International Energy Agency: Exploring the New Frontiers of Flexibility

Prepared by Brent Wanner and Claudia Pavarini, IEA.

Renewables, particularly wind and solar PV, are expected to make large gains in their share of electricity generation between now and 2040. In the Stated Policies Scenario of the 2019 World Energy Outlook (IEA 2019b), which reflects the impacts of implemented and announced government policies and evolution of the costs of energy technologies, electricity generation from renewables increases rapidly, surpassing coal by 2026. Wind and solar PV together provide over half of the growth in electricity supply, raising their share from 7% in 2018 to 24% in 2040. In the more environmentally ambitious Sustainable Development Scenario, which is consistent with limiting the temperature rise by 2100 to 1.8° C with a 66% probability, the gains by wind and solar PV are even more striking: rising to 40% of the global electricity supply by 2040.

Table 1. Global Electricity Generation by Source and Scenario (Terawatt-hours)

			Stated Policies				Sustainable Development	
	2000	2018	2025	2030	2035	2040	2030	2040
Coal	**5 994**	**10 123**	**10 291**	**10 408**	**10 444**	**10 431**	**5 504**	**2 428**
Of which carbon capture, utilization, and storage	-	-	1	16	43	69	246	994
Gas	**2 750**	**6 122**	**6 984**	**7 529**	**8 165**	**8 899**	**7 043**	**5 584**
Of which carbon capture, utilization, and storage	-	-	-	0	0	1	220	915
Oil	**1 207**	**809**	**724**	**622**	**556**	**490**	**355**	**197**
Nuclear	**2 591**	**2 718**	**2 801**	**3 073**	**3 282**	**3 475**	**3 435**	**4 409**
Renewables	**2 863**	**6 799**	**9 972**	**12 479**	**15 204**	**18 049**	**15 434**	**26 065**
Hydro	2613	4203	4759	5255	5685	6098	5685	6934
Bioenergy	164	636	916	1085	1266	1459	1335	2196
Wind	31	1265	2411	3317	4305	5226	4453	8295
Solar PV	1	592	1730	2562	3551	4705	3513	7208
Geothermal	52	90	125	182	248	316	282	552
CSP	1	12	28	67	124	196	153	805
Marine	1	1	2	10	25	49	14	75
Total	**15 427**	**26 607**	**30 803**	**34 140**	**37 682**	**41 373**	**31 800**	**38 713**

1.1 Power System Flexibility Requirements Will Increase Significantly

The rise in the share of VRE, namely wind and solar PV, in the electricity supply is the main driver for a significant increase in the need for more rapid flexibility—the ability of power systems to respond in a timely way to changes in electricity supply and demand. All regions will need more flexibility relative to the current energy systems and grid. Expressed as peak ramping requirements, flexibility needs will increase much faster than electricity demand. They increase

fastest in developing economies where almost 90% of the electricity demand growth in this scenario takes place, and particularly in India (Figure 1).

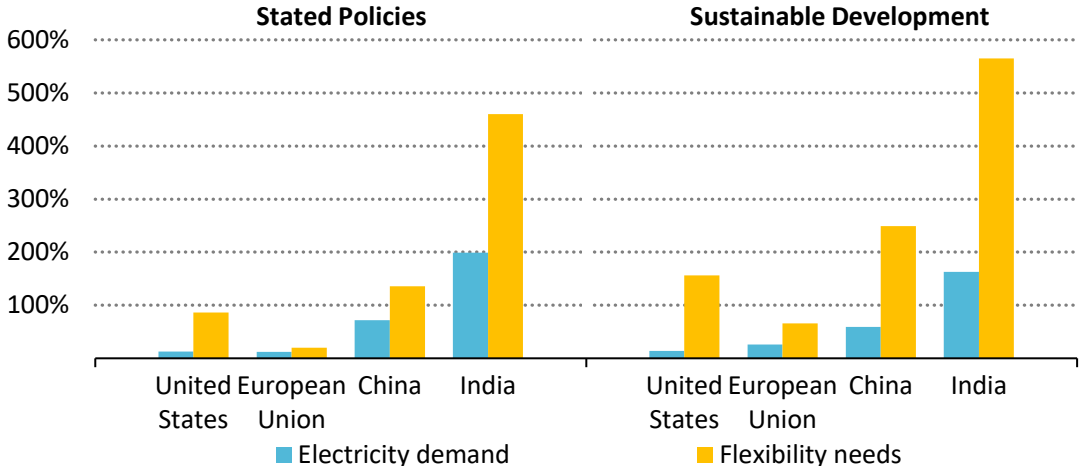

Figure 1. Growth in electricity demand and flexibility needs by selected region and scenario, 2018–2040

Source: IEA.

Key point: Flexibility needs[1] increase much faster than electricity demand, driven by rising shares of variable renewables, more electric vehicles, and higher demand for cooling.

The speed of increase in flexibility needs depends mainly on how fast the share of VRE expands. The share of variable renewables in the power generation mix is set to more than triple in China and the United States in the Stated Policies Scenario, as well as at the global level. In India, it increases fivefold, and in Southeast Asia, sevenfold.

Flexibility needs are also affected by the changing demand profile, how well the rising variable renewables supply matches the demand profile of a particular power system, and the power system size. Increasing use of air conditioners is adding to loads during the summer, particularly during peak periods. Electric vehicles potentially may strongly affect peak demand, especially if smart charging is not fully developed.

In the Sustainable Development Scenario, as the power sector moves toward decarbonisation and as electric mobility spreads, flexibility needs increase even more strongly. In this scenario, flexibility requirements in India's power system are six times today's level. In China they more than triple, and in the United States they are 150% higher.

[1] Flexibility is a multifaceted concept that refers to the ability of power systems to balance demand and supply and can be provided by different services (e.g., frequency regulation, operational reserves, load balancing). The change in the net load from one hour to the next (hourly ramping requirements) provides a useful indicator of flexibility and is used in this analysis. For more information on the drivers of increasing demand for flexibility and flexibility sources, see the *WEO-2018 Special Focus on Electricity* (IEA 2018b).

1.2 A Diverse Portfolio of Flexibility Options Will Be Required

Flexibility needs in the scenarios are based on analysis in which hourly demand profiles for projected years in different regions are assessed and fluctuations in net load are calculated in our World Energy Model. Based on the capacity mix of the specific region, the capability of the power system assets to change their output by the hour is simulated to identify which technologies can provide the flexibility required.

Conventional sources of flexibility in the form of power plants and interconnections have long maintained the reliability of power systems around the world. Today, thermal power plants (both fossil and nuclear) provide the bulk of the flexibility required by many electricity systems, and this remains the case to 2040 in the Stated Policies Scenario (Figure 2). This is made possible by the retrofitting of existing thermal power plants, which helps increase ramp rates (IEA 2018a), and by the construction of more flexible power plants such as gas turbines. Hydropower also remains an important source of flexibility in many regions. Interconnections between power systems and regions continue to alleviate network congestion by taking advantage of varying supply and demand patterns and pooling available flexibility resources.

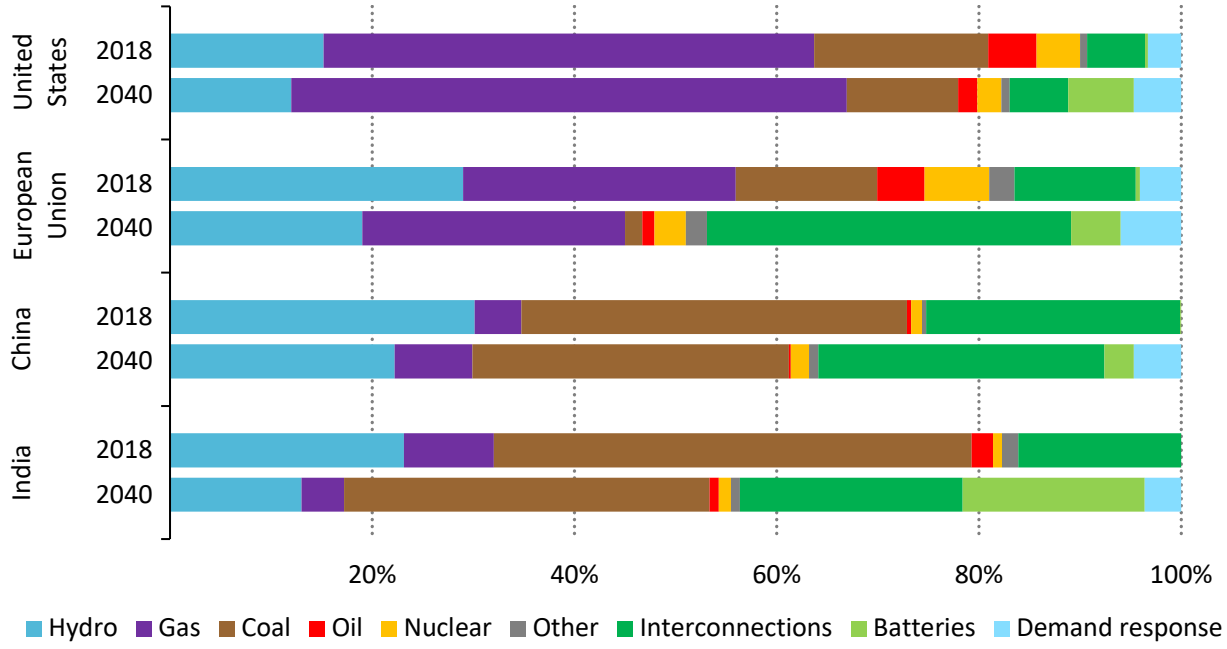

Figure 2. Sources of flexibility by region in the Stated Policies Scenario

Source: IEA.

Key point: Thermal power plants continue to provide the bulk of flexibility needs, along with interconnections, but batteries and demand-side response are rising fast.

Nonetheless, new flexibility sources will be needed. Batteries, demand response, and sector coupling are poised to play pivotal roles in making sure future power systems are secure and reliable. Demand-side response also has a large part to play in meeting rising flexibility needs, for example by shaving peak demand and redistributing electricity to time periods when the load is smaller, and electricity is cheaper. Distributed resources, including variable renewables, storage, and demand response, can also become key flexibility sources with appropriate market designs, as is happening in several countries (IEA 2019a).

Digitalisation is likely to have a major role in capitalising on the flexibility options. Regional trends to 2040 show there are no one-size-fits-all approach to flexibility. The European Union is expected to source a significant portion of its flexibility needs from the large-scale deployment of interconnections. China is set to rely on more flexible coal-fired power plants and large-scale interconnections. In the United States gas-fired power plants are set to remain a cheap source of power system flexibility through 2040. Most of India's additional flexibility needs are to be met by flexible coal-fired power plants, batteries, and interconnections.

Changes in policy and regulatory frameworks, as well as economic incentives, are essential to ensure timely investment in flexibility assets and to make the most of the flexibility potential of existing power plants. Competitive electricity markets were originally designed with dispatchable power plants in mind. The rise of variable renewables is now challenging the suitability of those market designs to deliver efficient and timely investment. For example, there is a widening gap between electricity supply costs and revenues from energy sales, particularly in the European Union and the United States (IEA 2019a). These markets may require reforms to spur investment and to establish a cost-effective set of flexibility measures.

The transformation of the power generation fleet is even more pronounced in the Sustainable Development Scenario, with variable renewables making up 40% of electricity generation by 2040. The increased reliance on variable renewables often translates into higher hourly ramp rates, which requires more flexibility, including what can be provided by batteries and demand response measures.

1.3 References

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