Solving Climate: The Need for Zero Carbon On-Demand Power

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National Coal Council
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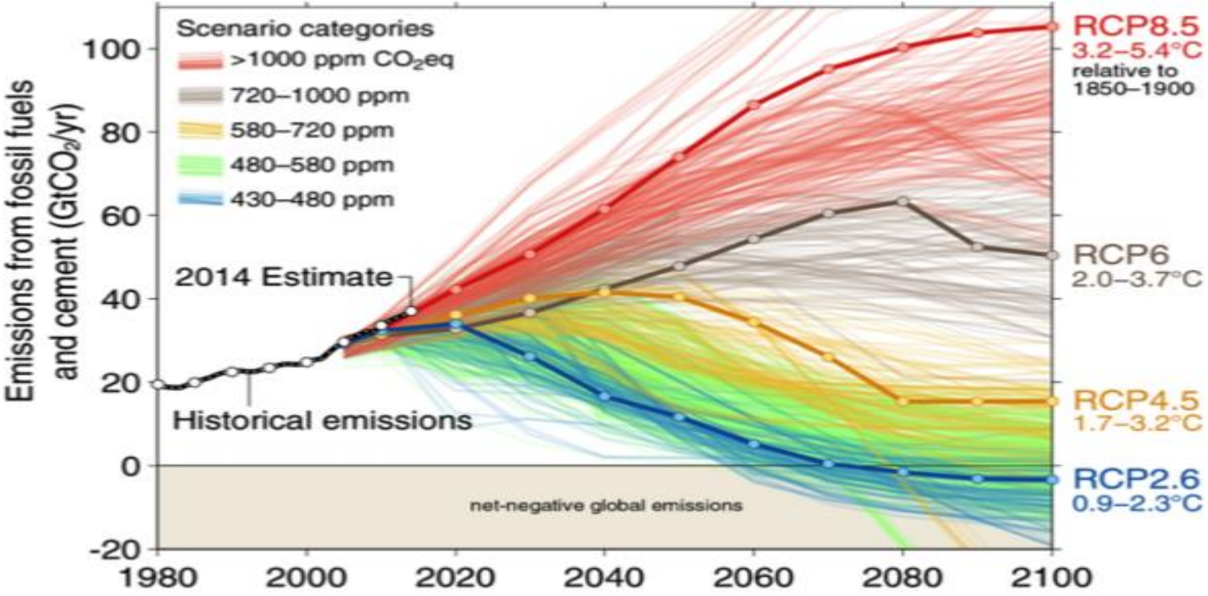
- STABILIZING CLIMATE MEANS ZERO EMISSIONS

- ZERO CARBON ON-DEMAND POWER SOURCES WILL BE NEEDED

- FAILURE TO DEPLOY THEM COULD LEAD US TO DECARBONIZATION “DEAD ENDS”

- WE NEED TO TAKE ACTION TODAY TO CREATE BETTER, CHEAPER ON-DEMAND OPTIONS

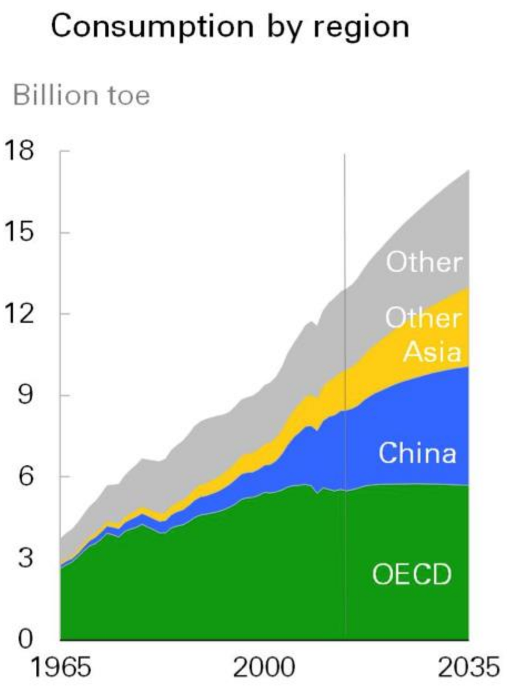
Paris targets mean zero emissions

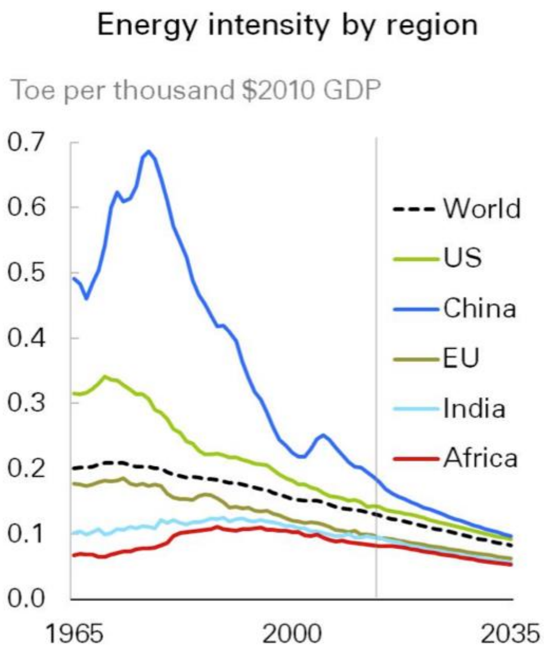


1.5-2 degree pathway

Fuss et al from IPCC AR5 (2014)

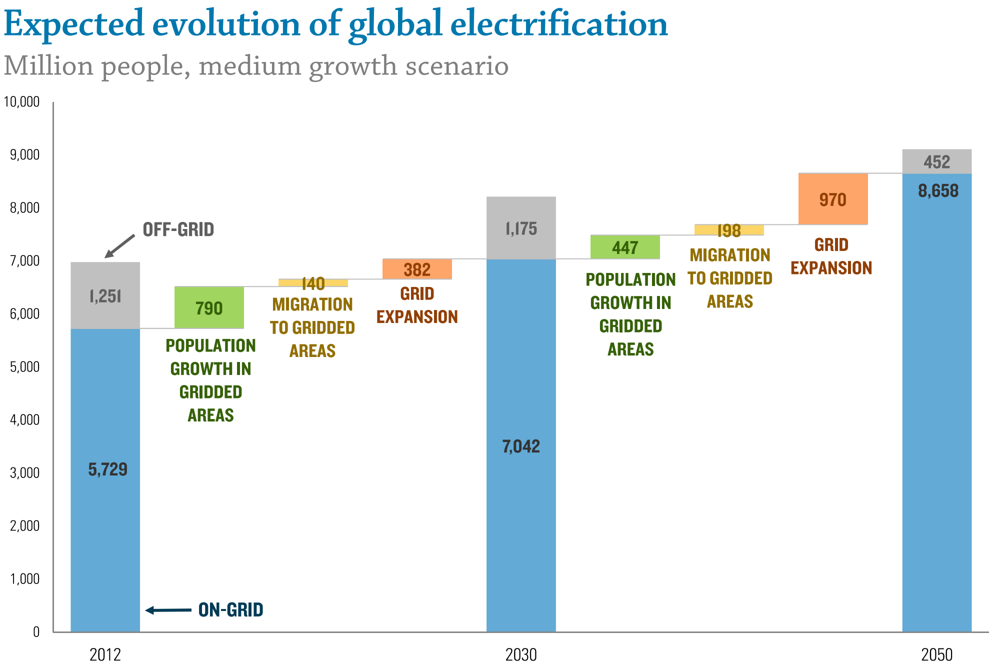
Need to do this in face of rising energy demand, despite efficiency gains



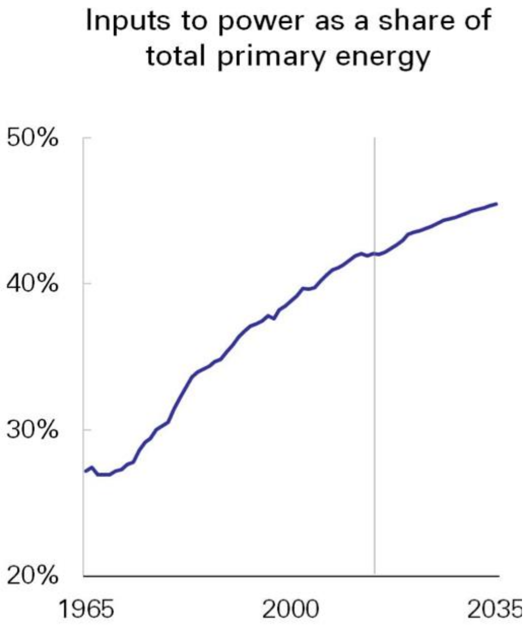


BP Energy Outlook 2016

Grid electricity comprises a growing share



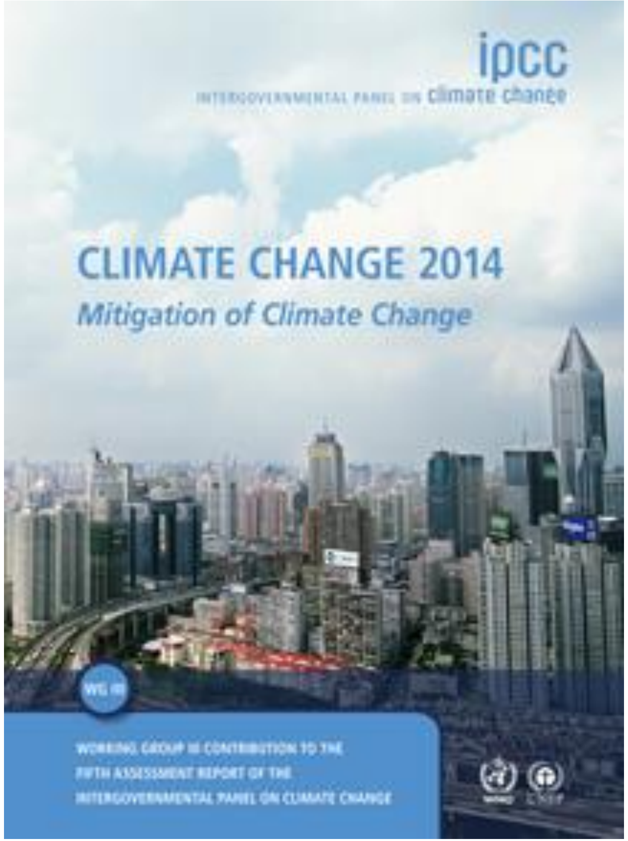
Source: IEA, World Bank, IIASA and RHG estimates

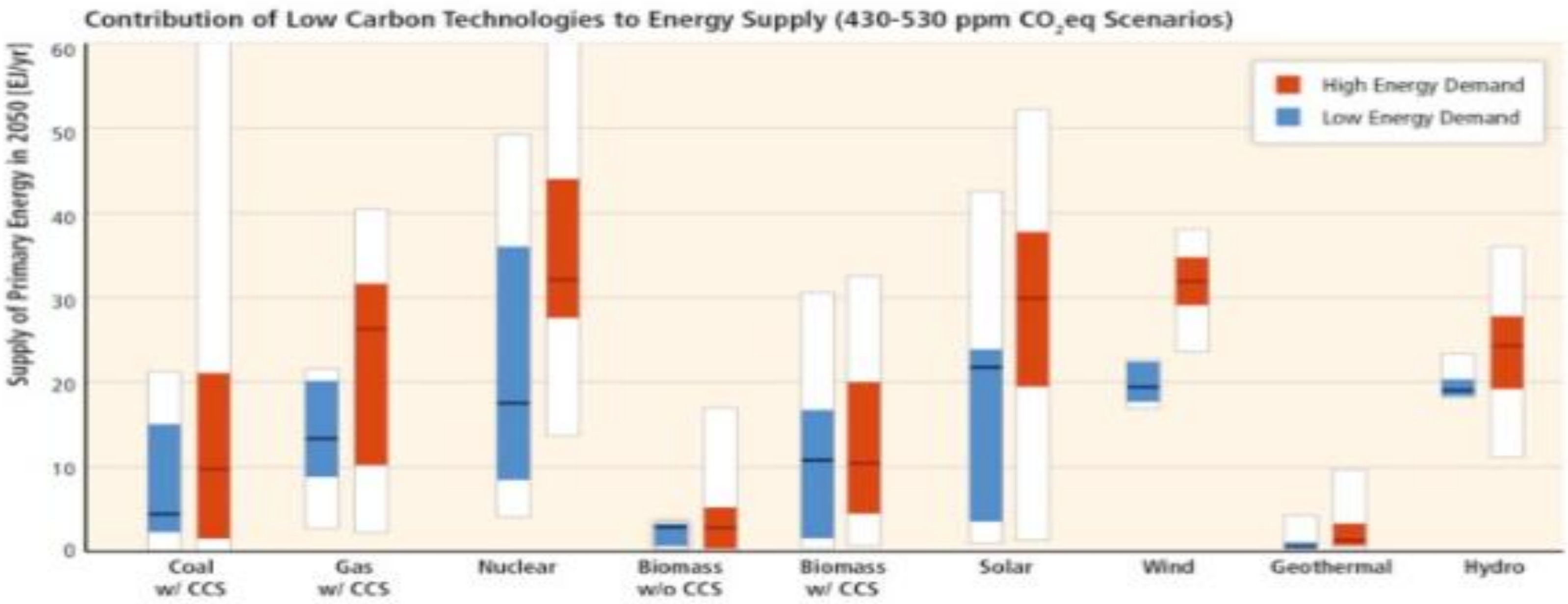


BP Energy Outlook 2016

“No single mitigation option in the energy supply sector will be sufficient. Achieving deep cuts [in emissions] will require more intensive use of low-GHG technologies such as renewable energy, nuclear energy, and CCS.”

-- IPCC, Assessment Report 5, Mitigation (2014)





Contribution of Low Carbon Technologies to Energy Supply (430-530 ppm CO_2eq Scenarios)
Supply of Primary Energy in 2050 [EJ/yr]
60
50
40
30
20
10
0
High Energy Demand
Low Energy Demand
Coal w/ CCS
Gas w/ CCS
Nuclear
Biomass w/o CCS
Biomass w/ CCS
Solar
Wind
Geothermal
Hydro

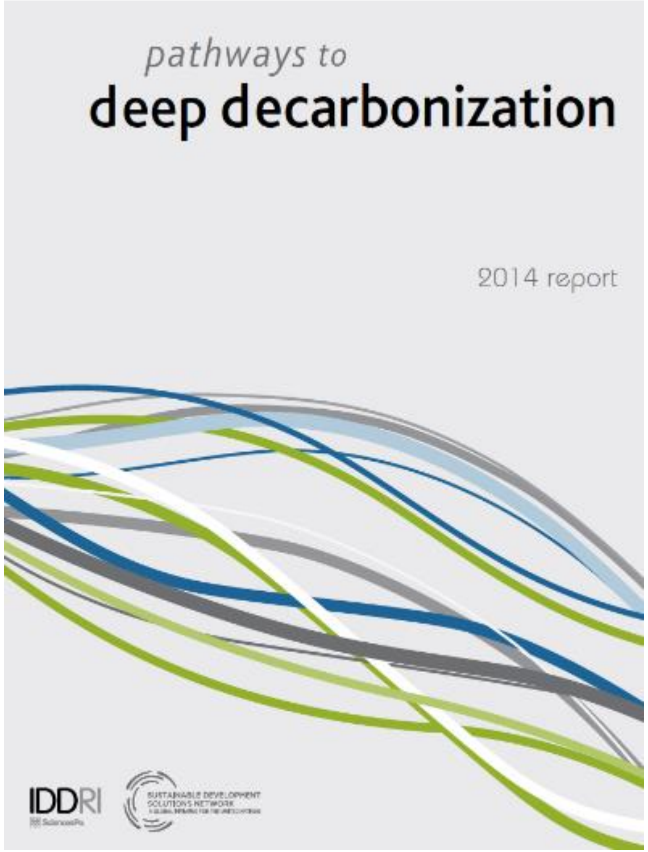
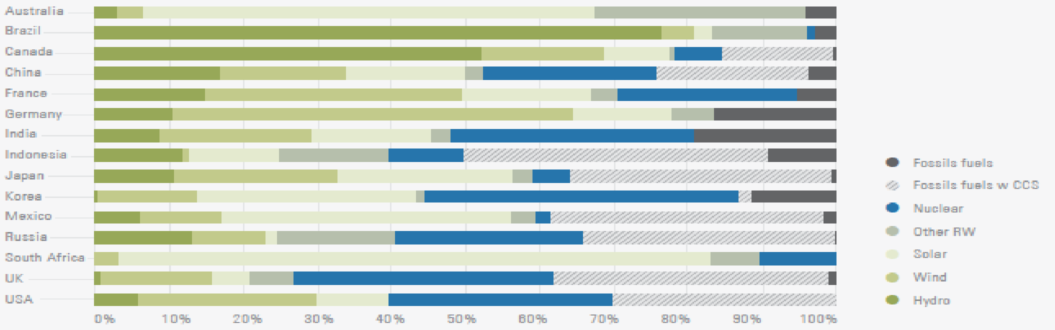


Figure 6.11. Electricity generation mix in 2050



Can weather-dependent renewables do it all?

Conclusions from multiple studies

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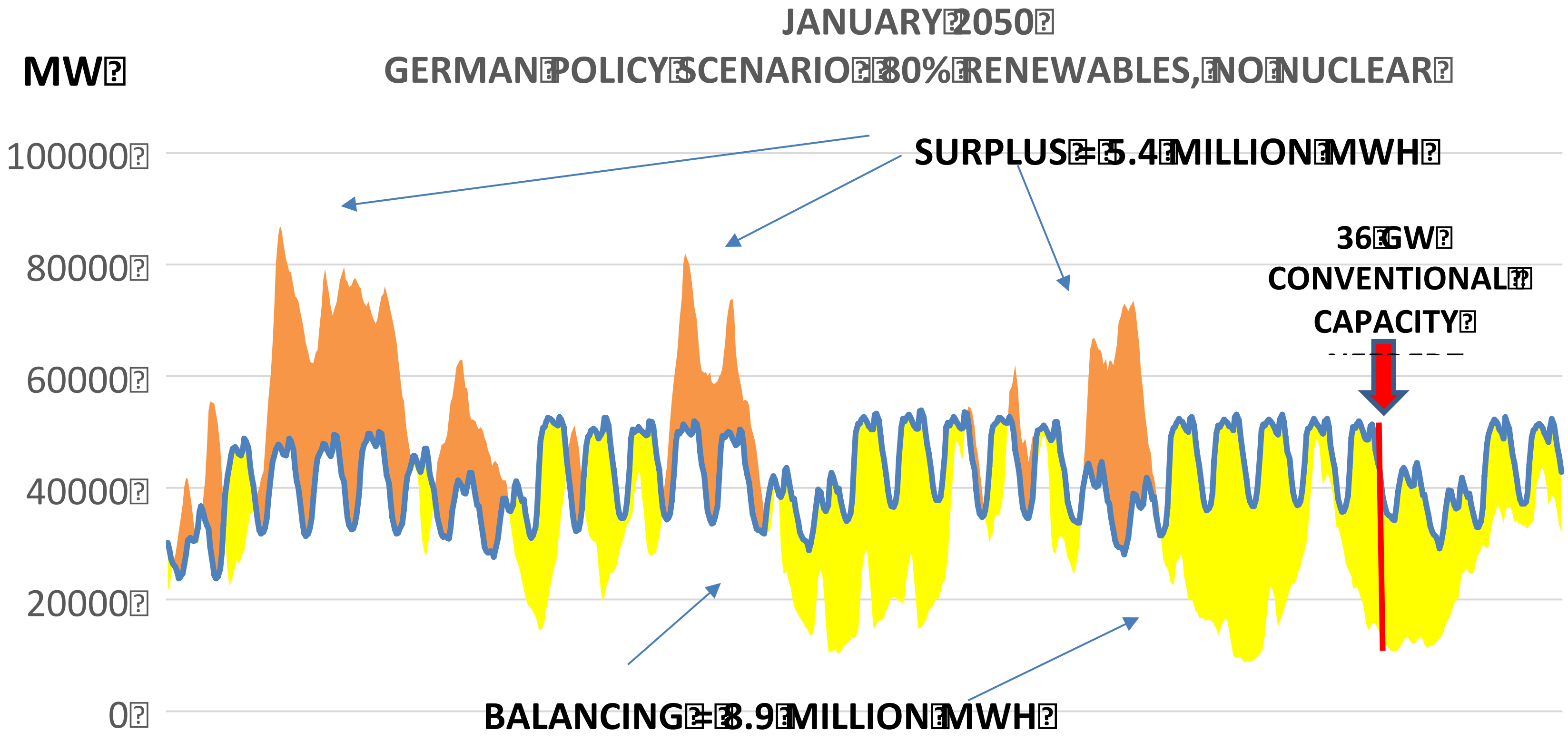
- High VRE systems are technically feasible but require significant dispatchable back-up capacity.
- This will add substantially to cost of decarbonization.
- Low cost storage, transmission and demand response do not FUNDAMENTALLY change the conclusion.
- This is due to large <u>*weekly and seasonal variation*</u> in VRE.
- High VRE systems have very big footprints, which may not be buildable or acceptable.
- ***Zero carbon baseload and dispatchable capacity (e.g. nuclear, decarbonized fossil) will likely be essential to deep carbon reductions.***

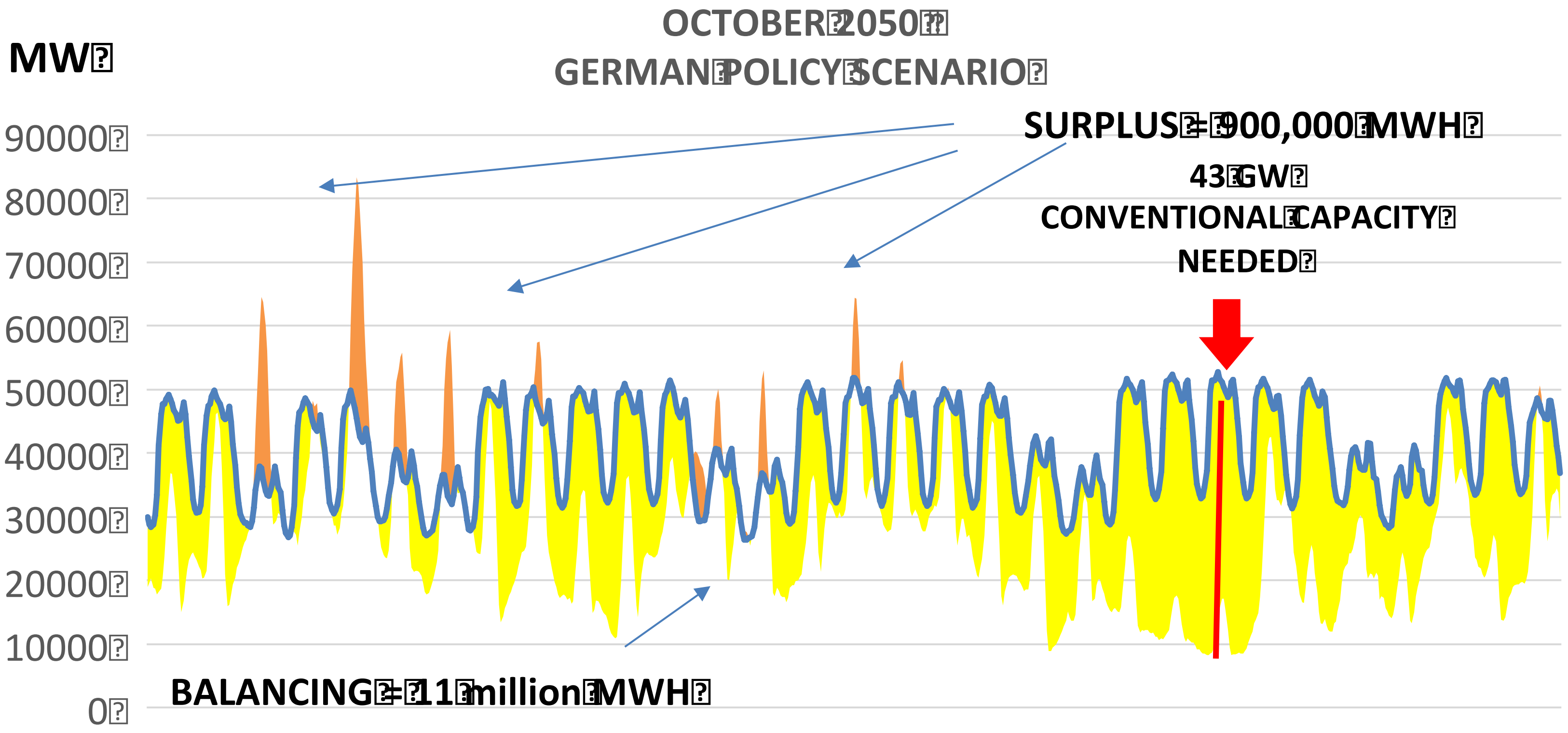
Germany case study

- Current German Policy
  - 80 GHG reduction below 1990 by 2050
  - 80 percent renewable electricity by 2050
  - 2050 electricity demand 25 percent below 2008
  - Accelerated nuclear phase-out by 2022

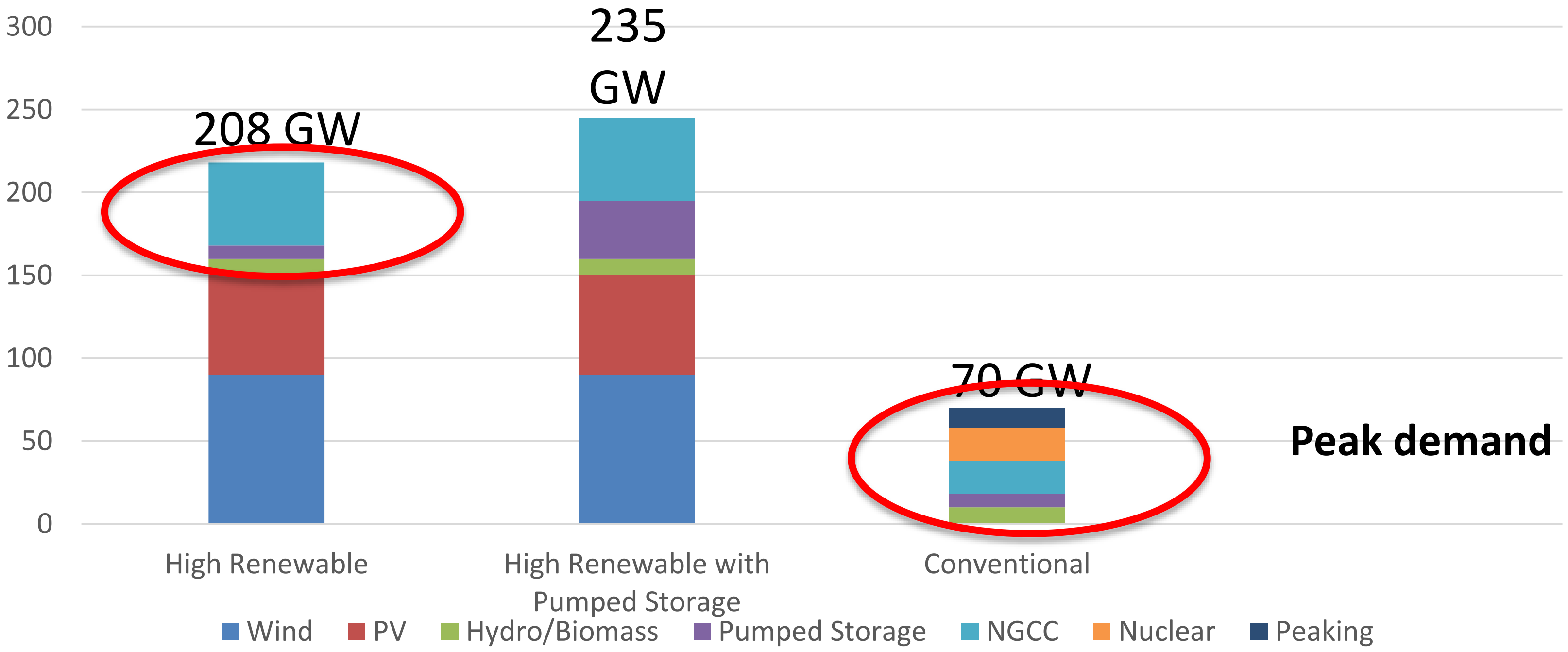
Modeled results: Jan. 2050



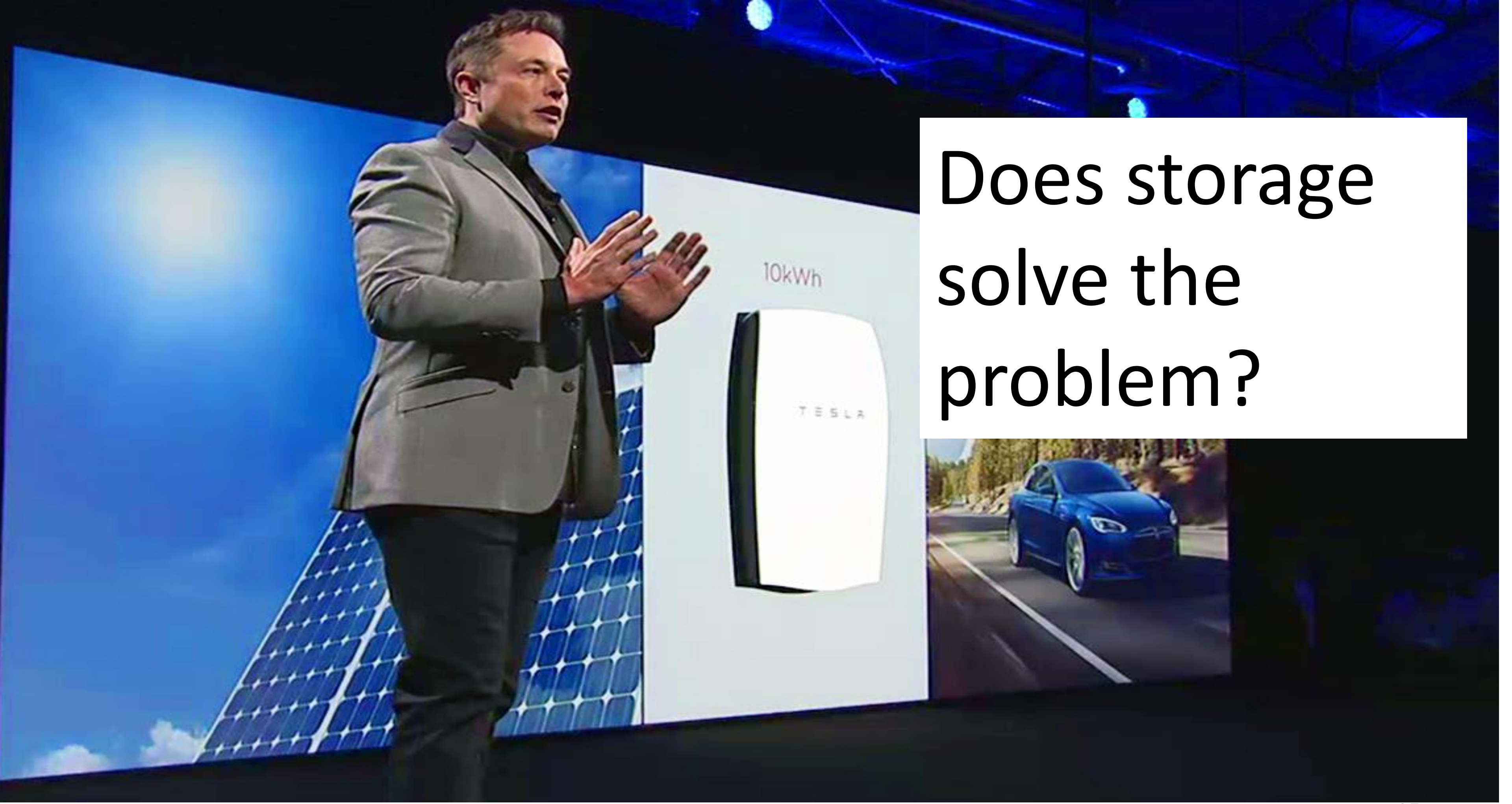
Modeled results: Oct. 2050



High VRE requires ~ same amount of non-VRE capacity as in low VRE case with nuclear



Does storage solve the problem?



Not really.....

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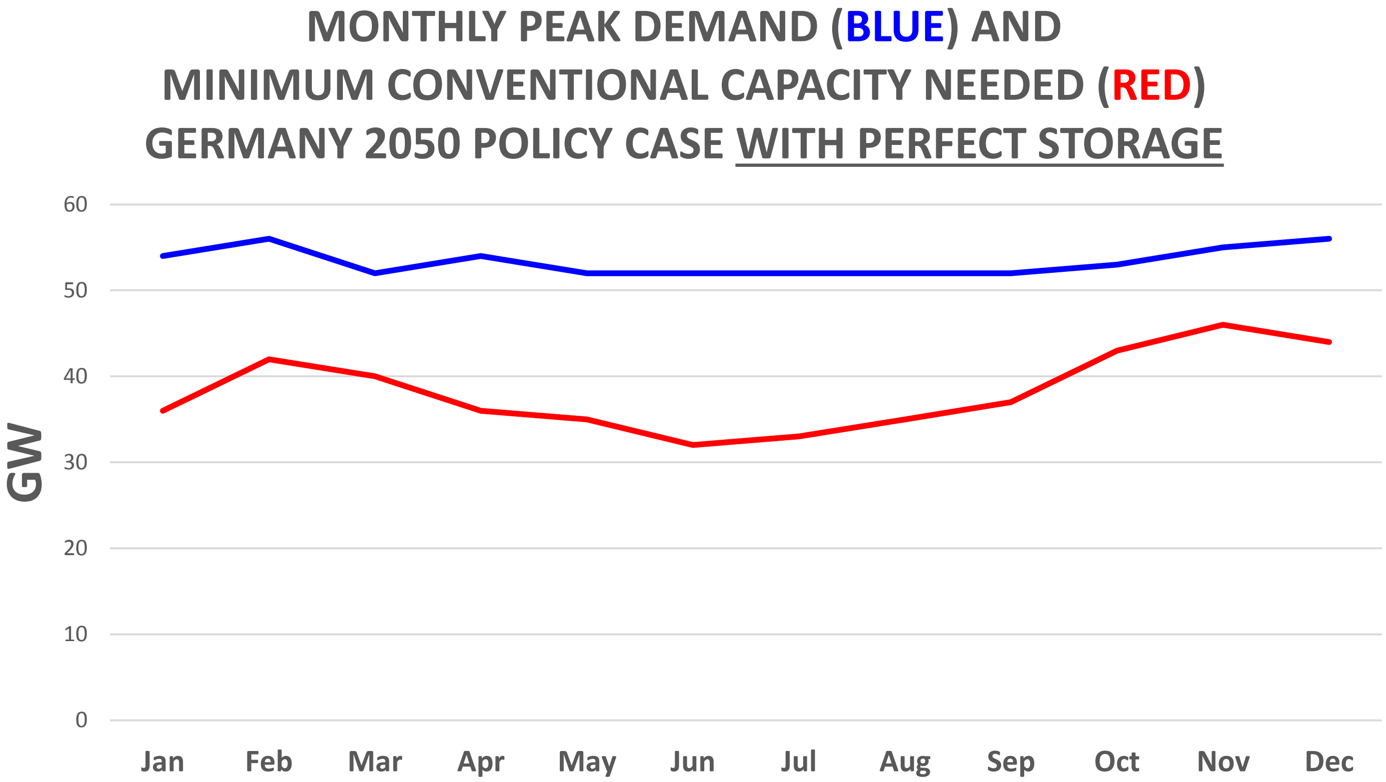
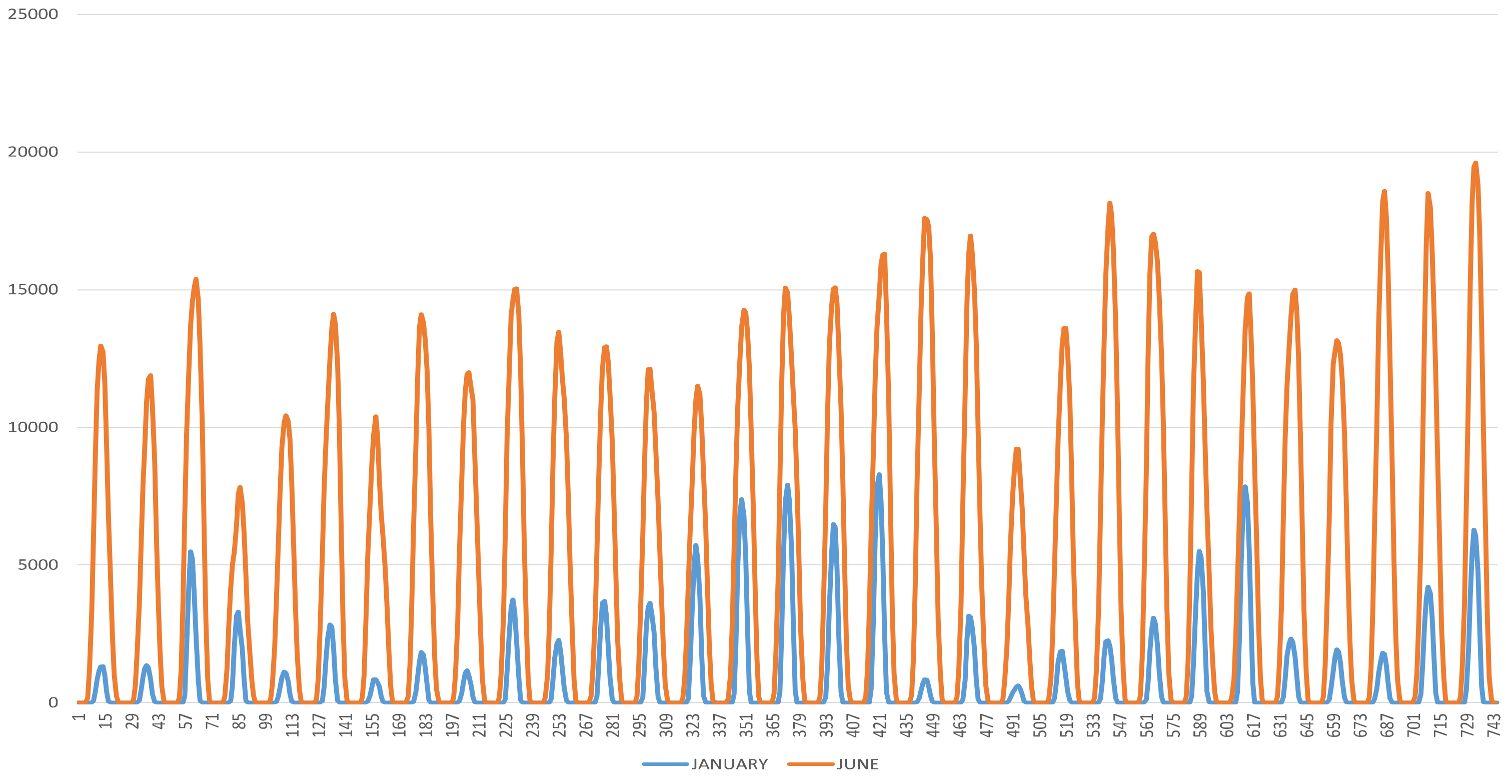
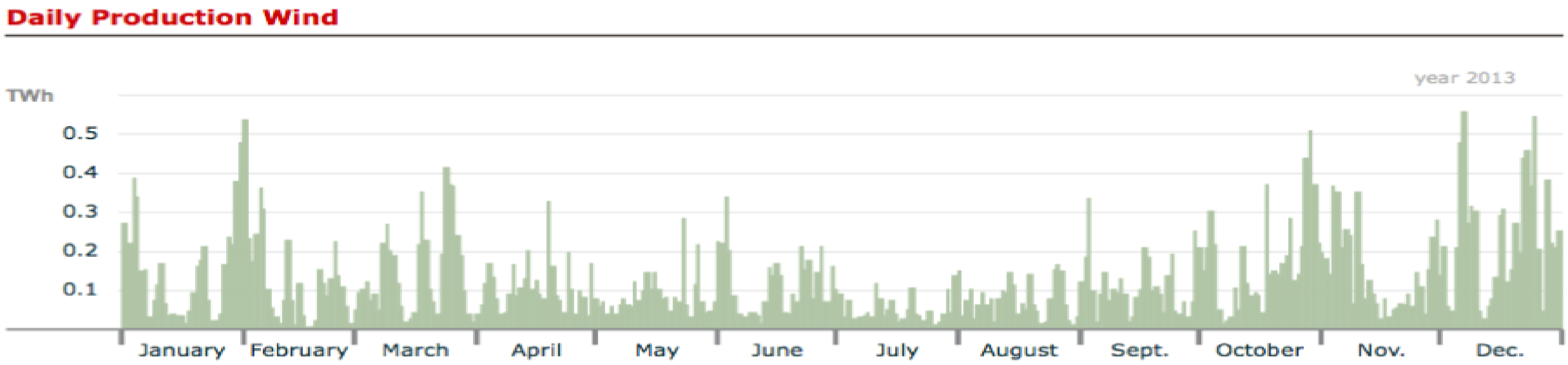


STORAGE CAN HELP ADDRESS ***<u>DAILY</u>*** FLUCTUATIONS

BUT DOES NOT SOLVE <u>MULTI-WEEK</u> AND <u>SEASONAL</u> VARIATION

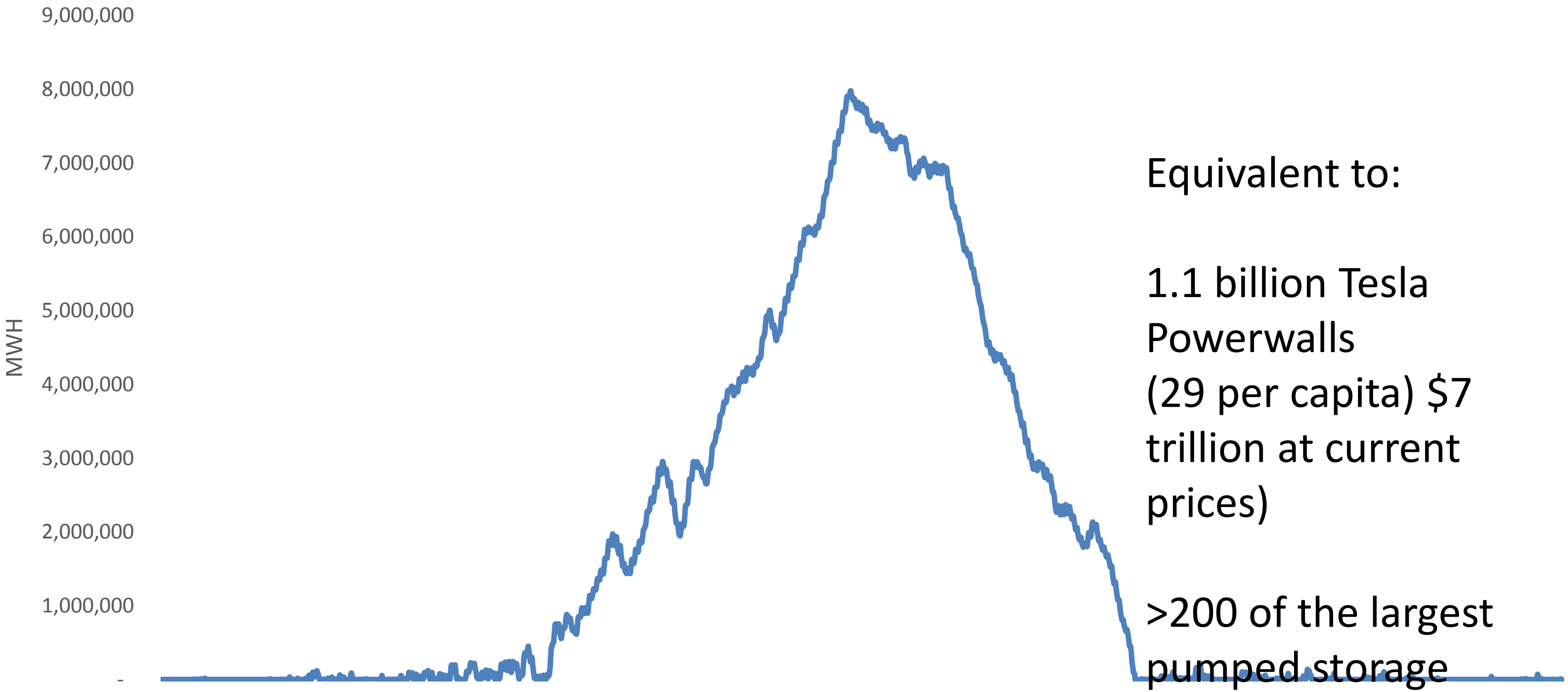
GERMAN SOLAR VARIABILITY
JANUARY VS JUNE





Daily Production Wind
year 2013
TWh
0.5
0.4
0.3
0.2
0.1
January
February
March
April
May
June
July
August
Sept.
October
Nov.
Dec.

CALIFORNIA CUMULATIVE SURPLUS
80 PERCENT RPS

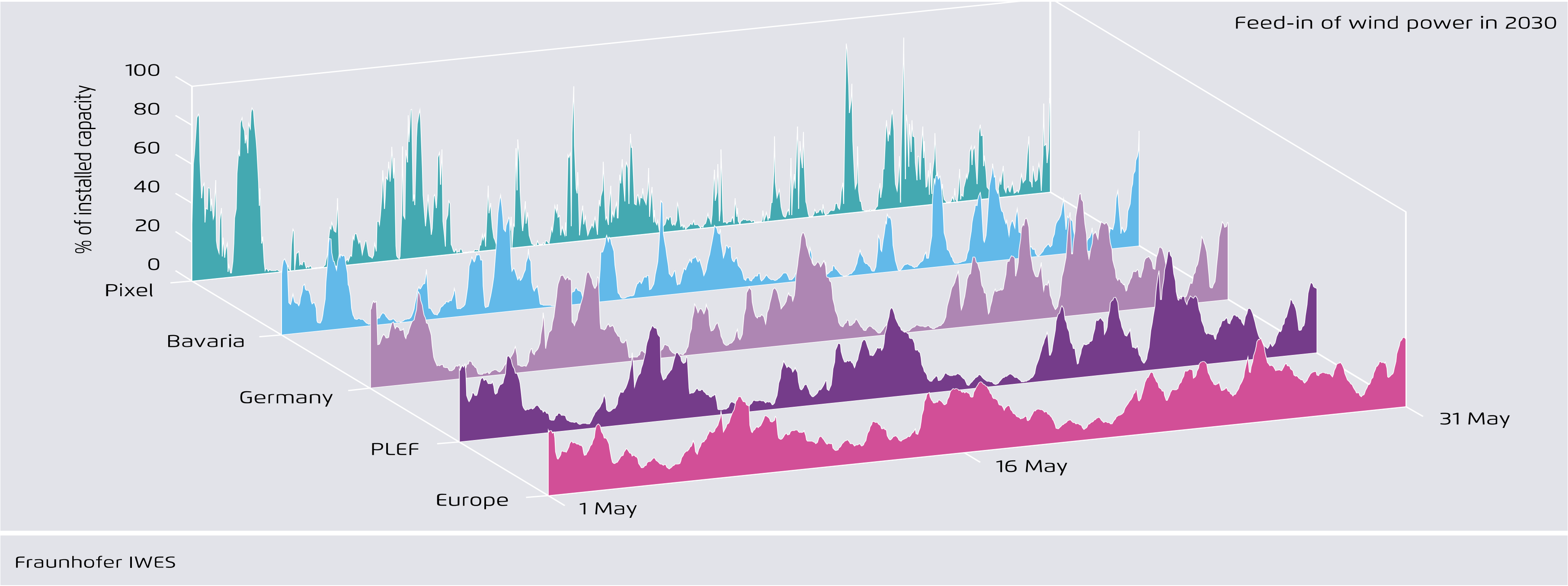


Equivalent to:

1.1 billion Tesla Powerwalls (29 per capita) $7 trillion at current prices)

>200 of the largest pumped storage plants in the US

Transmission doesn't solve the problem



Simulated daily wind capacity factors across EU (May 2030)

“Demand response”

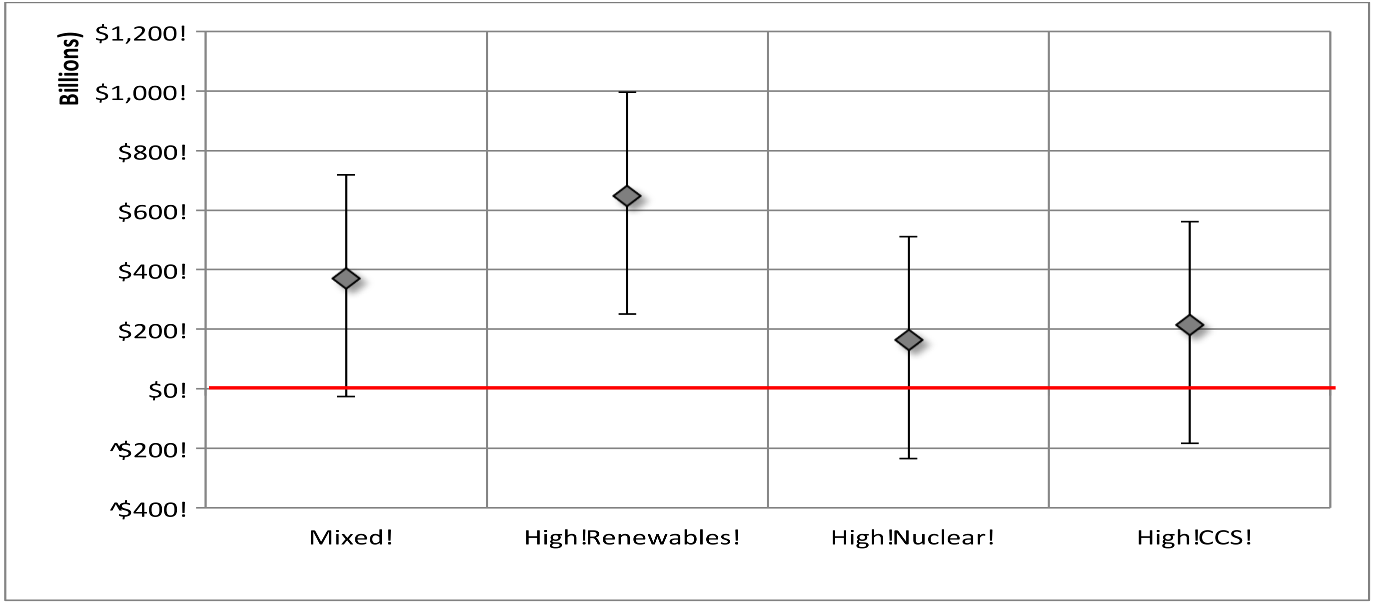
- Can substantial loads (e.g. industrial processes, heating and cooling, EV charging) be deferred ***over weeks or months***?
- Will major industrial capital investments be made to operate only at low capacity factor (i.e. at times when wind and sun surpluses are available)?

PJM DR 2009-2015

- Average annual total hours curtailed = 14 hours
- Average curtailment 4 X per year
- Average duration = 3.5 hours
- Average curtailment = 1% of peak
- How much far we extrapolate this to more hours, multi-day and week-long episodes?

Other analyses: UN DEEP DECARBONIZATION OF US

Figure)12.)Incremental)Energy)System)Costs)in)2050)



United Nations – IDDRI- Sustainable Solutions Network Deep Decarbonization Pathways Project – US Analysis (E3, LBL, PNNL, 2014)

Even acknowledging the possible contribution of DSM, interconnectors and storage to firming up weather dependent renewables, a deep decarbonisation of the grid will need a significant penetration of zero carbon firm capacity.

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100% clean and renewable wind, water, and sunlight (WWS) all-sector energy roadmaps for the 50 United States†

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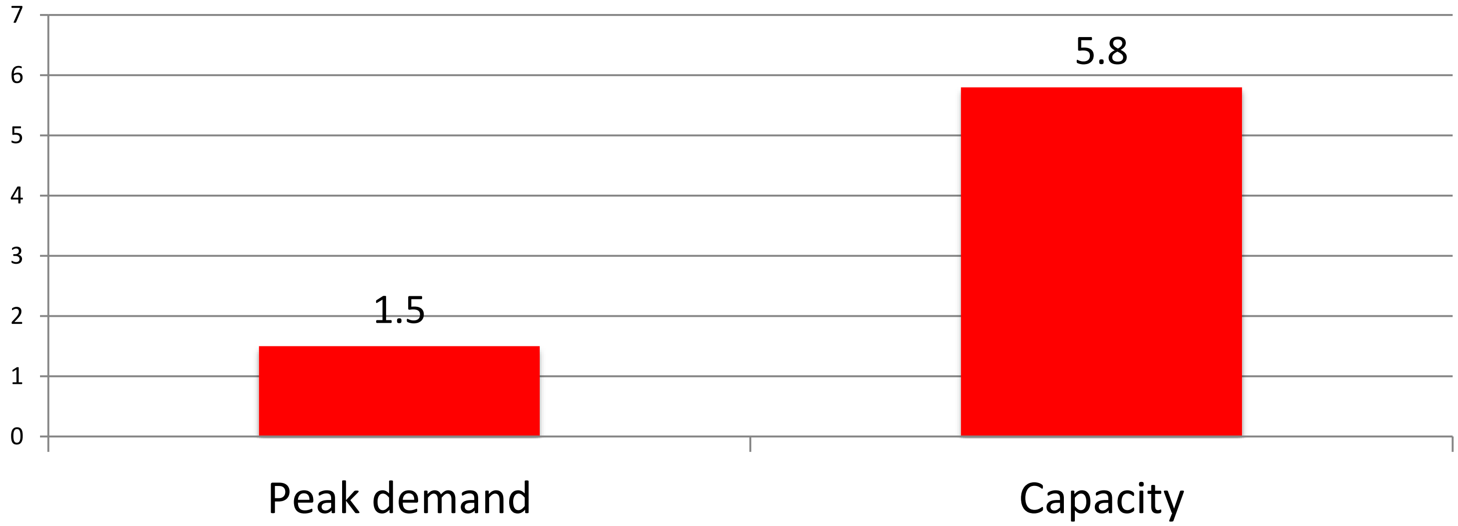
Build out required (TW)



- 1,670 offshore wind farms the size of Cape Wind (72 per coastal state) AND
- 2,400 Tehachapi-size wind farms onshore (or about 50 per state) AND
- 27,000 megawatts of wave machines (zero exist today) AND
- 227 Gigawatts of concentrated solar plants (or 580 Ivanpah-sized plants at 392 ME each, or 10 plus per state) to produce energy, and an additional 136 GW (7 per state) just for storage AND
- 2,300 GW of central solar PV plant, or 1,200 times more central PV capacity than exists today AND
- Additional 469 GW of solar thermal storage, or roughly 1.5 times the capacity of US coal AND
- 68% of all energy loads are made flexible by being coupled to thermal energy storage, mostly underground thermal energy storage -- enough storage to store 1.5-2 months of today's electricity consumption with capacity equal to 1 TW, or all of the US grid.

CAN THIS ALL BE ***TECHNICALLY*** ACCOMPLISHED?

PROBABLY

DO WE WANT TO BET THE PLANET THAT IT WILL BE?

PROBABLY NOT

Policies for zero carbon capacity

#1 Aggressive RD and D and early deployment policies to move forward cost and improve performance and innovation:

- Dispatchable renewables/storage
- CCS
- Advanced nuclear

NETPower High Efficiency Power Cycle With Carbon Separation

Technology

- NET Power broke ground on a 50 MW Texas demonstration plant in March.
- Its gas power technology produces pure, ready for storage CO_2.
- If successful, Net Power gas plants with CCS would cost the same as uncontrolled NGCCs.
- Demonstration plant results available in 24 months.
- If successful, commercial NET Power projects could arrive in 2020-2025.
- Potentially applicable to coal

#2 *Zero carbon capacity procurement incentives*

- Long run zero carbon capacity market auctions?
- Incentives for procurement of long-run firm zero carbon energy?
- In generation-regulated jurisdictions, resource procurement adders for capacity and dispatchability value?
- Special set aside procurements of zero carbon capacity, similar to California’s solicitation of energy storage?

#3 Making clean energy policies technology-neutral. Policies to consider would include:

- Allowing nuclear and CCS to participate in state clean energy or RPS programs
- Technology-neutral federal tax incentives such as the ITC and PTC.

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www.zerocarbongrid.org