NUCLEAR ENERGY – ECONOMICS, INVESTMENT COSTS

PREDICTIONS AND REALITY IN BOOM PERIOD OF NUCLEAR INSTALLATIONS

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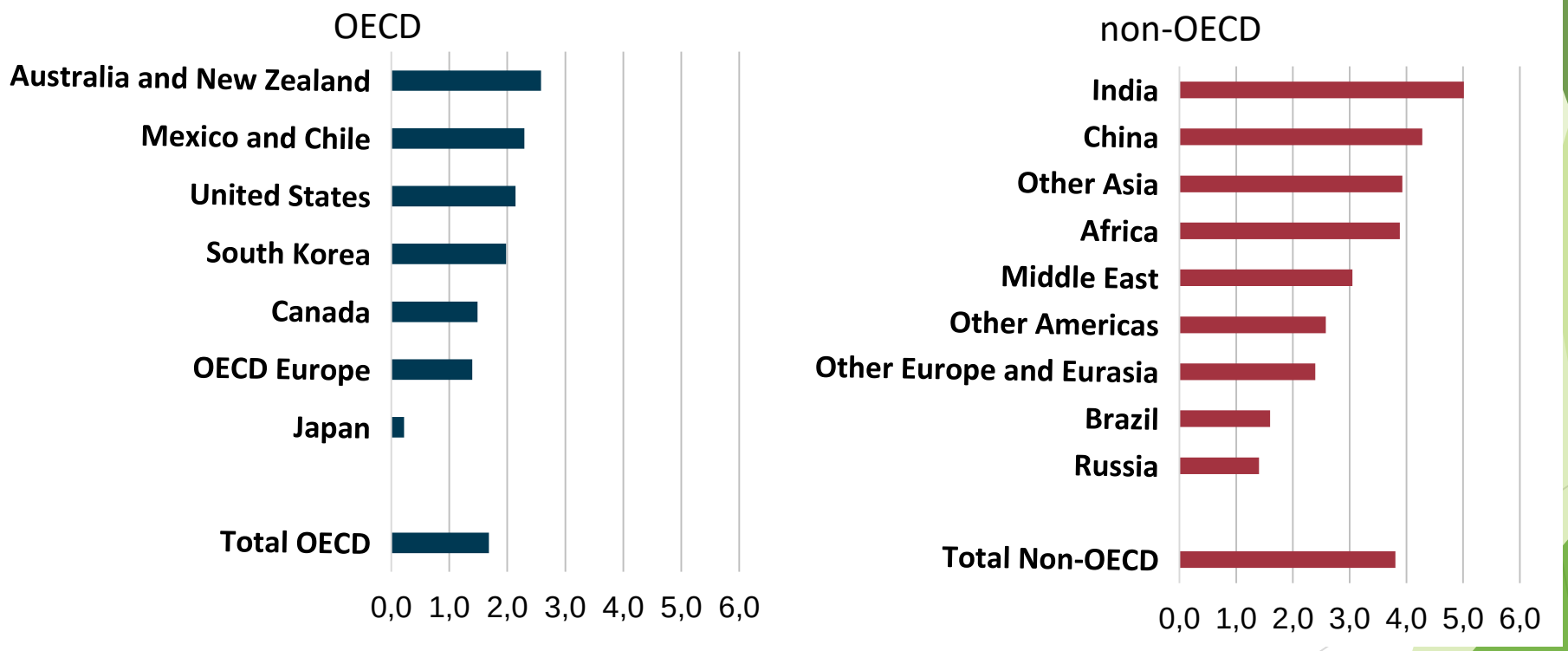
NUCLEAR ENERGY – ECONOMICS, ROI OF THE WORLDWIDE INSTALLATIONS

- Context of global economy, demography
- Global outlook of energy consumption
- Historical development of nuclear energy – aspects, investment costs, competitiveness
- Key factors of limited development – security of supply
- Conclusions

Economic growth varies widely across non-OECD regions

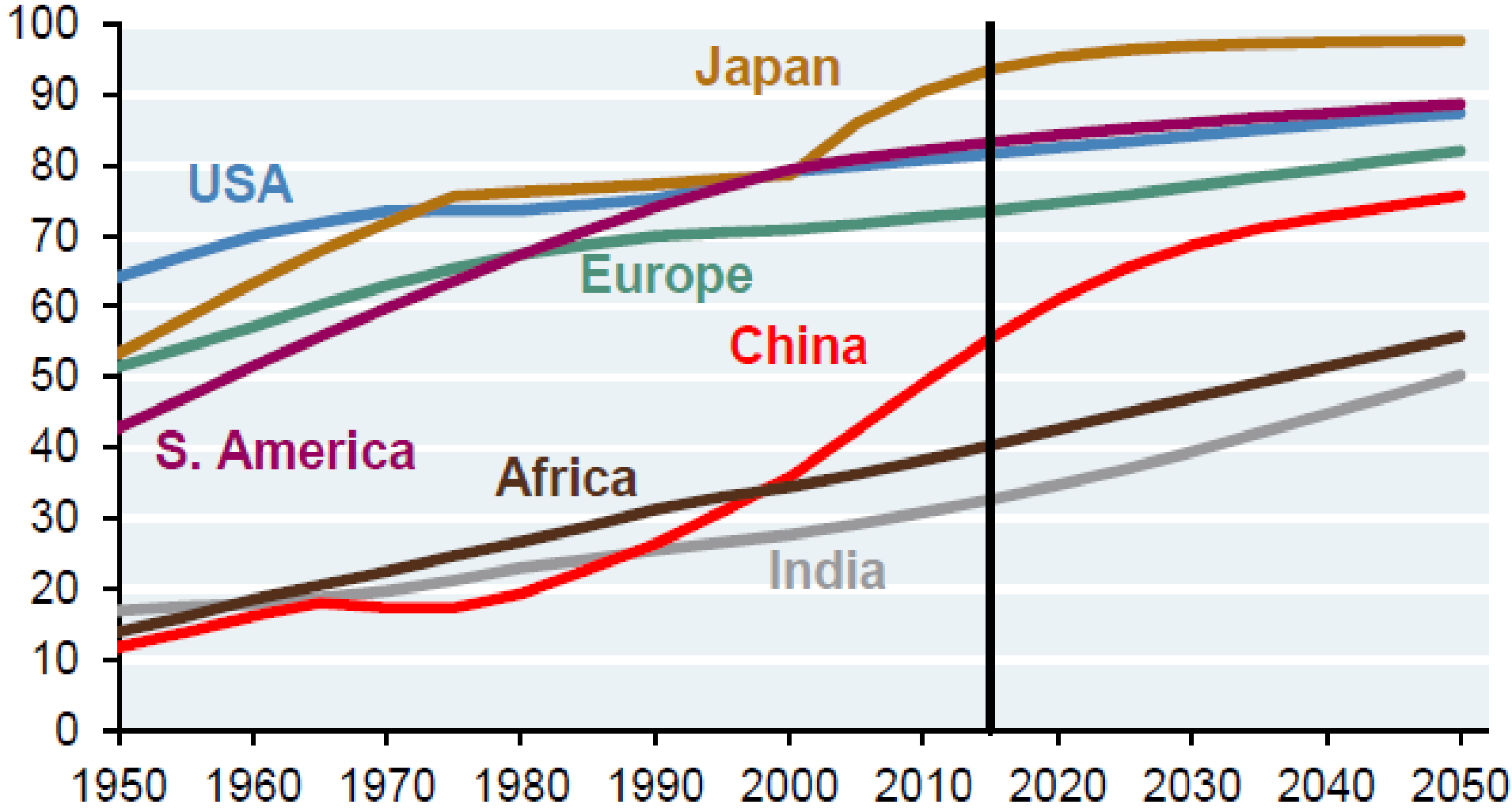
Average annual percent change in GDP, 2015-40
percent per year



SOURCE: EIA-IEO2017

Living for the city: global urbanization trends

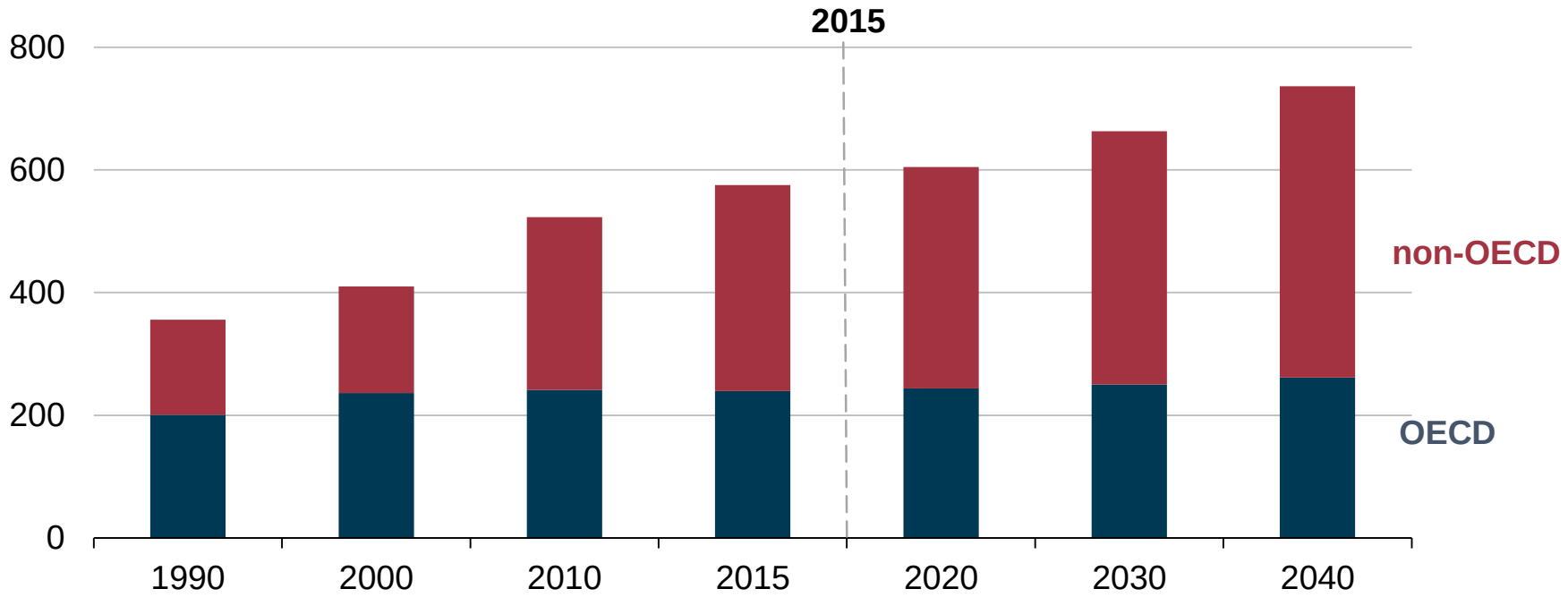
% of total population



Source: World Bank World Development Indicators. 2015, forecast to 2050.

World energy consumption rises 28% between 2015 and 2040

World energy consumption
quadrillion Btu



SOURCE: EIA-IEO2017

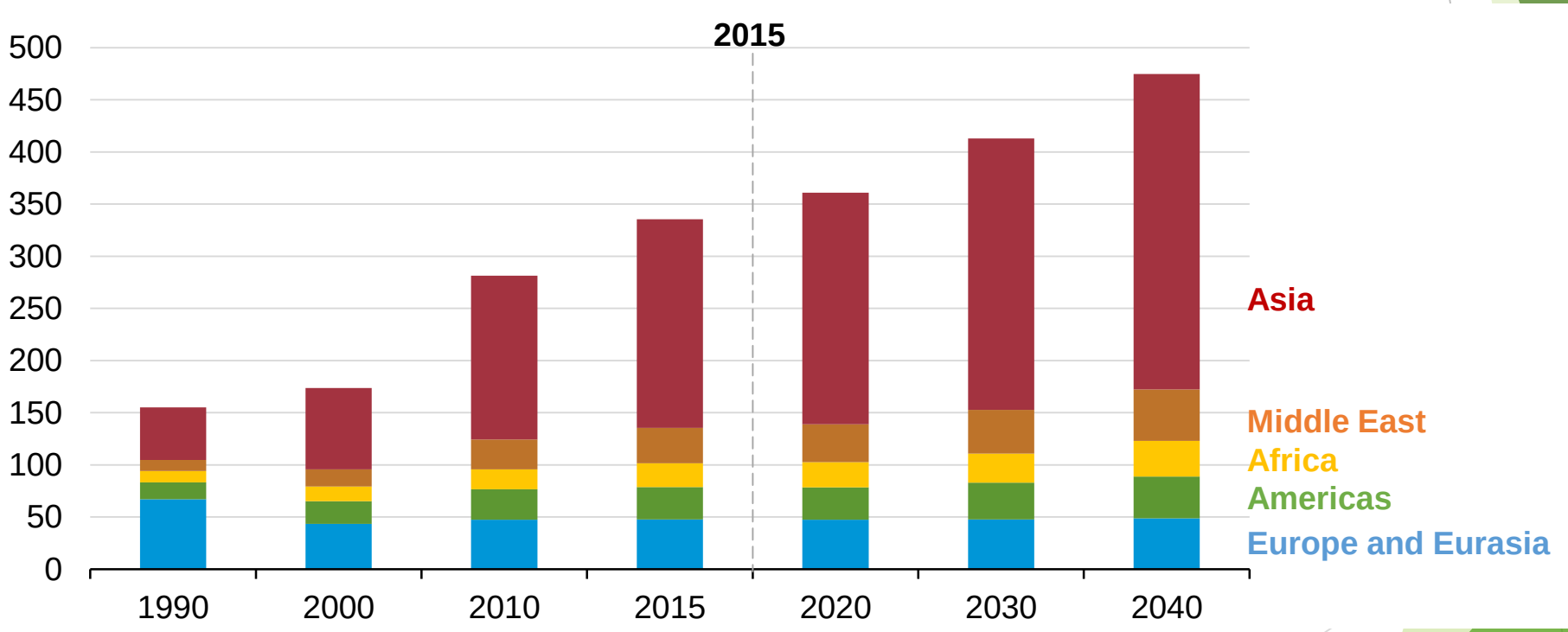
—with most of the increase occurring in non-OECD countries

- In the Reference case, world energy consumption increases from 575 quadrillion British thermal units (Btu) in 2015 to 663 quadrillion Btu by 2030 and then to 736 quadrillion Btu by 2040.
- Most of the increase in energy demand is expected to come from non-OECD countries, where strong economic growth, increased access to marketed energy, and quickly growing populations lead to rising demand for energy.
- Energy consumption in non-OECD countries increases 41% between 2015 and 2040 in contrast to a 9% increase in OECD countries.

SOURCE: EIA-IEO2017

Asia accounts for most of the increase in energy use in non-OECD regions

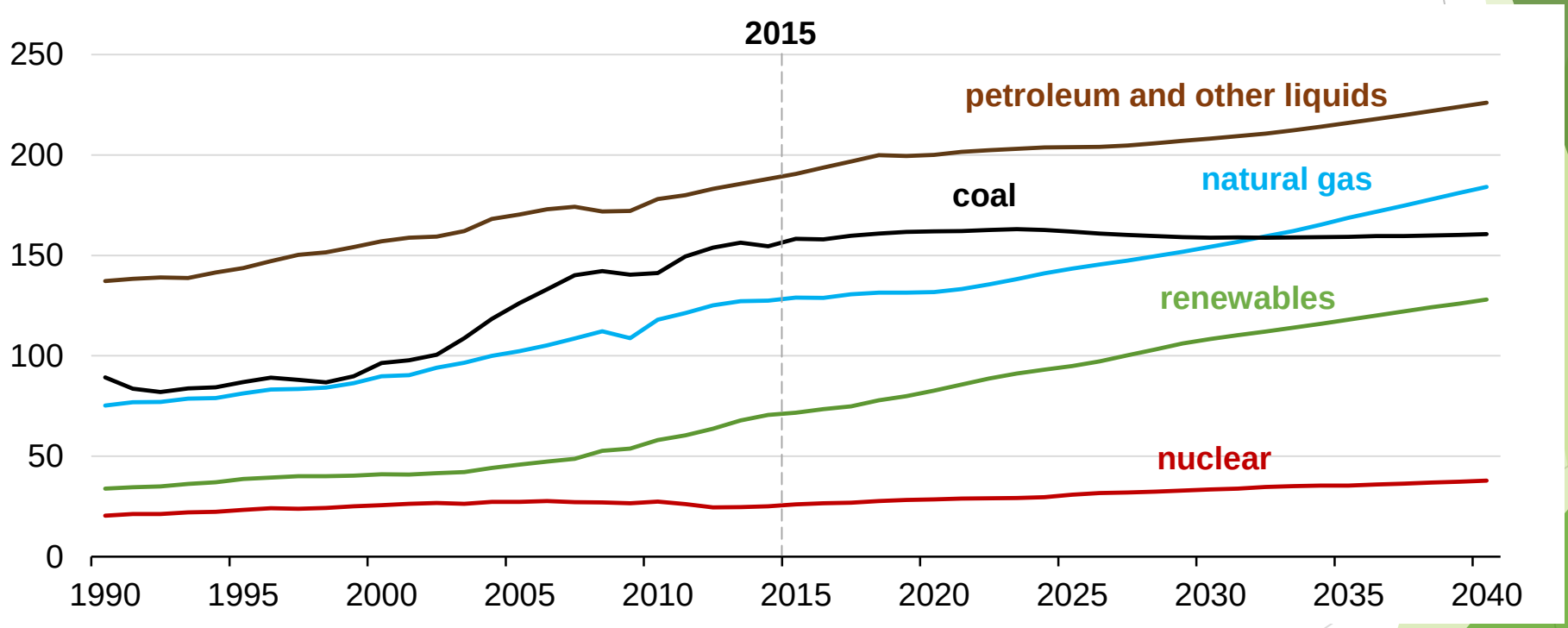
Non-OECD energy consumption by region
quadrillion Btu



SOURCE: EIA-IEO2017

Energy consumption increases over the projection for all fuels other than coal

World energy consumption by energy source
quadrillion Btu



SOURCE: EIA-IEO2017

—with renewables being the fastest-growing energy source

- Use of all fuels except coal grows throughout the Reference case. Although renewable energy and nuclear power are the world's fastest growing forms of energy, fossil fuels are expected to continue to meet much of world's energy demand.

- Petroleum and other liquids remains the largest source of energy, but its share of world marketed energy declines from 33% in 2015 to 31% in 2040. On a worldwide basis, liquids consumption increases in the industrial and transportation sectors, and declines in the electric power sector.

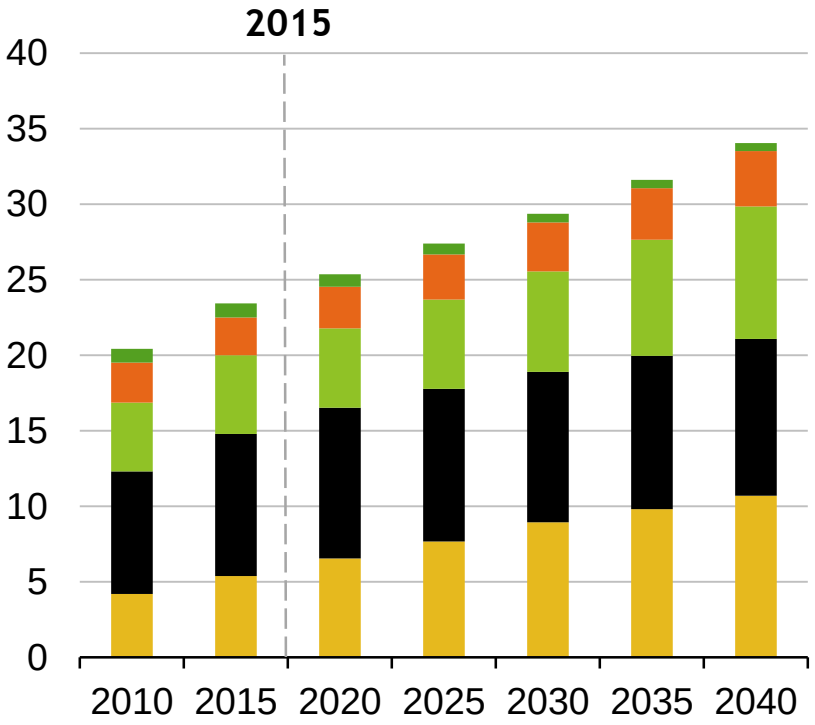
- Natural gas is the world's fastest growing fossil fuel, increasing by 1.4%/year, compared with liquid's 0.7%/year growth and virtually no growth in coal use (0.1%/year).

- Compared with the strong growth in coal use in the early 2000s, worldwide coal use is projected to remain flat—with declines in OECD regions and China offsetting growth in India and the other non-OECD Asian nations. Coal is increasingly replaced by natural gas, renewables, and nuclear power (in the case of China) in electricity generation. Industrial demand for coal also weakens.

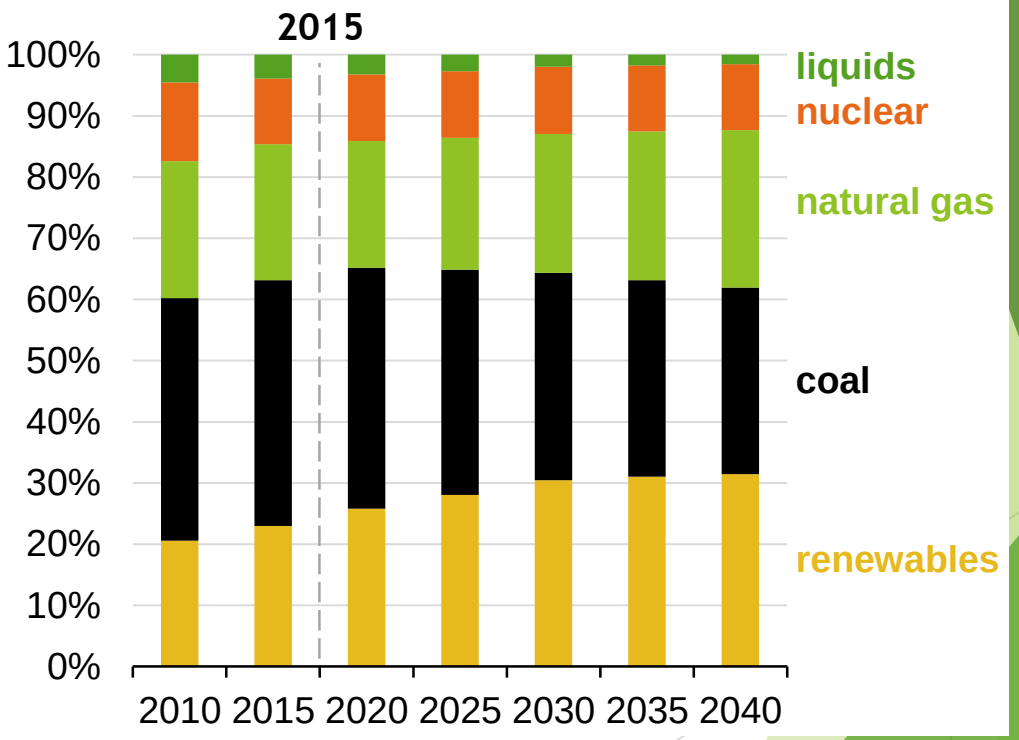
SOURCE: EIA-IEO2017

Renewables and natural gas provide much of the growth in electricity generation–

World net electricity generation by fuel
trillion kilowatthours



Share of net electricity generation
percent



SOURCE: EIA-IEO2017

—with their combined share of the total rising to 57% in 2040

- Renewables (including hydropower) are the fastest-growing sources of generation over the period of 2015–40, rising by an average of 2.8%/year, as technological improvements and government incentives in many countries support their increased use.
- Natural gas generation grows by an average 2.1%/year from 2015 to 2040, whereas nuclear generation grows by 1.5%/year.
- Coal's generation share declines from 40% in 2015 to 31% by 2040.
- In 2040, renewables provide the same share of world electricity generation as coal at 31%.

SOURCE: EIA-IEO2017

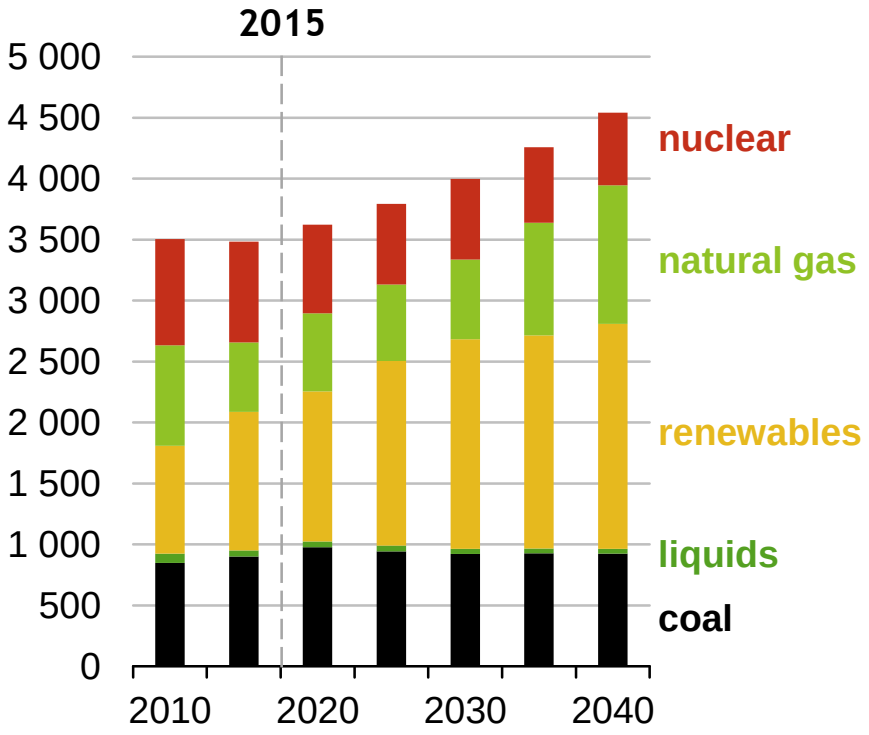
—and represent over two-thirds of related capacity additions by 2040

- Hydropower's share of renewable generation falls from 71% in 2015 to 53% in 2040 as resource availability in OECD countries and environmental concerns in many countries limit the number of new mid- and large-scale hydropower projects.
- Generation from non-hydropower renewables rises an average 4.9%/year from 2015 to 2040.
- Among non-hydroelectric renewable energy sources, wind and solar increase the most over the period of 2015–40, reaching 2.5 and 1.4 trillion kilowatthours, respectively, as these technologies become more cost competitive over time.

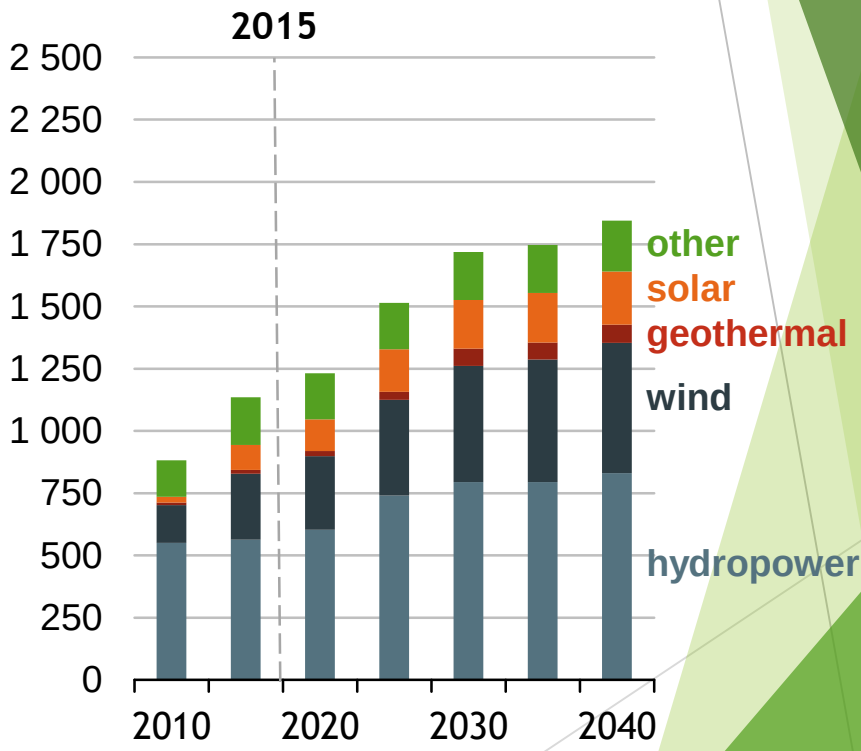
SOURCE: EIA-IEO2017

OECD Europe reduces nuclear generation–

Electricity generation in OECD Europe
billion kilowatthours



Renewable generation in OECD Europe
billion kilowatthours



SOURCE: EIA-IEO2017

—and adds capacity with natural gas and renewables

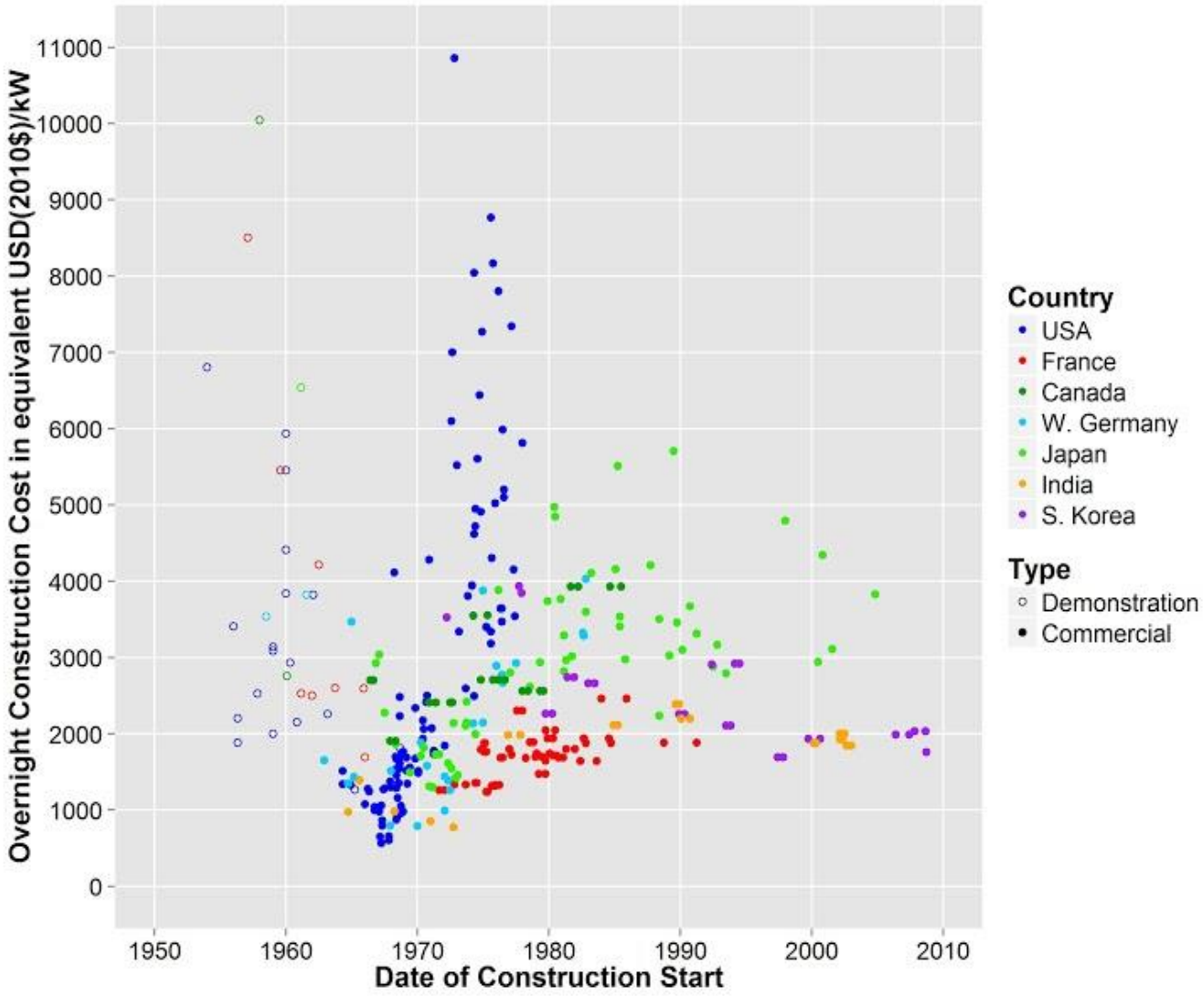
- Net electricity generation in OECD Europe is expected to increase slowly, by an average of 1.1%/year from 2015 to 2040, compared to the world average increase of 1.5%/year.
- The generation mix in OECD Europe changes considerably by 2040, with renewables and natural gas growing, coal remaining flat, and nuclear power and liquid fuels declining.
- Nuclear generation's share is expected to decline from around 25% in 2015 to less than 15% by 2040 because of stated policies to either cap or phase out nuclear power, including those adopted in France, Germany, and Sweden.
- The use of natural gas electricity generation in OECD Europe does not expand until 2030, mostly because of the large increases in projected renewables generation. In OECD Europe, when natural gas begins to gain market share in 2030, it displaces nuclear power, coal, and renewable generation.

SOURCE: EIA-IEO2017

HISTORICAL DATA – INVESTMENT COSTS, ECONOMICS

- The historical reactor-specific overnight construction cost (OCC) data are shown, covering the full cost history for 349 reactors in the US, France, Canada, West Germany, Japan, India, and South Korea encompassing 58% of all reactors built globally.
- Trends in costs have varied significantly in magnitude and in structure by era, country, and experience.
- In contrast to the rapid cost escalation that characterized nuclear construction in the United States post-Three Mile Island, found evidence of much milder cost escalation in many countries, including absolute cost declines in some countries and specific eras.
- The findings suggest that there is no inherent cost escalation trend associated with nuclear technology.

SOURCE:Historical construction costs of global nuclear power reactors, ENERGY POLICY, VOL.91, 2016 (http://www.sciencedirect.com/science/article/pii/S0301421516300106)

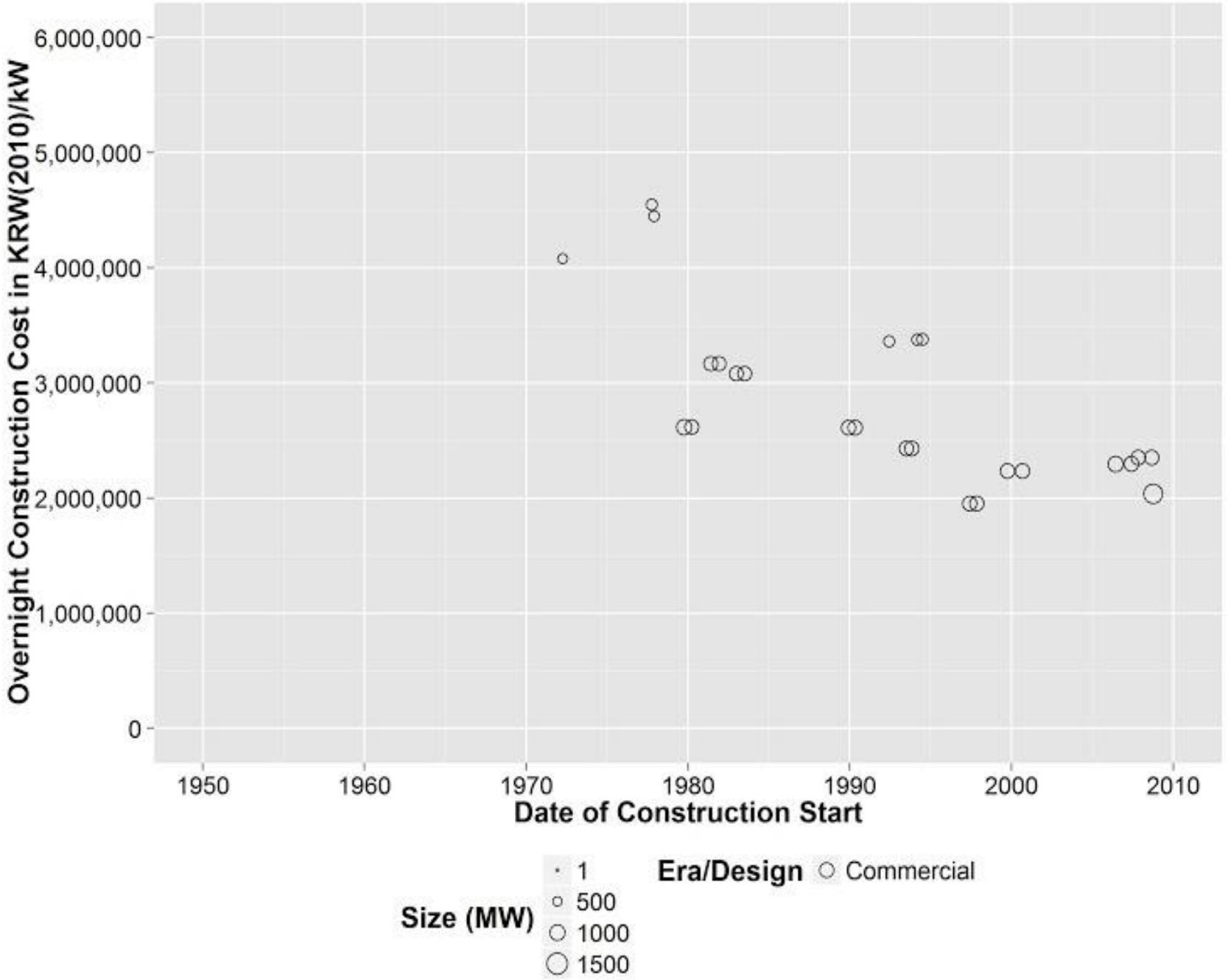


http://www.sciencedirect.com/science/article/pii/S0301421516300106

HISTORICAL DATA – INVESTMENT COSTS, ECONOMICS

- When cost trends are compared across these seven countries, it was found that the US case is specific.
- Even the existing literature on the US and France tends to ignore the early demonstration and commercial reactors.
- When looking at this full set of 349 reactors, It can be seen that later countries saw less cost escalation than the US, with costs stabilizing in recent decades.

http://www.sciencedirect.com/science/article/pii/S0301421516300106



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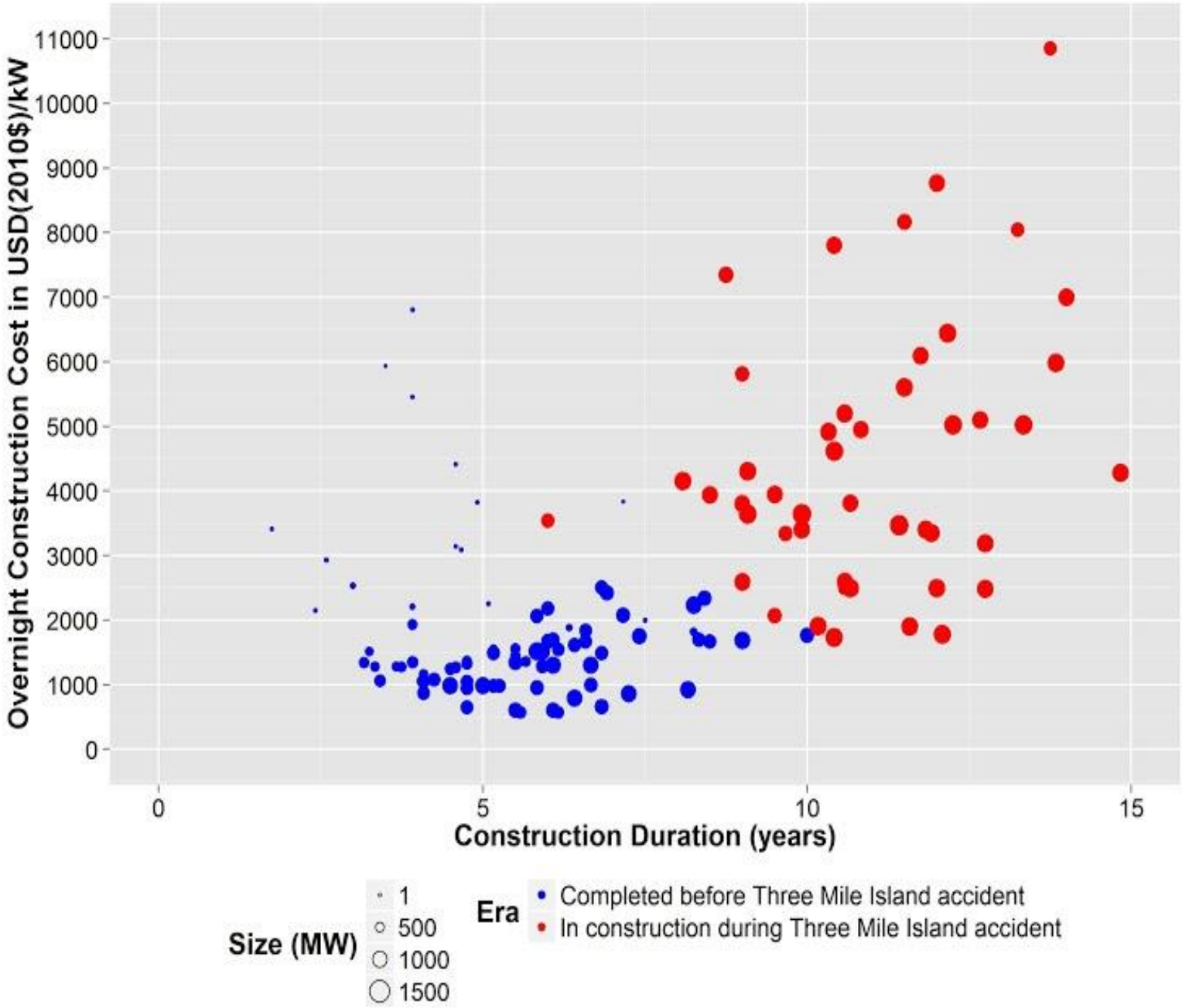
HISTORICAL DATA – INVESTMENT COSTS, ECONOMICS – SOUTH KOREA

- South Korea has a unique trend compared to the other six countries in the data set, with a continuous decline in costs over time.
- What makes South Korea's industry unique is that they started their nuclear program by importing large foreign reactors, skipping the early demonstration phase and not developing their own indigenous reactor design until later.
- More importantly, all of Korea's nuclear power plants are owned and operated by a single utility, Korea Hydro & Nuclear Power, which who also designs and builds the reactors.
- As the matter of fact, after some recent delay, the Korean nuclear programme has been resumed based on wide citizen´s acceptance.

http://www.sciencedirect.com/science/article/pii/S0301421516300106



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HISTORICAL DATA – INVESTMENT COSTS, ECONOMICS

- When looking at the history of nuclear costs in the US, it's easy to blame the accident at Three-Mile Island for the rapid cost escalation in the later 1970s.
- Looking at the previous chart, both construction costs and duration explode for plants that were under construction at the time of the accident (no plants began construction after the accident until 2009).
- But it is also notable the large variance in cost and duration. For example, the second to last reactor completed in the US, St. Lucie-2 in Florida, was completed in just six years at a cost of $3,100 (2010USD), relatively competitive for large power plants.
- After this period of regulatory and utility flux, how would costs have evolved?

http://www.sciencedirect.com/science/article/pii/S0301421516300106

HISTORICAL DATA – INVESTMENT COSTS, ECONOMICS

- Plant owners have realized increased ROI by extending the output of their licensed plants (capacity available) through uprating and modernizing equipment to achieve higher efficiencies in the steam cycle.
- From an economic view it makes sense for owners to run nuclear units as long as possible since construction costs are largely sunk and the plants are profitable.
- The marginal generating costs of capacity uprates and life-time extensions are roughly only one third of those for new nuclear plants (World Energy Council, 2007).
- Due to global cost reductions in construction, financing and plant operations, waste management and decommissioning, the World Nuclear Association (2006a) forecasts that nuclear will remain competitive.

HISTORICAL DATA – INVESTMENT COSTS, ECONOMICS

- For new nuclear power projects it is considered that:
  - Standardized design, shorter construction times and more efficient generation technologies will sharply reduce construction costs per kW,
  - Financing costs for new units will decrease as new technologies develop,
  - License streamlining will reduce regulatory costs and uncertainty by establishing predictable technical parameters and timescales from design certification to turnkey operation,
  - Eventually, regional solutions will arise to safely transport and store global nuclear waste.

2016 Cost Summary ($/MWh)

Category	Number of Plants / Sites	Fuel	Capital	Operating	Total Operating (Fuel + Operating)	Total Generating (Fuel + Capital + Operating)
All U.S.	60*	6.76	6.74	20.43	27.19	33.93
Plant Size						
Single-Unit	25	6.77	8.67	25.95	32.72	41.39
Multi-Unit	35	6.75	6.15	18.73	25.48	31.63
Operator						
Single	12	7.18	8.19	21.20	28.38	36.57
Fleet	48	6.63	6.32	20.21	26.84	33.16

**Costs exclude shutdown plants.*
Source: Electric Utility Cost Group (EUCG)

CONCLUSIONS

- Reliable and sustainable energy supply is a precaution of any kind of economic and societal growth.
- The energy policy is in the ultimate responsibility of governments and any kind of an EU energy policy is a sort of framework – no responsibility taken!
- The recent economic downturn (far too long in the EU) was a result of the restrictive and business unfriendly environment in the community.
- A good example how to govern the energy policy is the UK and in Finland, in fact, with their most recent nuclear projects!
- Even the most infamous Olkiluoto would be a success in terms of security of supply and energy pricing!
- It is really alarming to see the economic growth rate (OECD – Europe). Obviously not enough in terms of the CR.
- The nuclear complex can provide not only the energy independence, but it can substantially contribute to further development of qualified research work and sustainable development in its original sense!

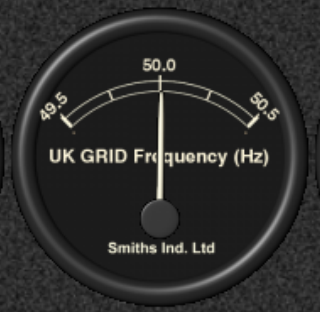
Download data sets (CSV): Download | Links | Info

New! Gridwatch France

G.B. National Grid Status

Data courtesy of Elexon portal and Sheffield University

Demand 42.48GW



Frequency 50.005Hz

Coal 4.69GW (11.04%)

Nuclear 8.26GW (19.44%)

CCGT 24.20GW (56.96%)

Wind 0.84GW (1.98%)

Pumped 0.32GW (0.75%)

Hydro 0.72GW (1.69%)

Biomass 0.10GW (0.24%)

Solar 1.20GW (2.82%)

OCGT 0.00GW (0.00%)

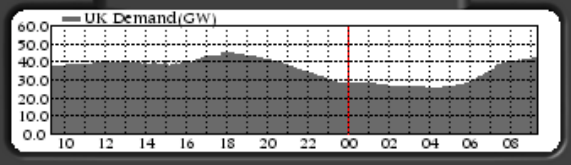
French ICT -2.04GW (-4.80%)

Dutch ICT 0.78GW (1.84%)

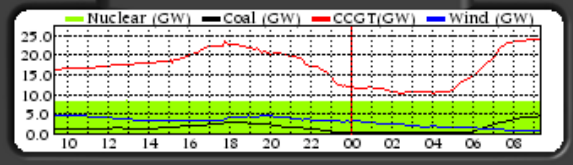
Irish ICT -0.25GW (-0.59%)

E-W ICT -0.28GW (-0.66%)

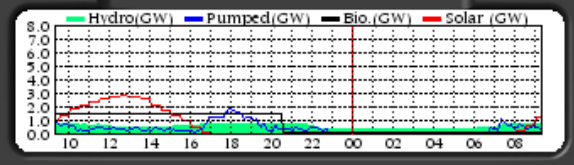
Daily Demand (GW)



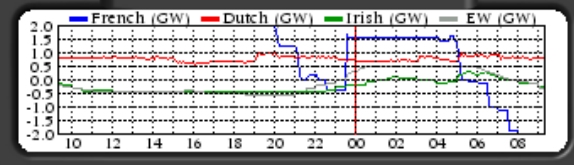
Daily Nuclear/Coal/CCGT/Wind (GW)



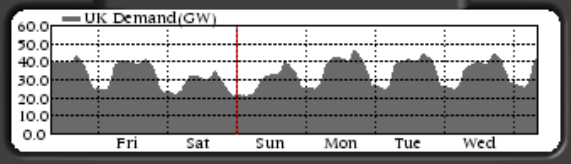
Daily Hydro/Pumped/Bio. (GW)



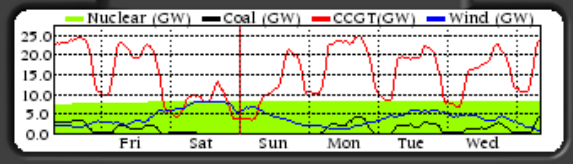
Daily French/Irish/Dutch/EW ICT (GW)



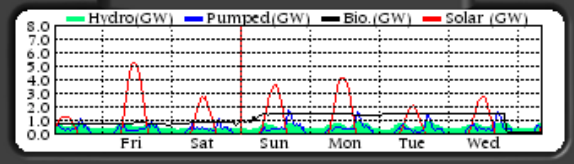
Weekly Demand (GW)



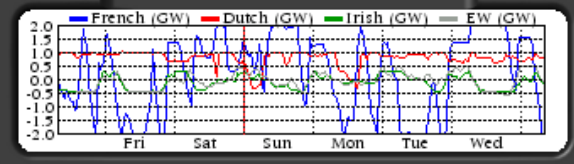
Weekly Nuclear/Coal/CCGT/Wind (GW)



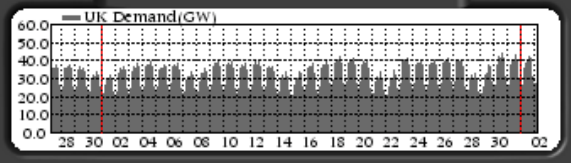
Weekly Hydro/Pumped/Bio. (GW)



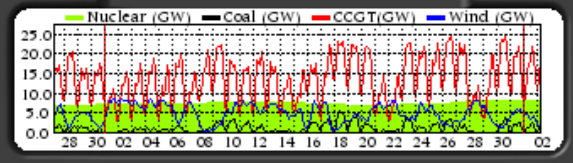
Weekly French/Irish/Dutch/EW ICT (GW)



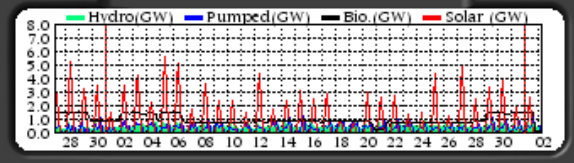
Monthly Demand (GW)



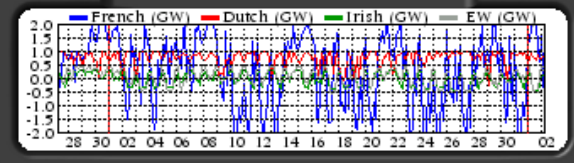
Monthly Nuclear/Coal/CCGT/Wind (GW)



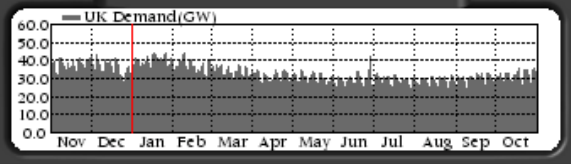
Monthly Hydro/Pumped/Bio. (GW)



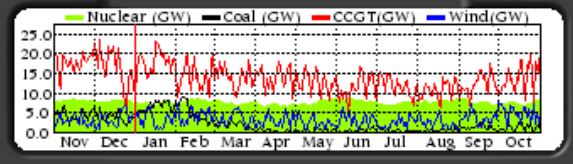
Monthly French/Irish/Dutch/EW ICT (GW)



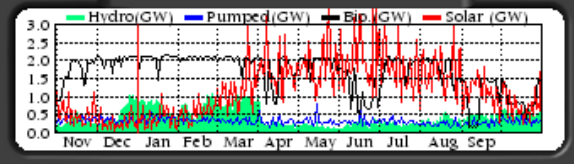
Yearly Demand (GW)



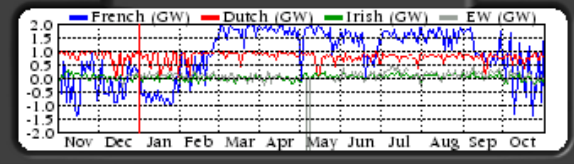
Yearly Nuclear/Coal/CCGT/Wind (GW)



Yearly Hydro/Pumped/Bio.(GW)



Yearly French/Irish/Dutch/EW ICT (GW)



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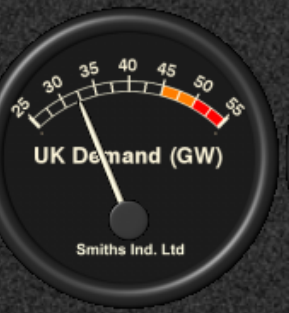
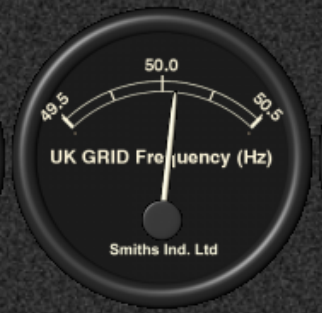


Demand 32.27GW



Frequency 50.069Hz

Coal 0.98GW (3.04%)

Nuclear 6.54GW (20.27%)

CCGT 15.46GW (47.91%)

Wind 3.81GW (11.81%)

Pumped 0.29GW (0.90%)

Hydro 0.60GW (1.86%)

Biomass 0.09GW (0.28%)

Solar 0.10GW (0.31%)

OCGT 0.00GW (0.00%)

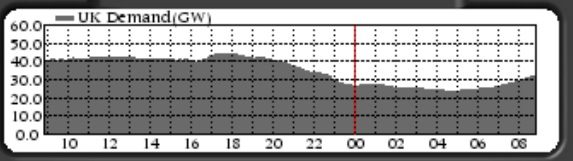
French ICT 2.00GW (6.20%)

Dutch ICT 0.97GW (3.01%)

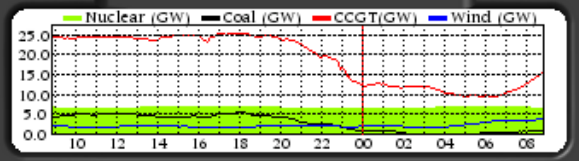
Irish ICT -0.08GW (-0.25%)

E-W ICT 0.07GW (0.22%)

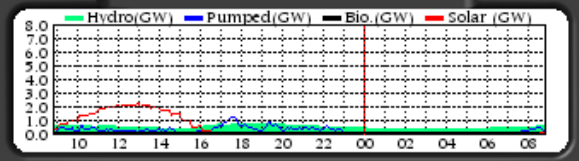
Daily Demand (GW)



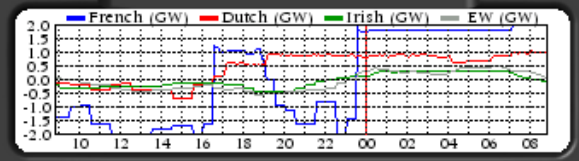
Daily Nuclear/Coal/CCGT/Wind (GW)



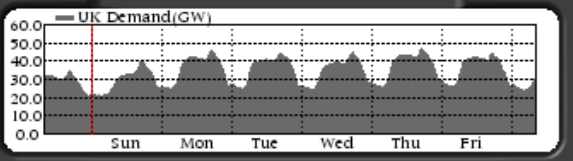
Daily Hydro/Pumped/Bio. (GW)



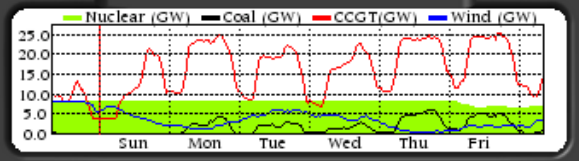
Daily French/Irish/Dutch/EW ICT (GW)



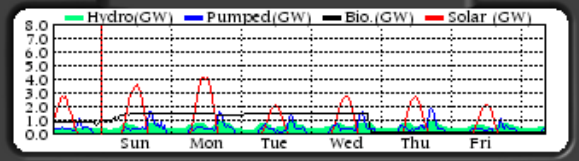
Weekly Demand (GW)



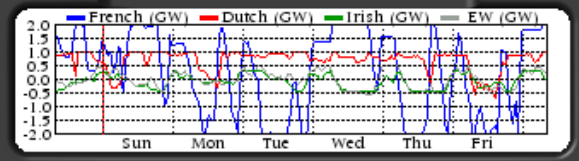
Weekly Nuclear/Coal/CCGT/Wind (GW)



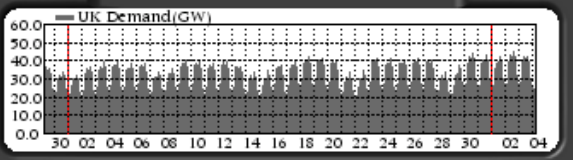
Weekly Hydro/Pumped/Bio. (GW)



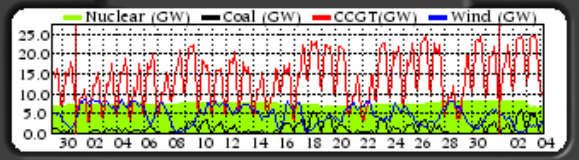
Weekly French/Irish/Dutch/EW ICT (GW)



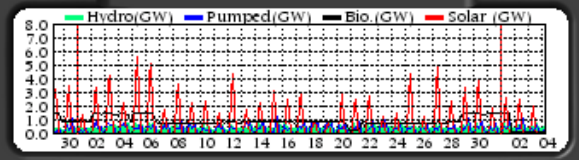
Monthly Demand (GW)



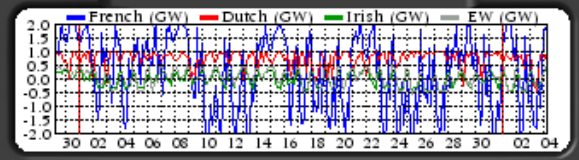
Monthly Nuclear/Coal/CCGT/Wind (GW)



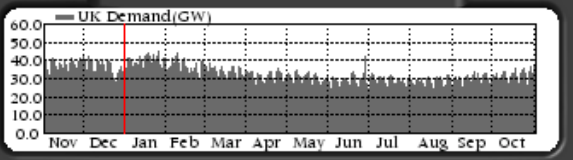
Monthly Hydro/Pumped/Bio. (GW)



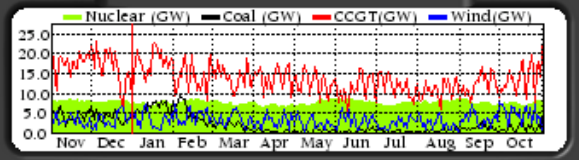
Monthly French/Irish/Dutch/EW ICT (GW)



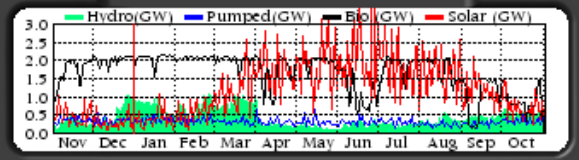
Yearly Demand (GW)



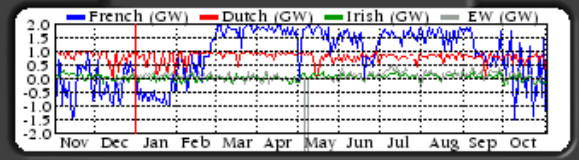
Yearly Nuclear/Coal/CCGT/Wind (GW)



Yearly Hydro/Pumped/Bio.(GW)



Yearly French/Irish/Dutch/EW ICT (GW)



Data last recorded on Saturday the 4th. of November, 2017 at 08:50 GMT