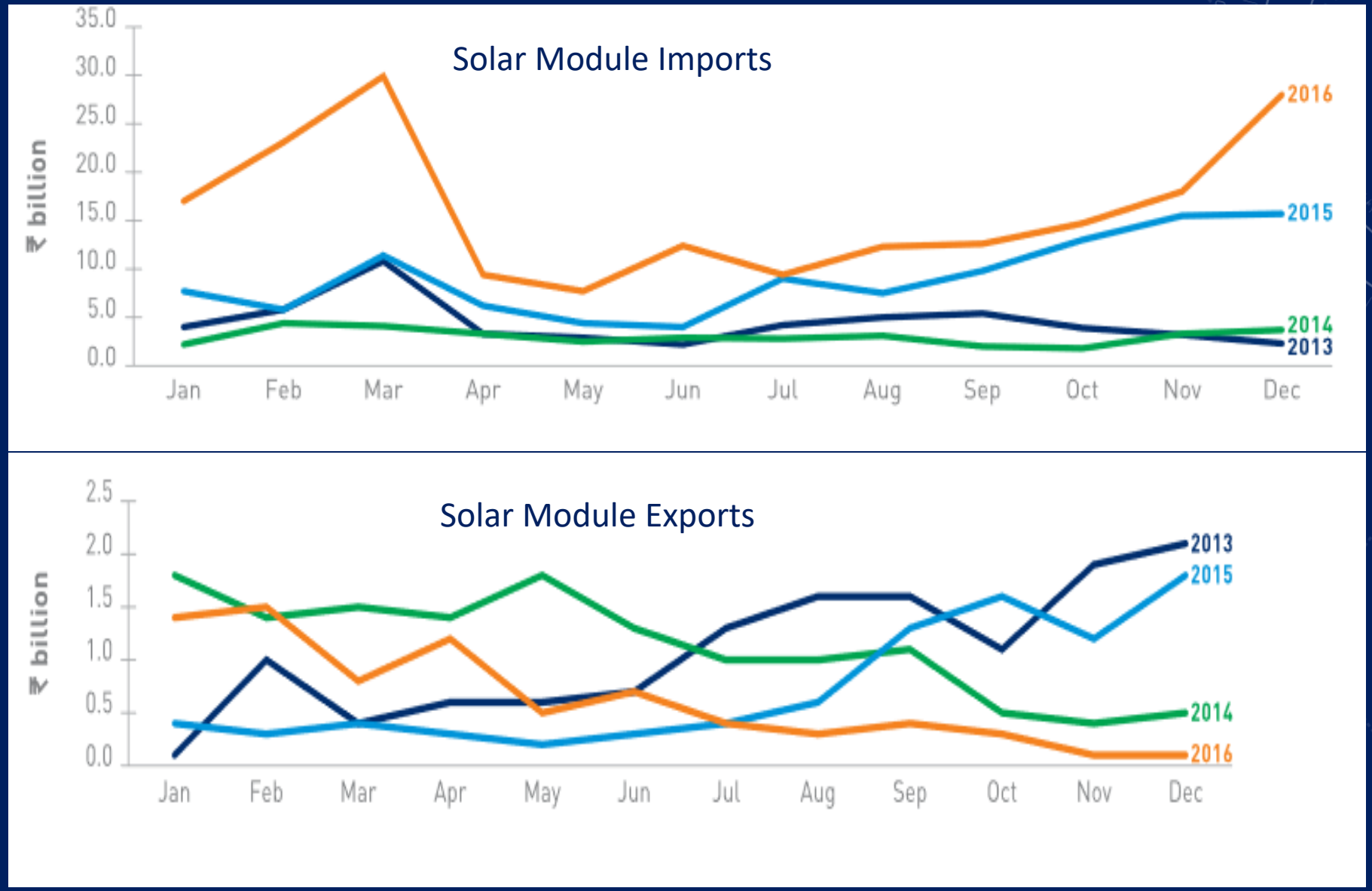
Projected Renewable Generation







Cost of Solar Module Imports and Exports

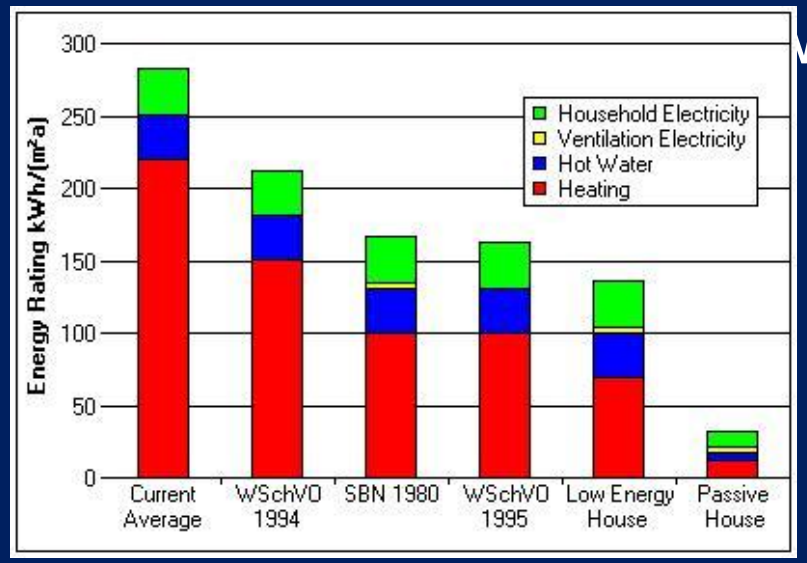


Source: Bridge to India, India Solar Handbook, 2017

PV Manufacturing in India

- Module Manufacturing Capacity 5286 MW (December 2016) operational out of 6800 MW installed
- Domestic module production in 2016 1330 MW
- Low capacity utilization – unable to compete
- 88% of domestic supply – Imports (84% from China)
- Imports 2016-17 FY 3 billion US $ (180 Billion Rupees) 5.7 GW of modules (2.8% of trade deficit)
- Cell manufacturing capacity 1753 MW (operational 1448 MW)

Passive House, Zero Energy Buildings



www.passiv.de

(Germany/Sweden)

http://www.pasivnidomy.cz/domy/

TEAM SHUNYA
Building a sustainable future

House in Versailles – 26th June, 2014

House in Dezhou – August, 2018

70 students 13 disciplines 12 faculty

Summary

- Sustainability- economic, environment, climate, equity
- Centralised vs Decentralised, Lock in
- Energy Transitions imminent
- Need to a-priori assess impacts – equity, income, quality of life
- Technology development , R&D and jobs, alternate strategies, innovation
- Socio-technical problem – stranded assets regional imbalances, jobs lost

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- Power Grid Corporation Of India Ltd, Gurgaon, “Report on Green Energy Corridors-Transmission Plan for Envisaged Renewable Capacity”, Vol 1, C/SG/RE/2012/01 ,July 2012.
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