Presentation at IENE's 27th National Energy Conference on Energy and Development

Questions needing answers

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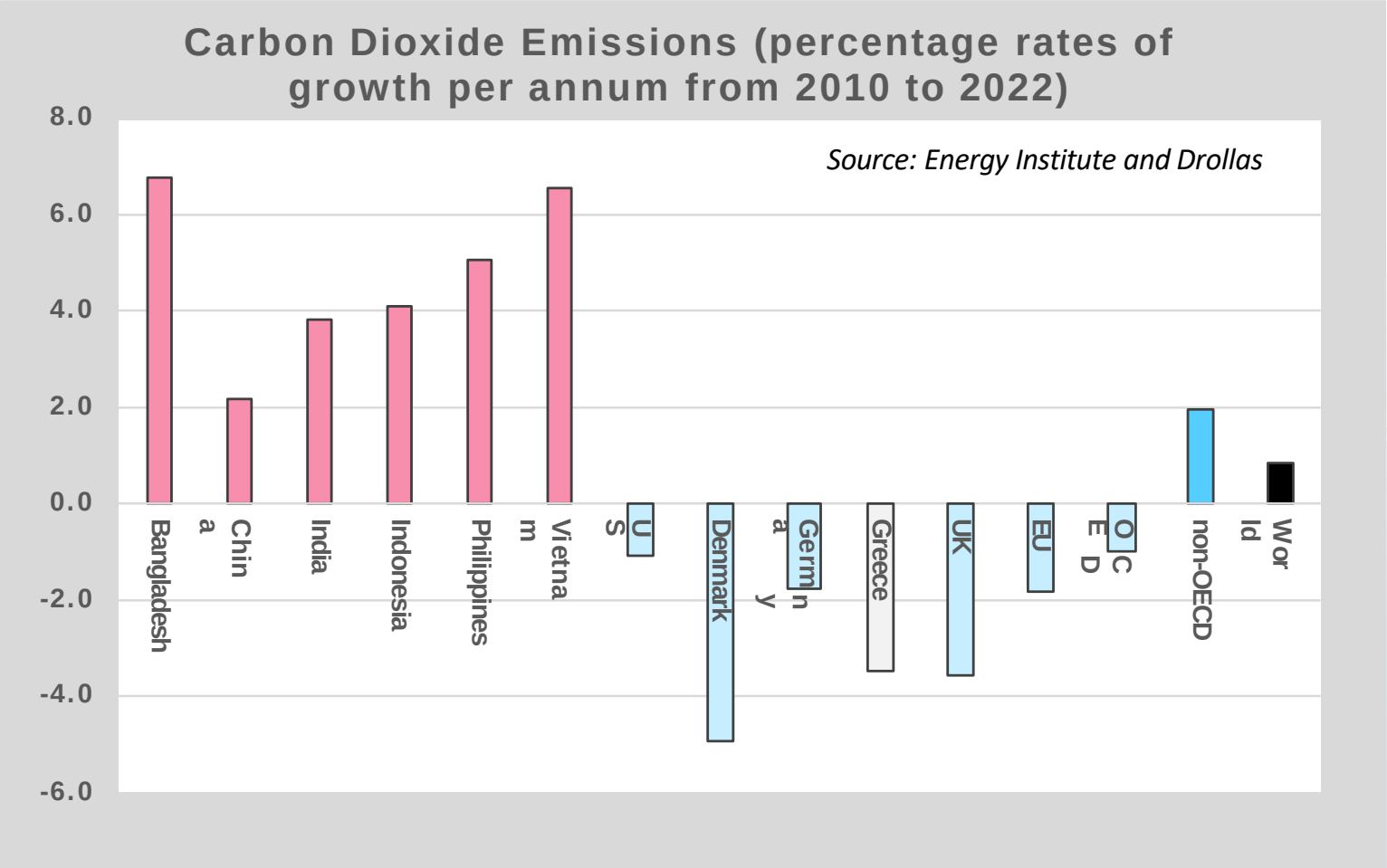
Questions, questions…

- How sure are we that rising CO_2 is so harmful that urgent global action in mitigation is required?
- How important is achieving Net Zero by 2050?
- How fast should the transition away from fossil fuels be? After all, fossil fuels accounted for a hefty 82% of primary energy in 2022 [31.6% oil, 23.5% natural gas and 26.7% coal].
- Which countries will bear the main burden of the transition as opposed to the countries that should bear the burden.
- What will be the cost? The IEA says investment in clean energy has hit $1.8tn/year versus $1tn invested in fossil fuels per annum.
- Can wind and solar power cope with motor transport, space heating and industrial needs without natural gas backup, nuclear power as base load and battery storage on a large scale? Can air and sea transport do without liquid fuels, preferably from renewable sources?
- Finally, and more parochially, why is electricity so expensive in Greece when so much investment has gone into wind and solar power?

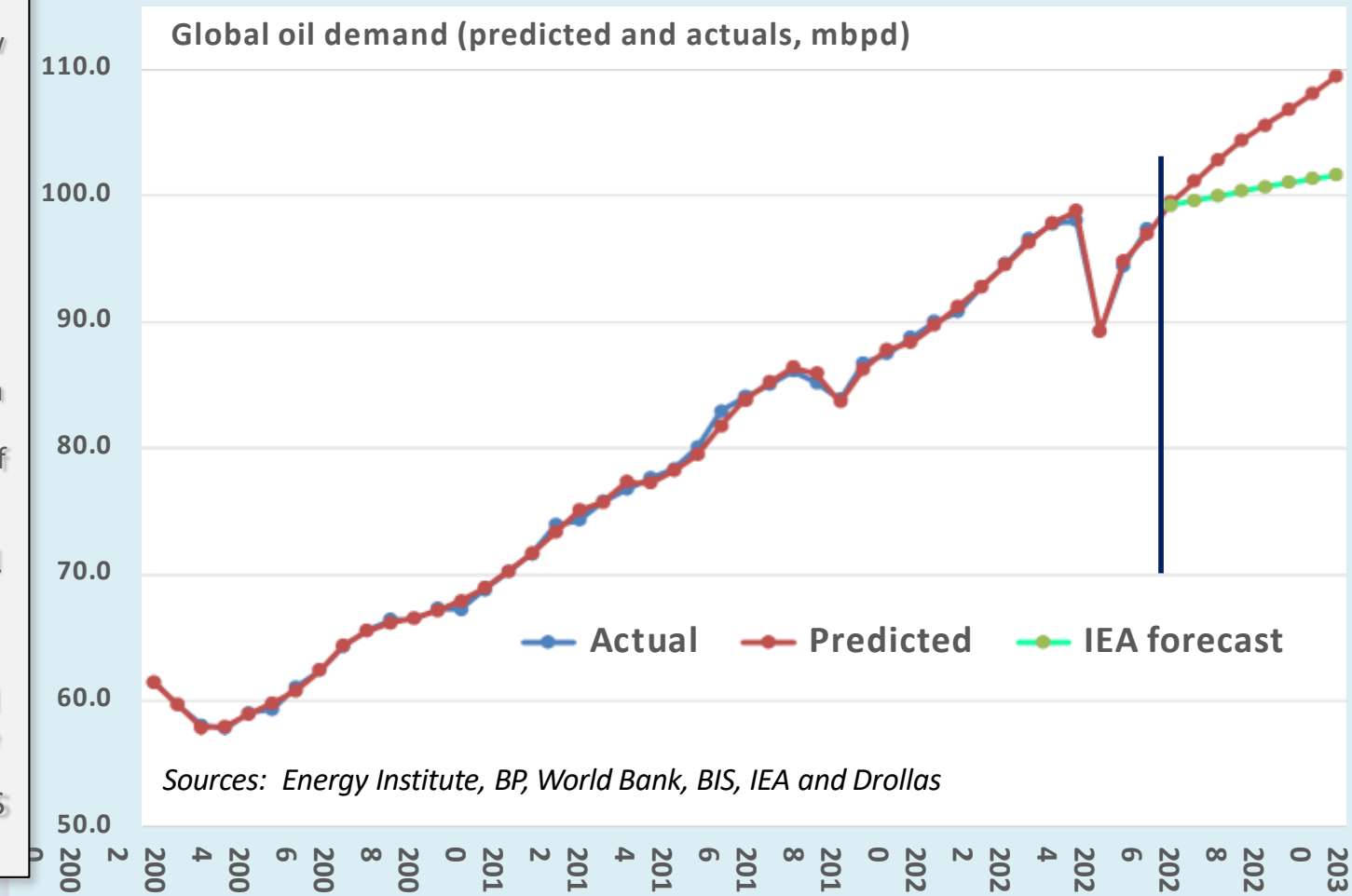
Growth rates of CO_2 emissions: 2010 to 2022



China's share of global CO_2 emissions amounted to 31pc in 2022, the world's largest, with the US second at 14pc and India third at 7.6pc. Greece's share of such emissions was a miniscule 0.2pc, Germany's 1.8pc, Denmark's 0.1pc and the UK's 1pc. The non-OECD share was a massive 66.3pc and the OECD's 33.7pc.

Global oil demand: dynamic regression model [Drollas]

The measure of a good model is how well it can explain the past. The one-period ahead forecasts of global oil demand of this model are based on actuals and projections of global real income and nominal $ oil prices deflated by world inflation and the effective exchange rate of the US Dollar.

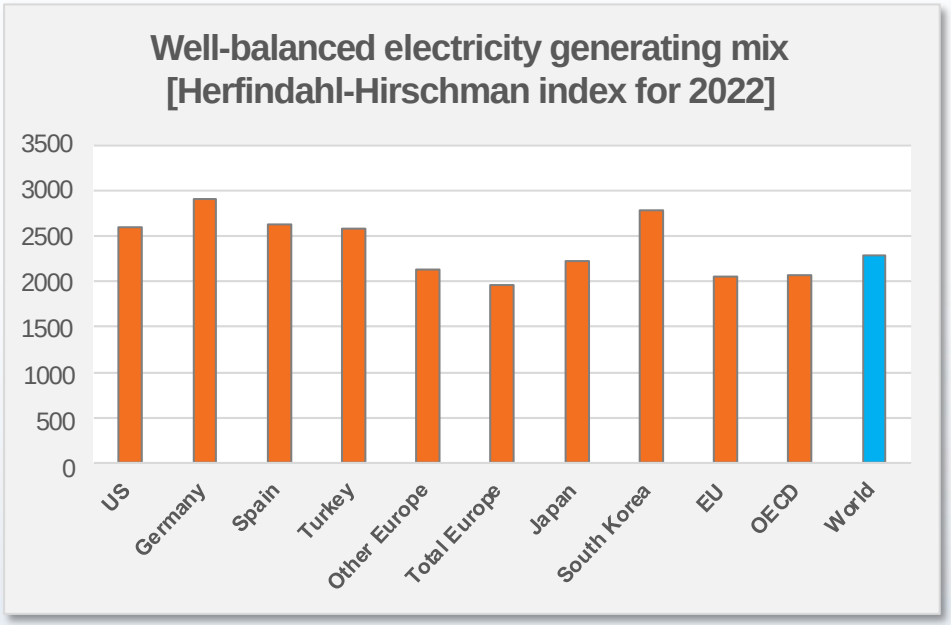


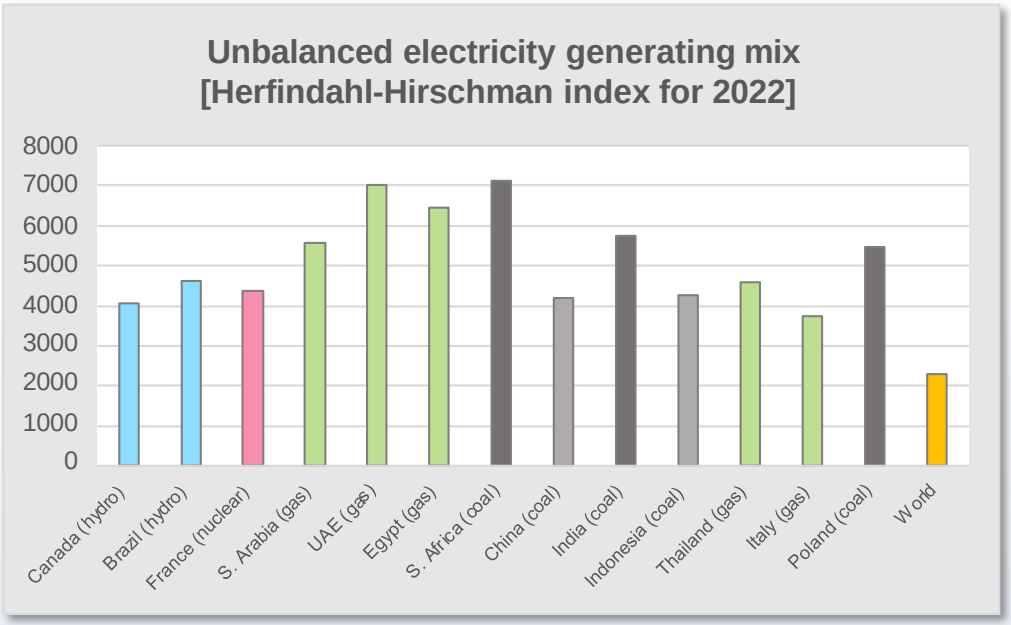
The IEA believes that with the right mandated policies the global demand for oil will plateau at just over 101 mbpd by 2030 (excluding biofuels). I believe that the assumptions required by the model to reach this lower level of demand are unrealistic.

Assumptions to generate the IEA's forecast: (a) real global GDP growth 2023-30 > 0.8pc/year [vs 2010-22 > 2.7pc/yr] and (b) nominal oil price > 5.2pc/yr [vs 2.1pc/yr] to yield oil demand growth of 0.3pc/year from 2023 to 2030 compared with 1pc/year from 2010 to 2022.

The concentration of electricity generation in 2022

Source: Energy Institute and Drollas



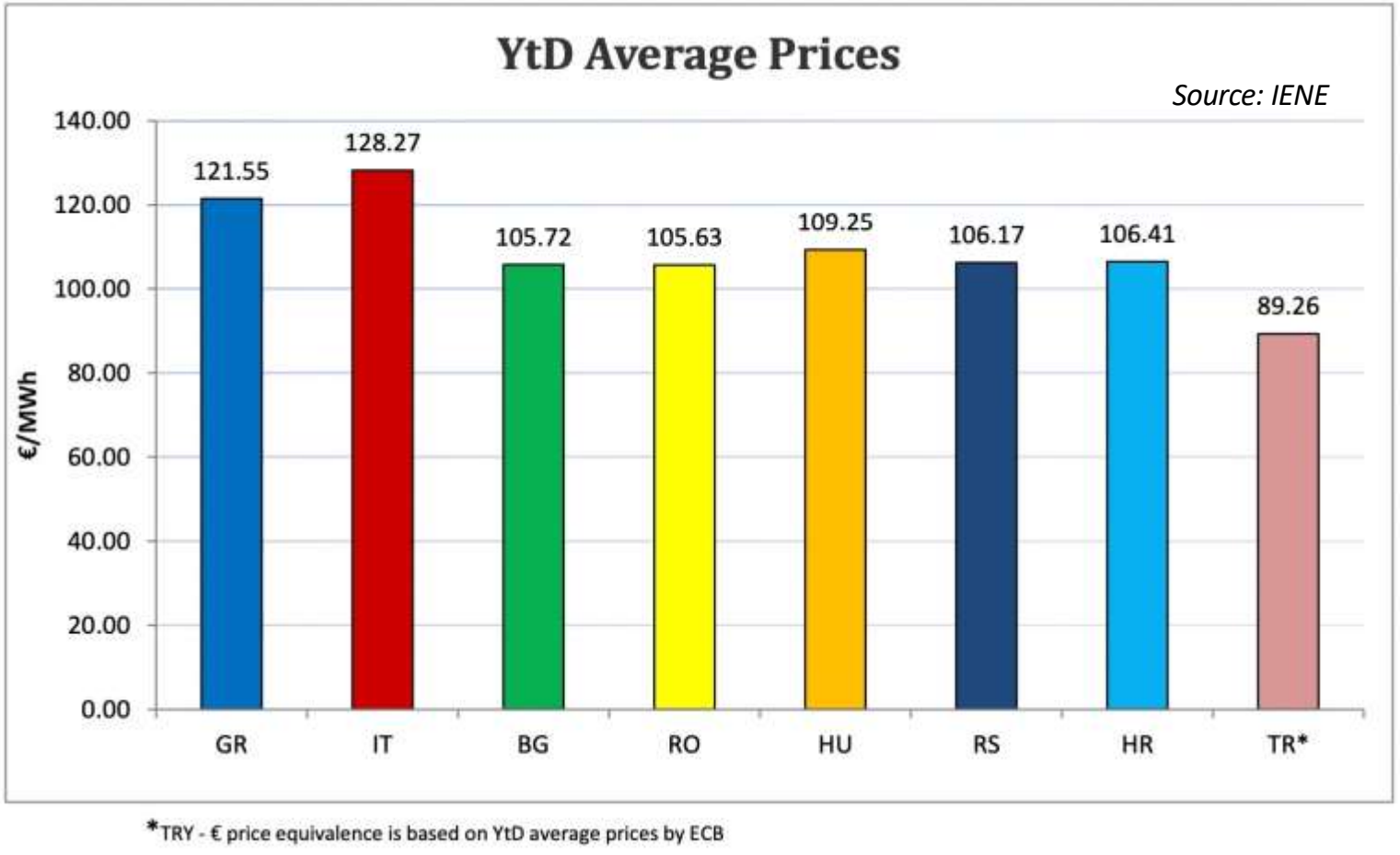


The Herfindahl-Hirschman Index (summing the squared shares of each fuel in power generation) shows how balanced power generation is in a country or group of countries. The index ranges from a minimum of 1,429 for the most-balanced electricity generation (incorporating 7 fuel categories) to 10,000 for use of a single fuel only.

The larger the grouping of countries the lower the HH index tends to be The lowest value was for the European Union at 2,046, followed by the OECD at 2,067. The US' index was at 2,593, Japan's at 2,228 and Spain's at 2,623. At the other end of the scale the United Arab Emirates' HH index was at 7,003, due to gas' 82.5pc share in its power generation, South Africa's was at 7,128 due to coal's 84pc share in S. Africa's electricity generation, and India's was at 5,741 due to coal's 74pc share.

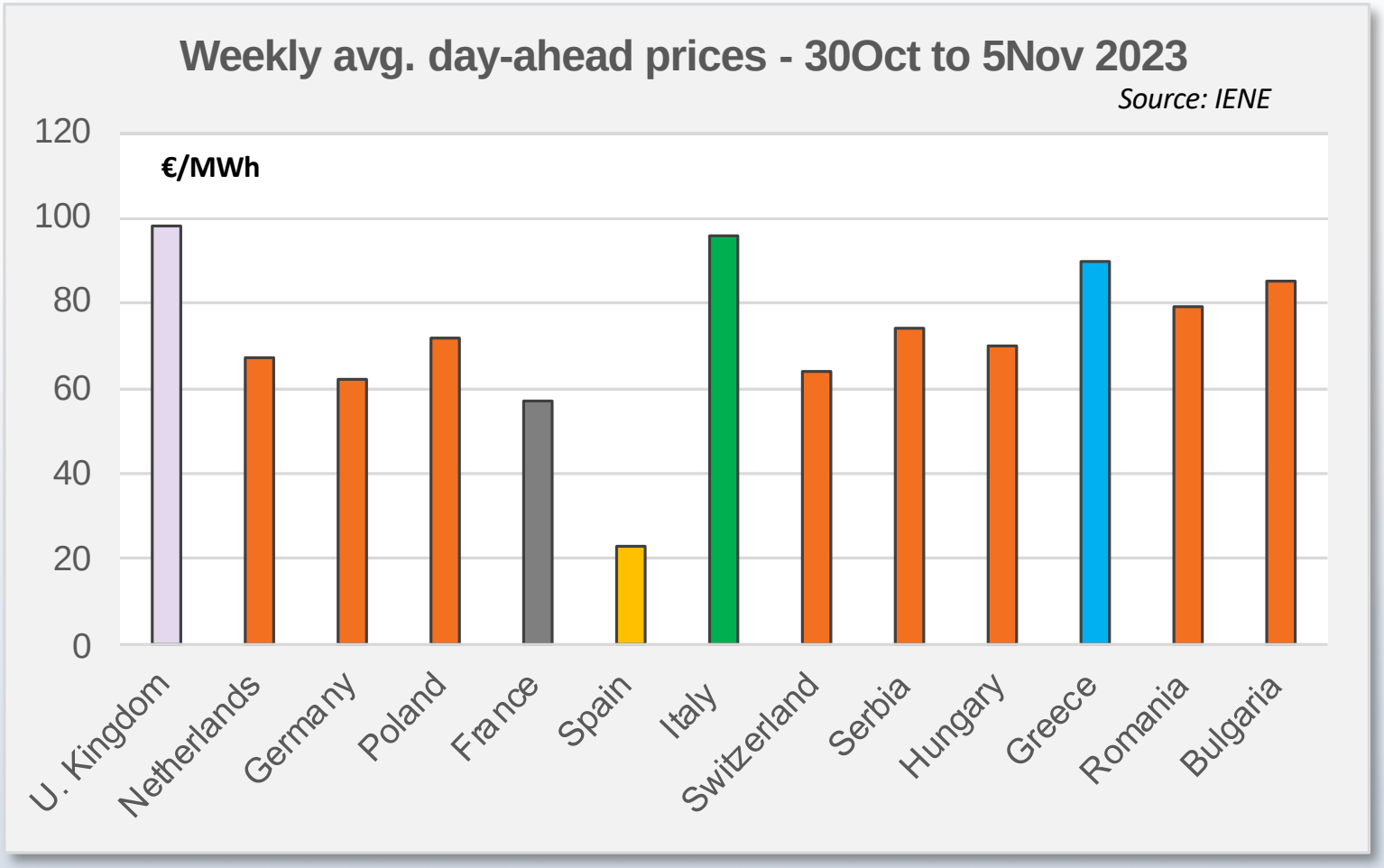
Selective average day-ahead electricity prices – 2023*

* Until 5th Nov-23.



In 2022, Greece's electricity generating capacity from wind was 4.9GW and from solar 5.6GW versus Italy's 11.8GW and 25.1GW respectively. Bulgaria had hardly any wind capacity (0.7GW), but it had nuclear energy. Neither Greece nor Italy have nuclear power stations, but Hungary, Romania and Bulgaria all have. Turkey is building a four-unit 4.8GW nuclear power plant [Akkuyu]; Greece should definitely follow suit.

Recent day-ahead electricity prices - 2023

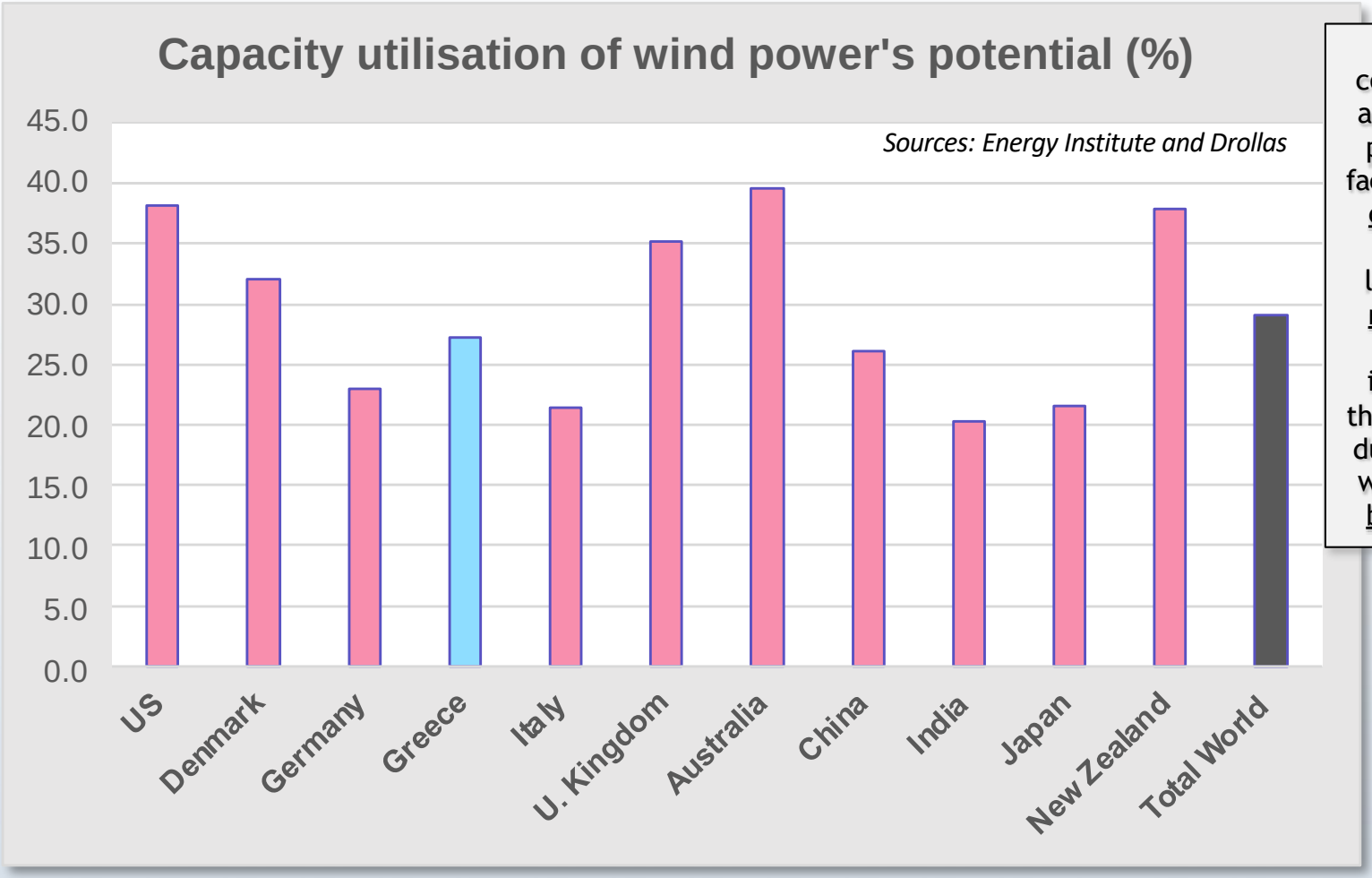


In the week ending on the 5th of November 2023, Greece at €90/MWh had some of the highest wholesale electricity prices in Europe. Only the UK (€98/MWh), Ireland (€120/MWh) and Italy (€96/MWh) had higher wholesale prices. Spain's were exceptionally low due to its relatively large wind and solar generating capacity (plus nuclear). France's were low due to its huge nuclear capability. Greece could do with nuclear, imitating Hungary, Romania and Bulgaria.

Wind power – important considerations

- Wind is a fluctuating stream of low-density energy. The Betz limit caps the energy that can be extracted from a moving fluid. Wind turbines are already effective machines in extracting wind energy.
- The problem is the wind itself, which is intermittent. As the British science writer Matt Ridley wrote, *'Mankind stopped using it [wind power] for mission-critical transport and mechanical power long ago, for sound reasons. It's just not very good'.*
- The turbines' propellers appear to turn lazily, but the speeds of their blade tips average about 240 kms/hour (150 miles/hr), hence the large number of birds and bats killed by them.
- A 2-MW turbine weighs about 250 tonnes and its manufacture requires 150 tonnes of coal to make the steel structure and the cement base. The 2 tonnes of rare earths for the magnets generate epic pollution, but out of sight in far-away places like Mongolia.
- A 2-MW turbine costs at present $2.6mn and its EAC (Equivalent Annual Cost) at 7pc interest and with an economic life of 15 years is $327,466 (including operating and maintenance costs of $42,000). At a yield factor of 30pc the cost of its power is $43.3/MWh (or €40.48/MWh).

Wind power's ability to deliver in 2022

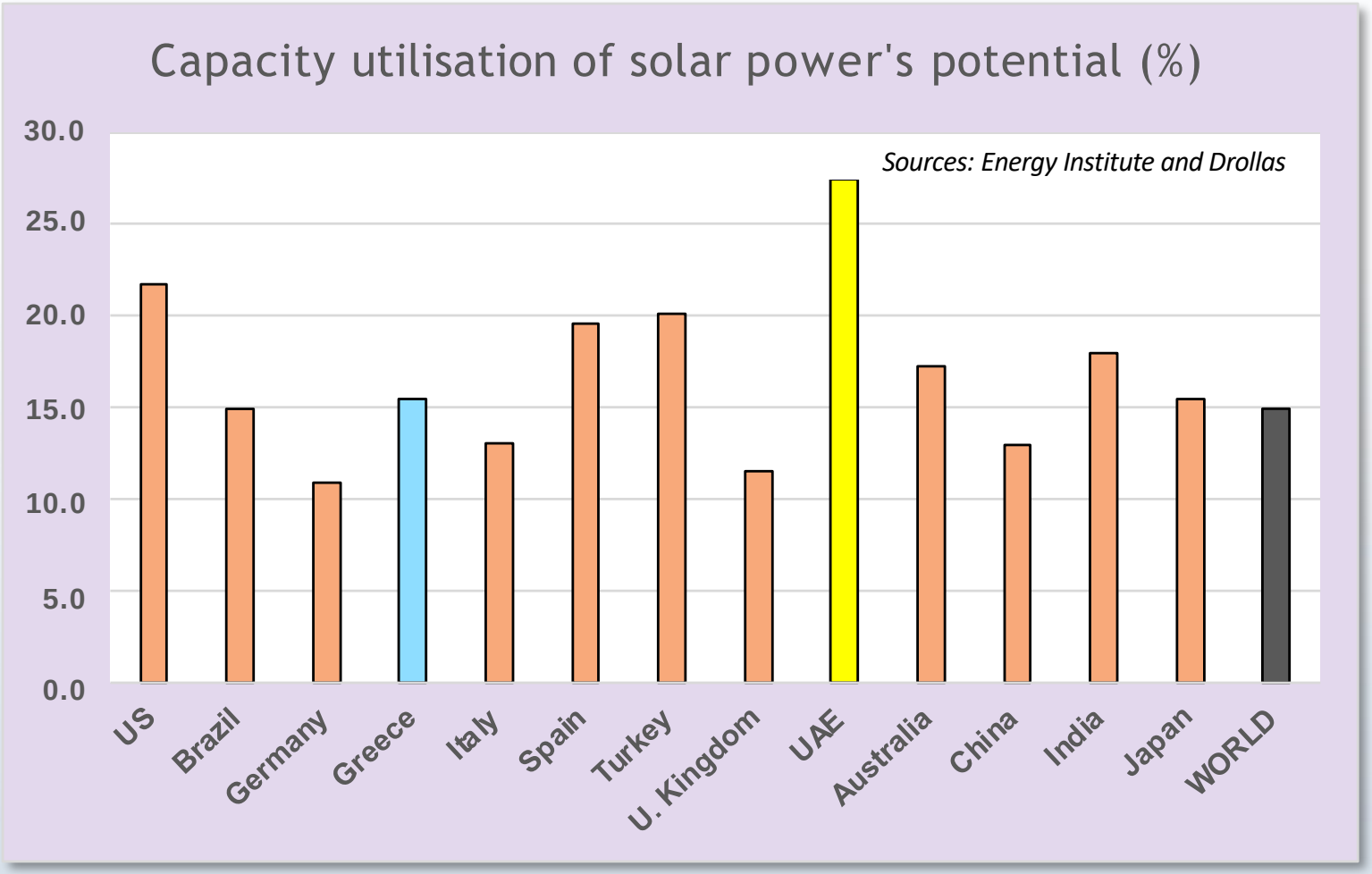


The key considerations affecting wind power's load factors are wind conditions in the various locations, the maintenance periods involved and the number and duration of the wind turbines' breakdowns.

The US' share of global wind turbine capacity in 2022 was 15.7pc, China's was 40.7pc, Germany's 7.4pc, Denmark's 0.8pc, Greece's 0.5pc, Spain's 3.3pc, the UK's 3.2pc, India's 4.7pc, Australia's 1.1pc and Japan's 0.5pc.

* It has been assumed that a universal 15 days a year are set aside for maintenance of the wind turbines and dealing with breakdowns, reducing wind power's potential of 8,760 operational hours in a year by 360 hours.

Solar power's ability to deliver in 2022



The US' share of global solar power capacity in 2022 was 10.7pc, China's was 37.3pc, Germany's 6.3pc, Italy's 2.4pc, Greece's 0.5pc, Spain's 1.9pc, the UK's 1.4pc, India's 6.0pc, Australia's 2.5pc and Japan's 7.5pc.

* It has been assumed that 15 days per annum are set aside for maintenance of the photovoltaic panels and dealing with breakdowns, reducing solar power's potential of 8,760 operational hours in a year by 360 hours.

Concluding remarks

- For the EU to achieve net zero emissions of CO_2, key current areas of fossil fuel usage need to be replaced with renewable energy – motor transport, space heating, process heat for industrial applications, and liquid fuels for air and sea transport.
- To use wind power to supply electricity for large EV fleets, tens of thousands of additional wind turbines will be needed, costing many billions of Euros and needing a lot of space and infrastructure expenditure (for access roads, transmission lines, substations, etc…). The UK's National Grid reckons it needs £19bn to upgrade the grid. The main problem with wind turbines is that wind is an unreliable source of low-density energy.
- Because of this, gas-fired or other power systems need to be available as back-up and/or extensive storage systems developed, increasing considerably the cost of wind power. It would be cheaper in the long run to develop nuclear power more extensively (preferably with SMRs) and to retain considerable gas-fired generating capacity.
- Activist investors are shunning hydrocarbons, which will have two undesirable results during the transition period: [A] their prices will be higher than otherwise would have been the case, adding to general inflation and increasing fuel poverty for the vulnerable, and [B] global dependence on oil and gas production in geopolitically volatile regions will rise.