INTERNATIONAL ENERGY STATUS AND OUTLOOK

Presentation at the 2019 China New Energy Networking Meeting

Kaare Sandholt, Chief Expert, China National Renewable Energy Centre

INTERNATIONAL ENERGY TRENDS

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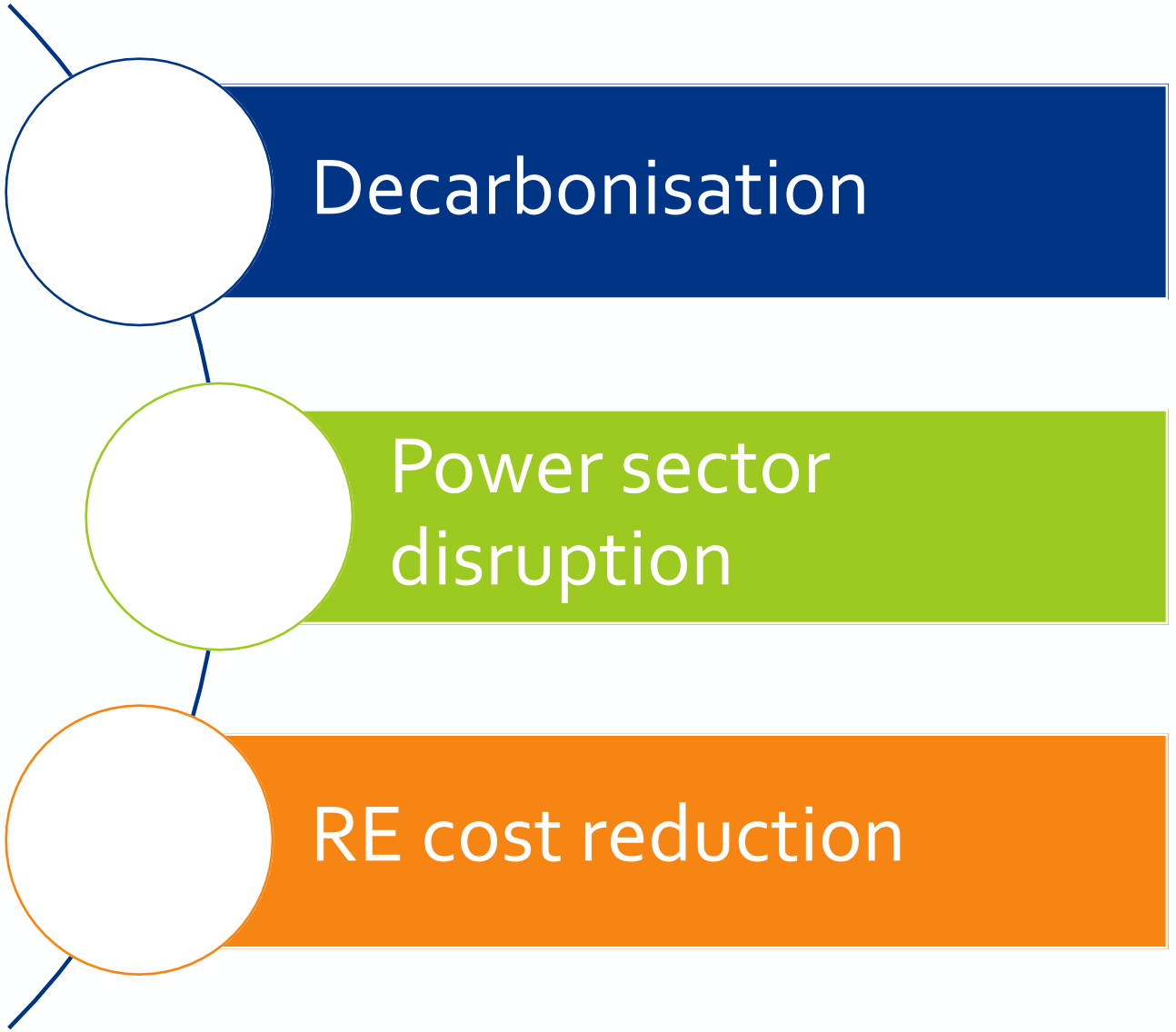
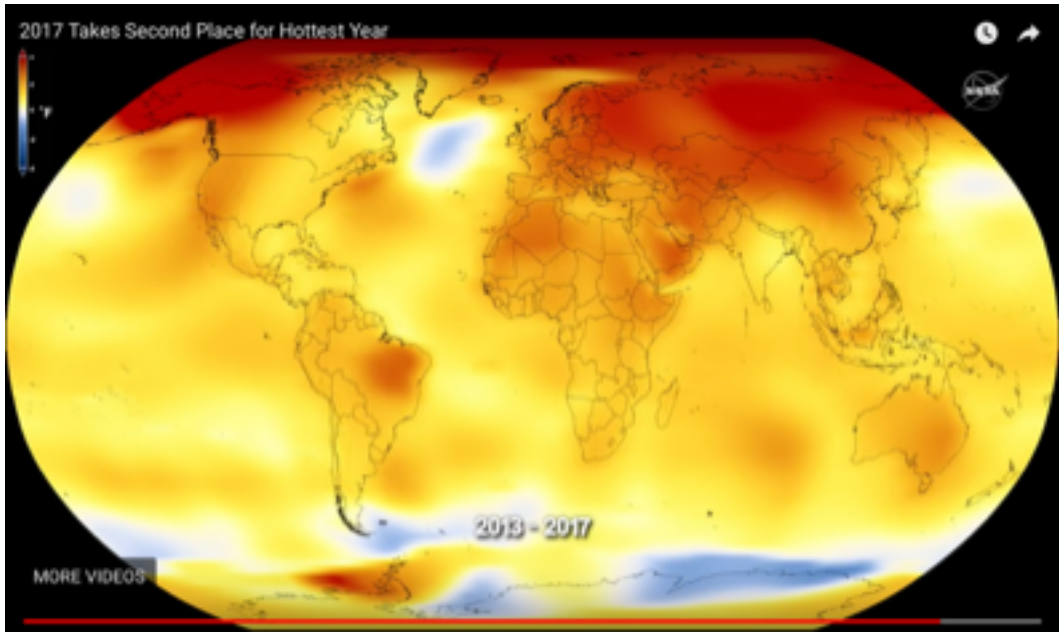
Global game changers



Global game changers

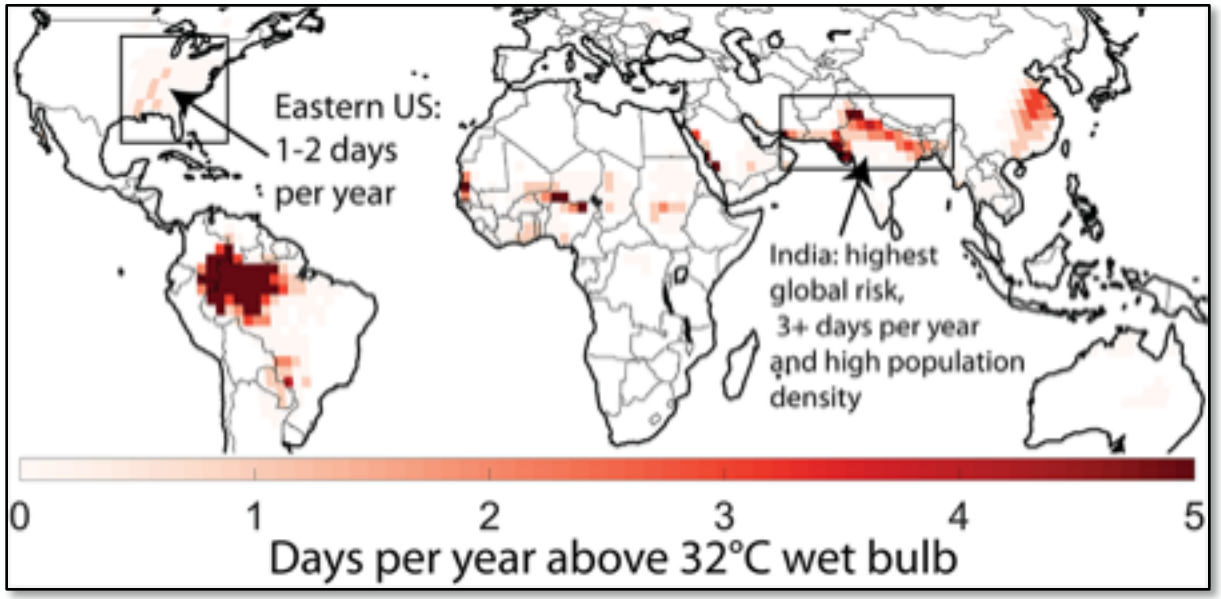
DECARBONISATION

Global warming – not theory but reality



2018 the fourth hottest year on record, 2017 the second hottest year, 2016 the hottest year

A study projects that drastic combinations of heat and humidity may hit large areas of the world later this century. (Map: Ethan Coffel)



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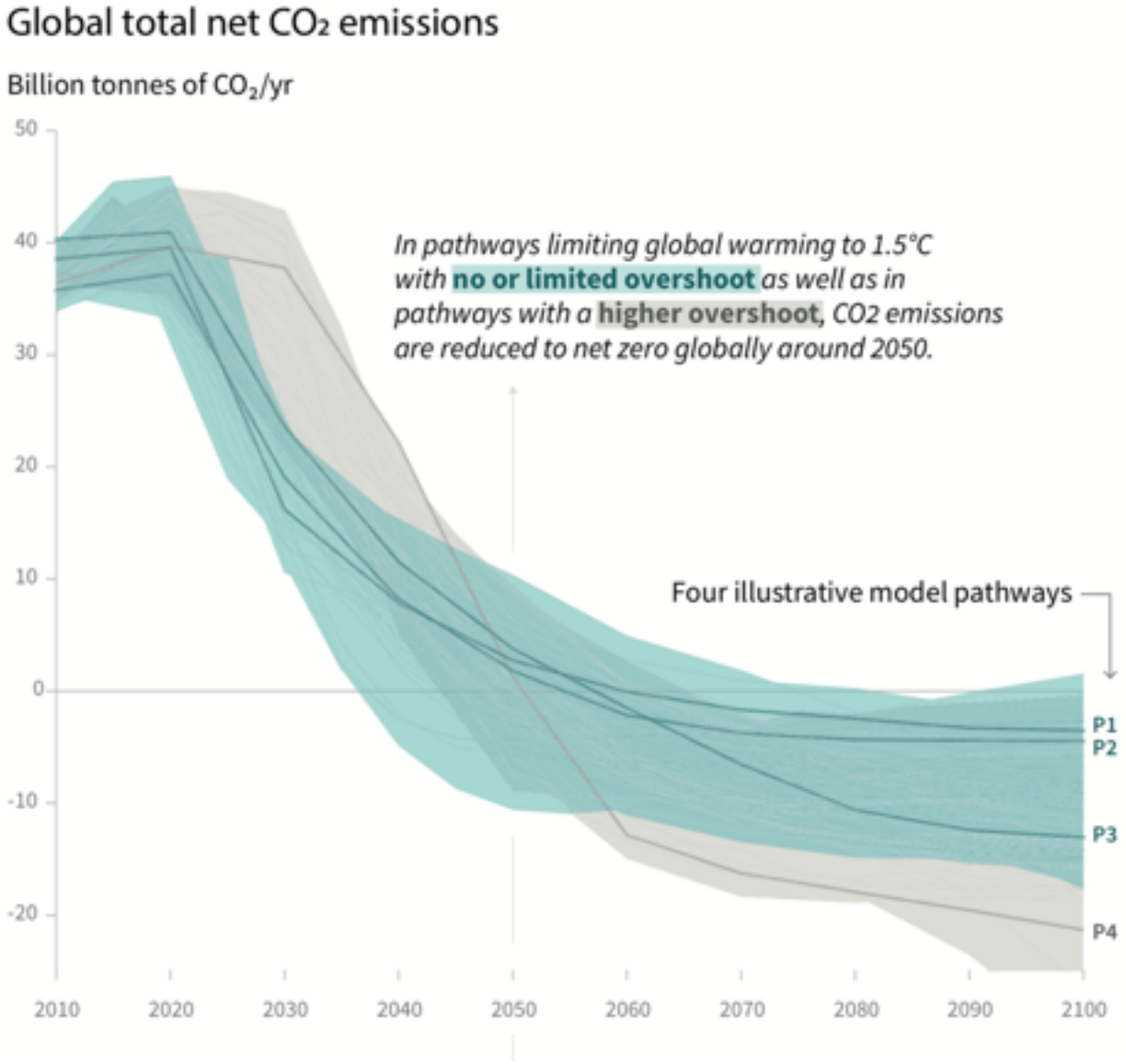
Rapid decrease in CO2 emissions needed to comply with the Paris agreement



Source: IPCC, 2018: *Global Warming of 1.5°C.*

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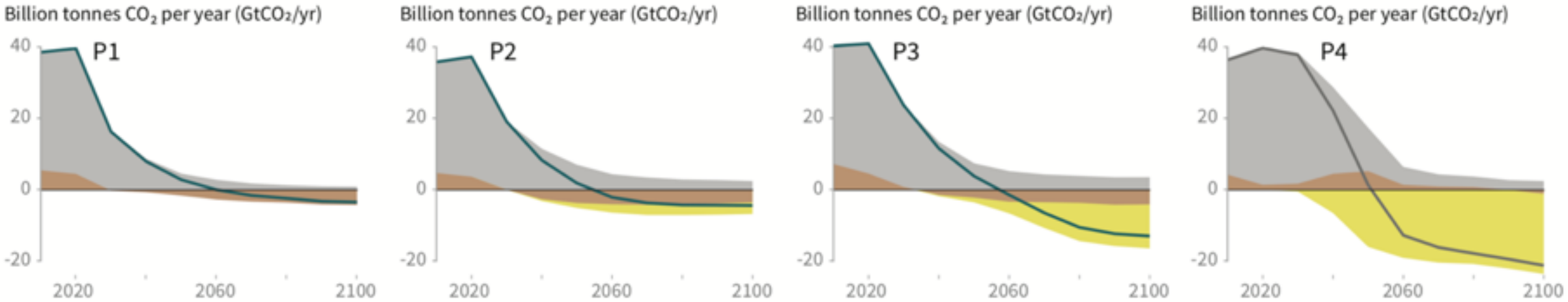
Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways

Fossil fuel and industry AFOLU BECCS



P1: A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonization of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource- and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas-intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

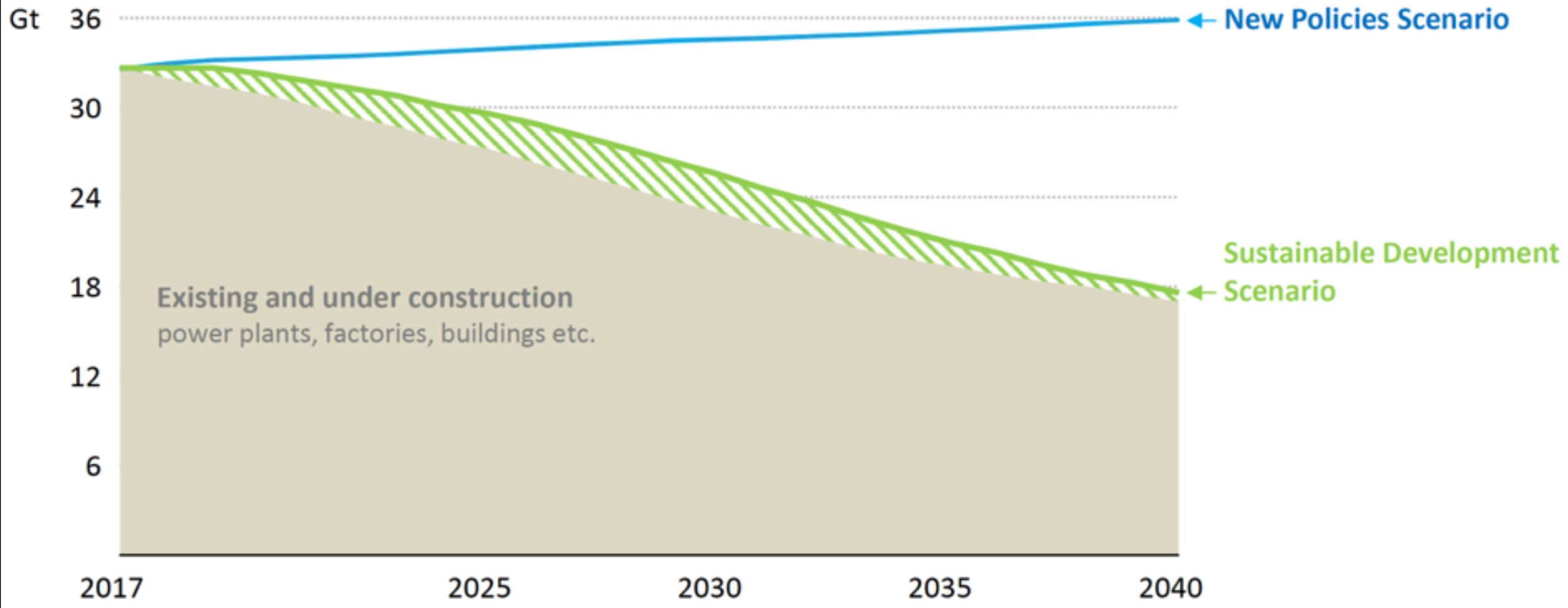
Table 1.1 ▻ World primary energy demand by fuel and scenario (Mtoe)

			New Policies		Sustainable Development	
	2000	2017	2025	2040	2025	2040
Coal	2 308	3 750	3 768	3 809	3 045	1 597
Oil	3 665	4 435	4 754	4 894	4 334	3 156
Gas	2 071	3 107	3 539	4 436	3 454	3 433
Nuclear	675	688	805	971	861	1 293
Renewables	662	1 334	1 855	3 014	2 056	4 159
Hydro	225	353	415	531	431	601
Modern bioenergy	377	727	924	1 260	976	1 427
Other	60	254	516	1 223	648	2 132
Solid biomass	646	658	666	591	396	77
Total	**10 027**	**13 972**	**15 388**	**17 715**	**14 146**	**13 715**
Fossil fuel share	*80%*	*81%*	*78%*	*74%*	*77%*	*60%*
CO_2 emissions (Gt)	**23.1**	**32.6**	**33.9**	**35.9**	**29.5**	**17.6**

Notes: Mtoe = million tonnes of oil equivalent; Gt = gigatonnes. Solid biomass includes its traditional use in three-stone fires and in improved cookstoves.

Source: IEA WEO 2018

Global energy-related CO_2 emissions



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Source: IEA WEO 2018

Global game changers

RE COST REDUCTION

IEA: 2018 RE market report

Figure 5.5 LCOE ranges for new utility-scale onshore wind, solar PV and coal and gas plants by commissioning date, 2011-23

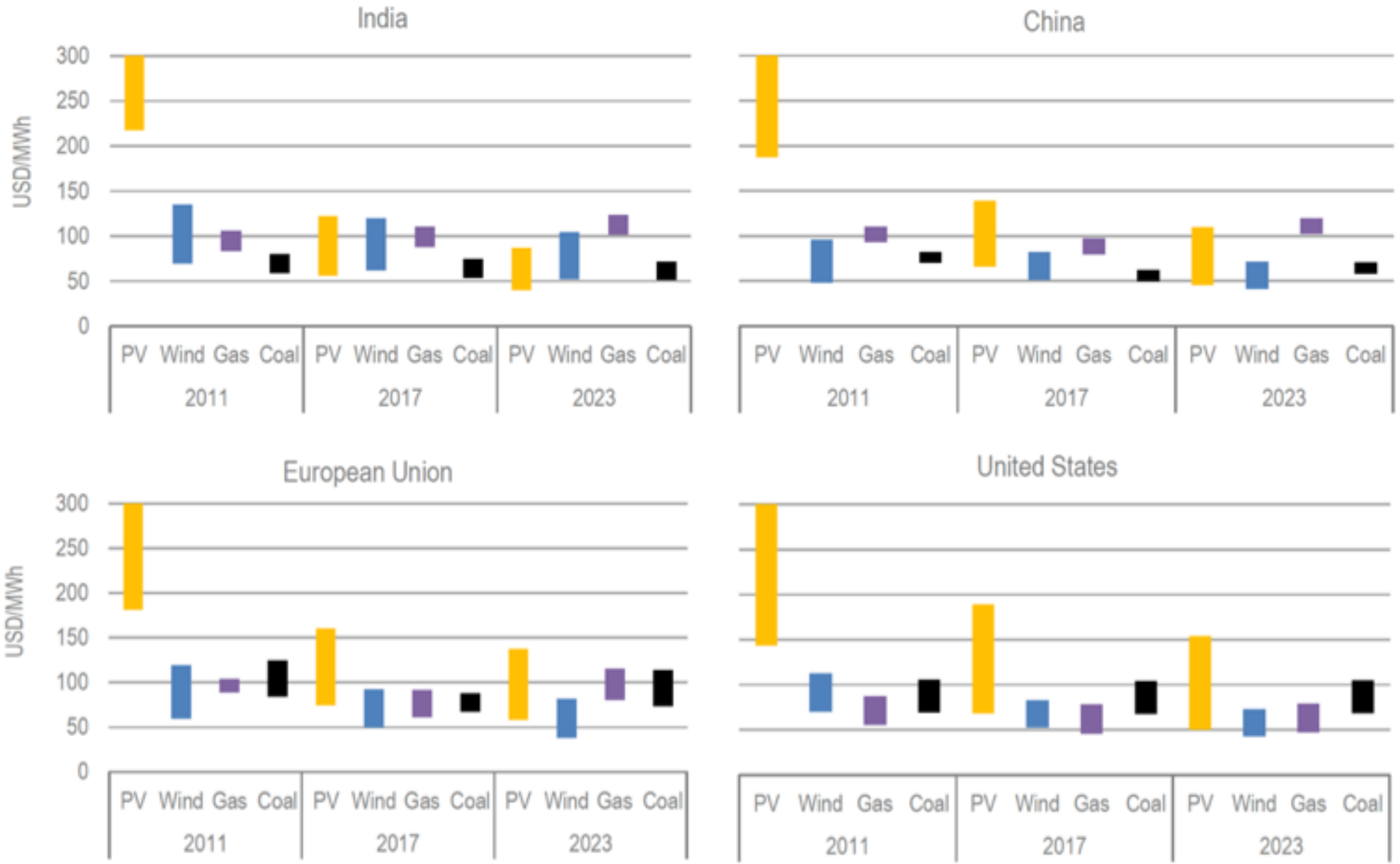
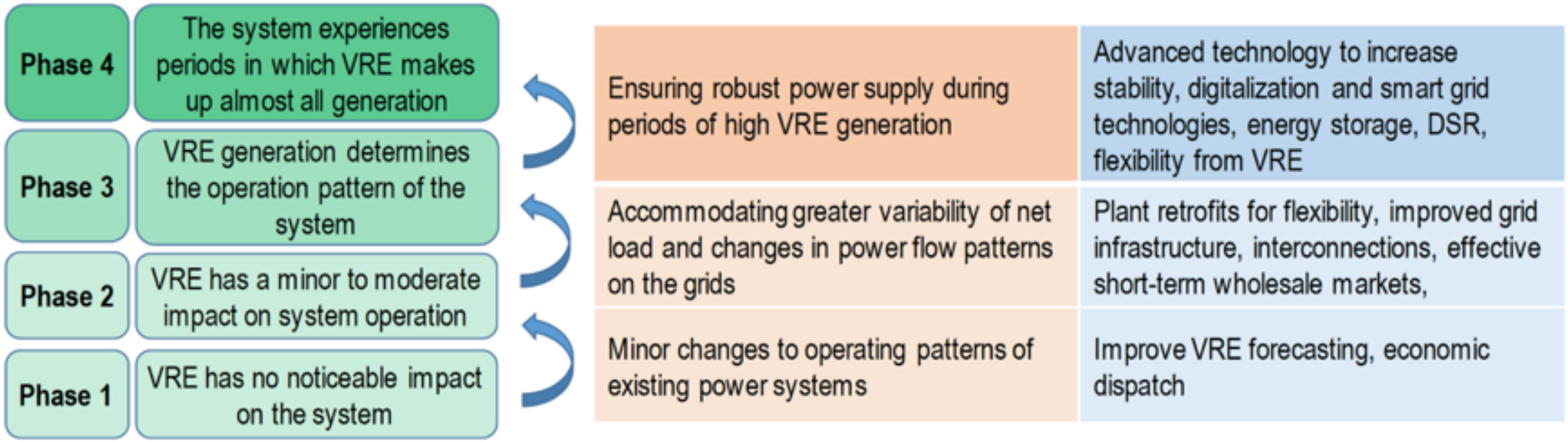


Figure 5.11 System integration phases, transition challenges and flexibility measures



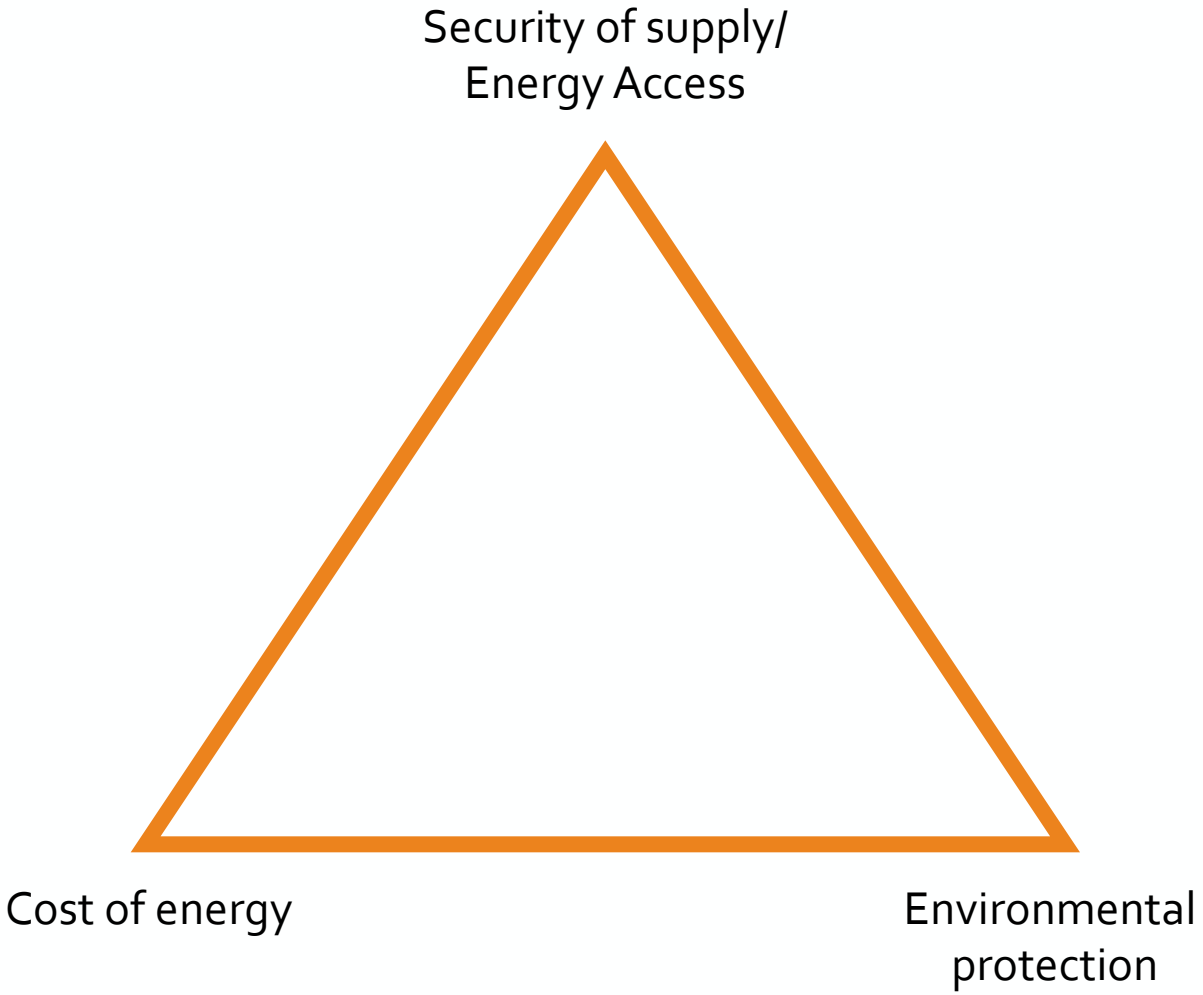
Note: DSR = demand-side response.

IEA: 2018 RE market report

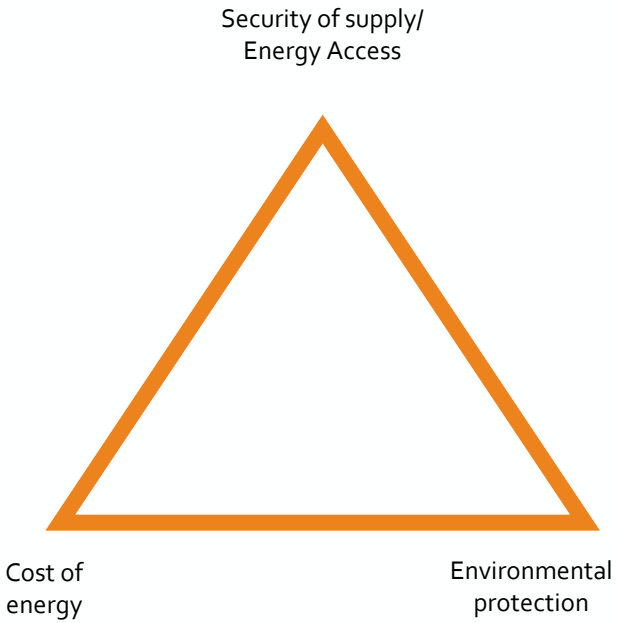
Global game changers

POWER SYSTEM DISRUPTION

Energy Policy Priorities



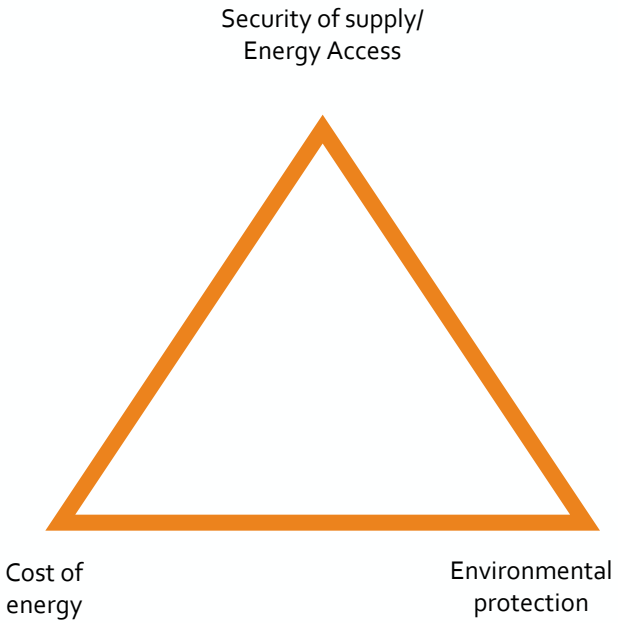
Paradigm shifts



Before

Now

Paradigm shifts



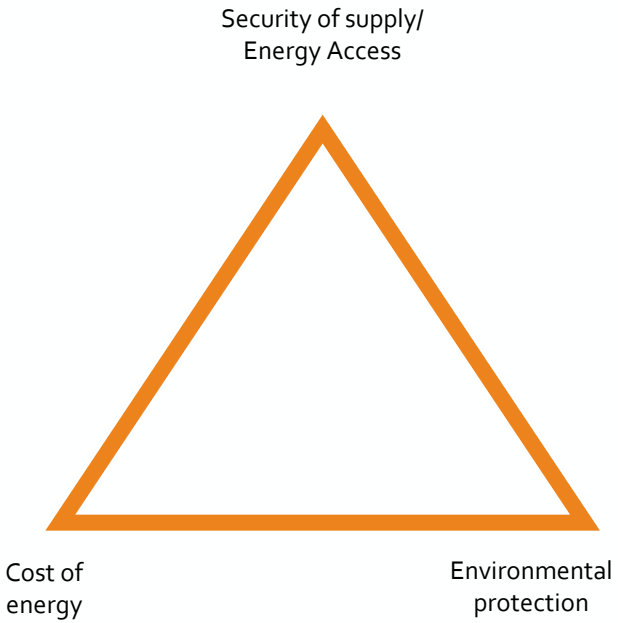
Before

Flue gas cleaning

Now

Decarbonisation

Paradigm shifts



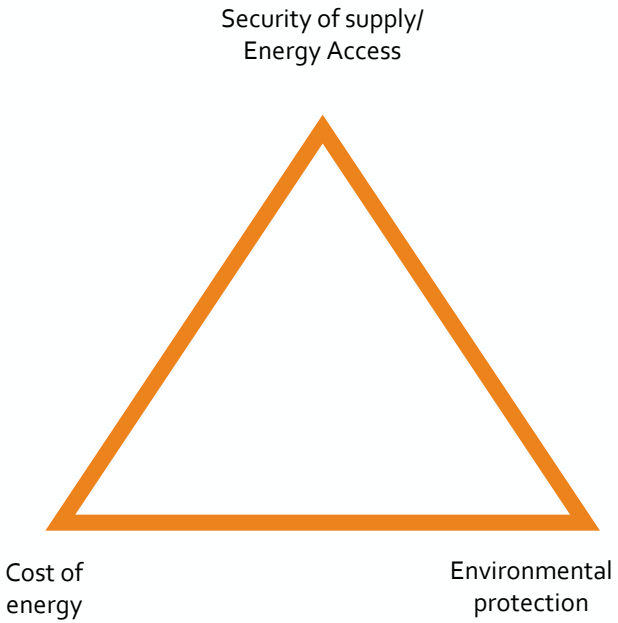
Before

- Flue gas cleaning
- One-way supply

Now

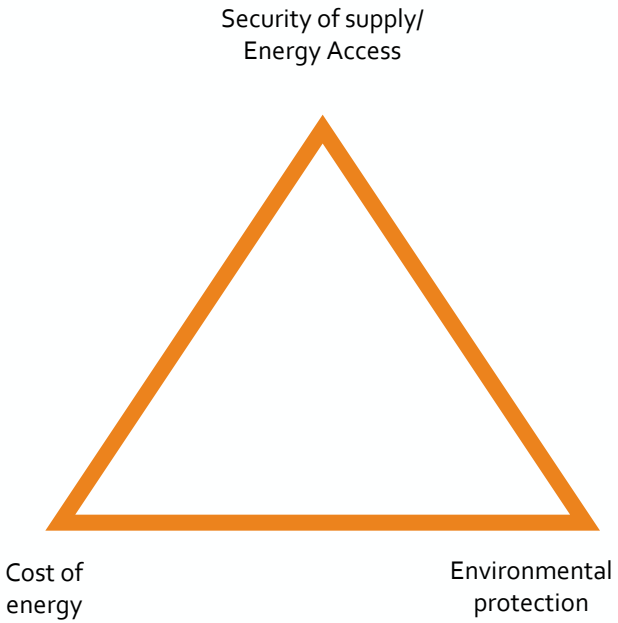
- Decarbonisation
- Diversified supply and prosumers

Paradigm shifts



Before	Now
Flue gas cleaning	Decarbonisation
One-way supply	Diversified supply and prosumers
Monopoly and vertical integration	Markets and data transparency

Paradigm shifts



Before	Now
Flue gas cleaning	Decarbonisation
One-way supply	Diversified supply and prosumers
Monopoly and vertical integration	Markets and data transparency
Data monopoly and data shortage	Digital revolution and smart systems

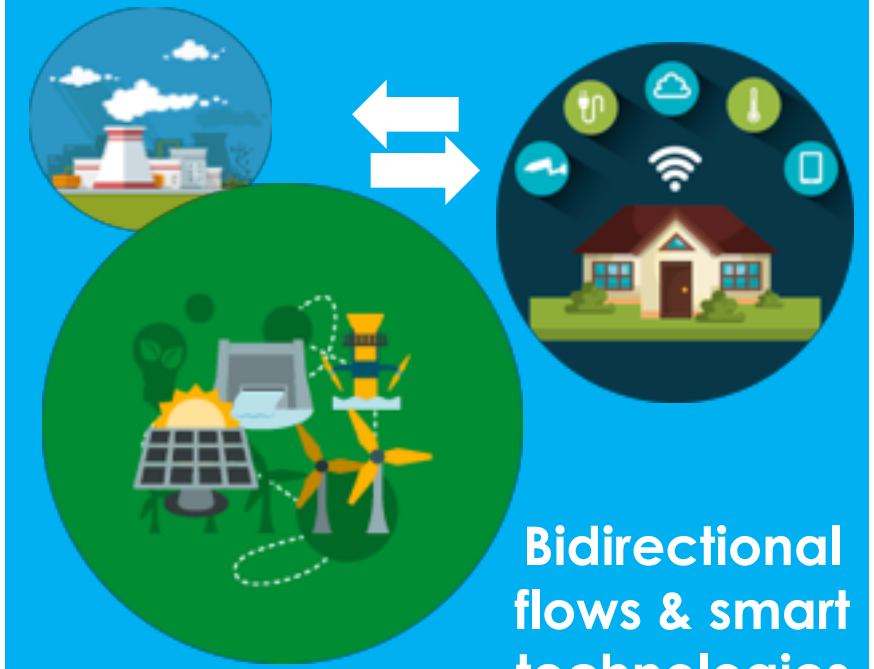
PAST

One-way power flows

Predictability

PRESENT

Variability & decentralisation



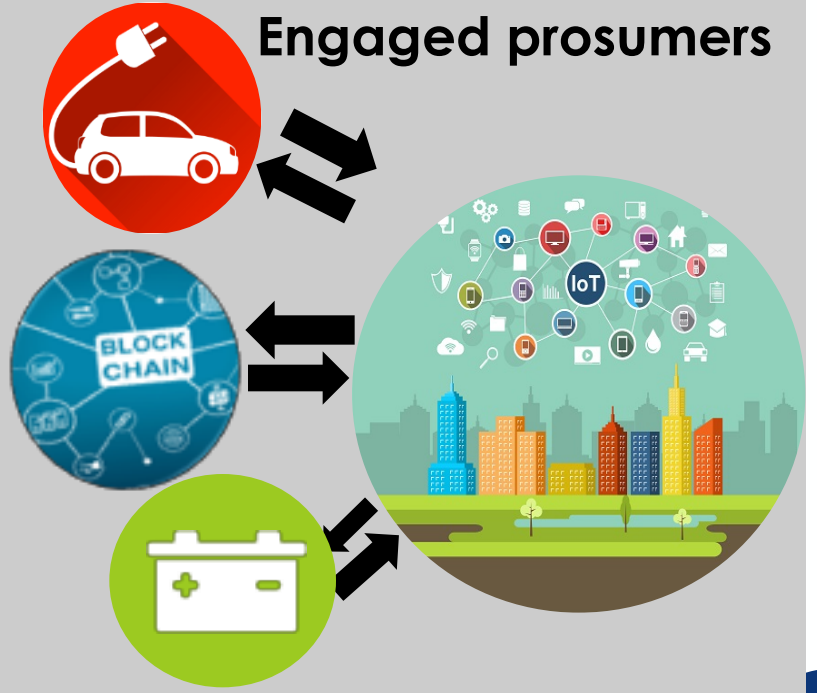
Bidirectional flows & smart technologies

FUTURE?

Smart, data-centric system

Electrification of transport

Engaged prosumers



Technology Disruption

Utilities are disrupted by four types of technology – and this disruption has a huge impact on markets and regulators

I. Energy Technology

Distributed Energy Resources

Solar PV

Storage

Wind

Fuel Cells

Microgrids

Electric Vehicles

Energy from Waste

II. Consumer Technology

Smart Appliances

Prosumer Enablement

Convergence of Industries

Energy Efficient Equipment (LED Lights)

Social Networks

Disruption

- New participants driving bottom up change enabled by new technology
- Setting affordable cost & service targets reflecting rise of microgrids
- Designing Regulatory models fit for the future, not based on the past

Automated Demand Response

Embedded Systems

Process Equipment

Smart Grid/Grid Digitization

Situational Awareness

IV. Grid / Operational Technology

Cognitive Computing

Blockchain

Big Data & Analytics

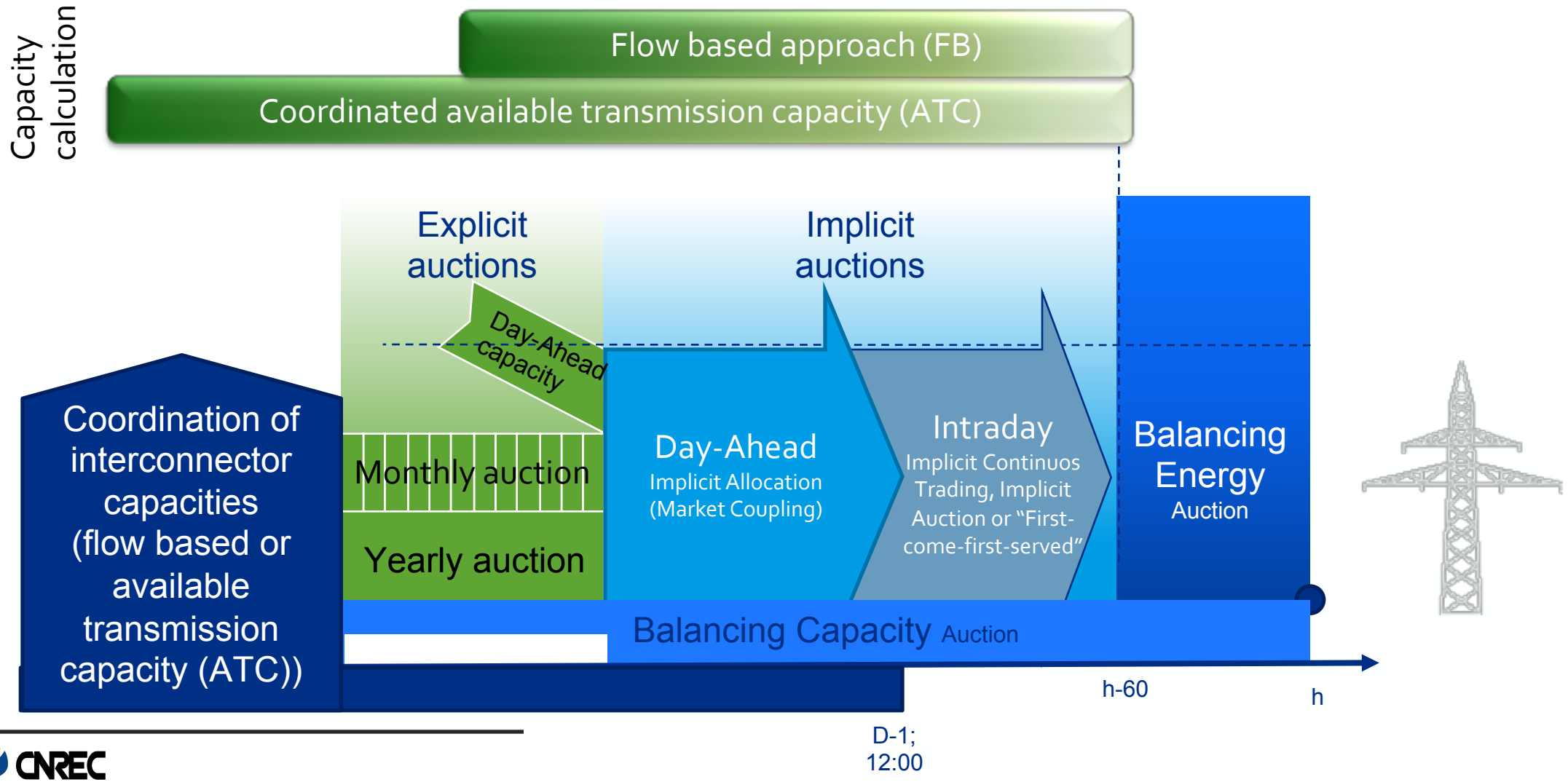
Internet of Things

Mobile

Cloud

III. Information Technology

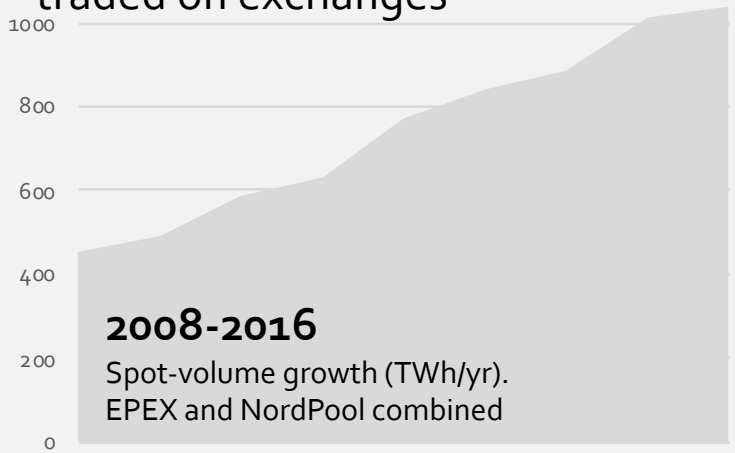
The European power market: the IEM Target Model



Benefits Case #1: Promote Wholesale Markets

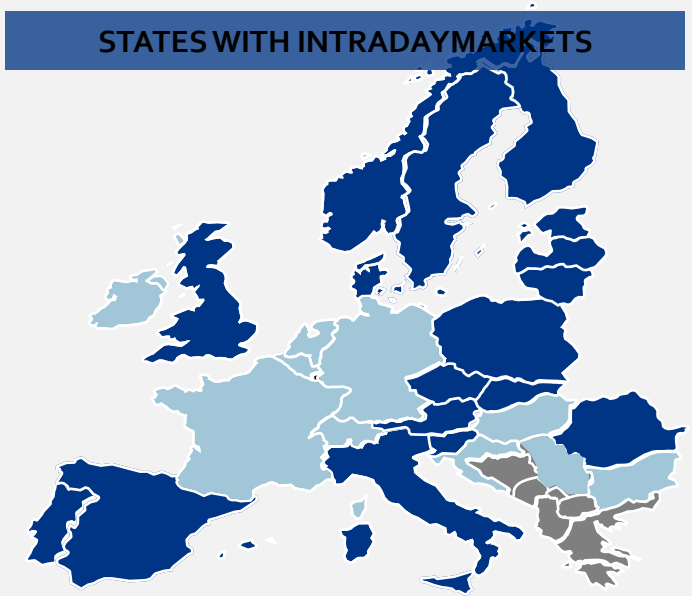
DAY-AHEAD MARKETS

- **1 B€** in social welfare
- **~100 M€/year** of benefits from flow-based in CWE
- **84%** efficient use of capacity given to the market
- **1500 TWh**(**~50%** of consumption) traded on exchanges



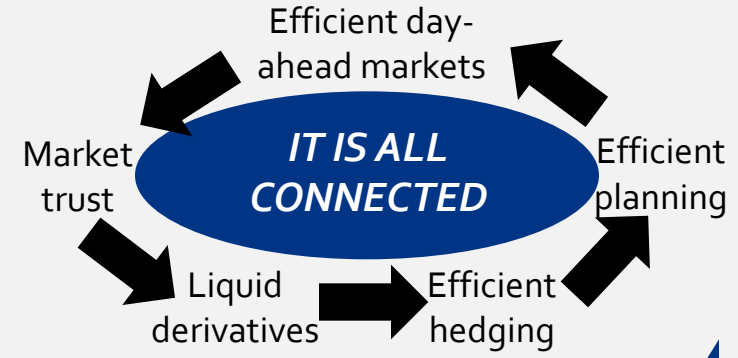
INTRADAY MARKETS

- **120 TWh** traded on main power exchanges in 2016
- **3,6%** average annual volume growth last 5 years



✓ **Continuous trading**
✓ **15 minutes auctions**

DERIVATIVES MARKETS



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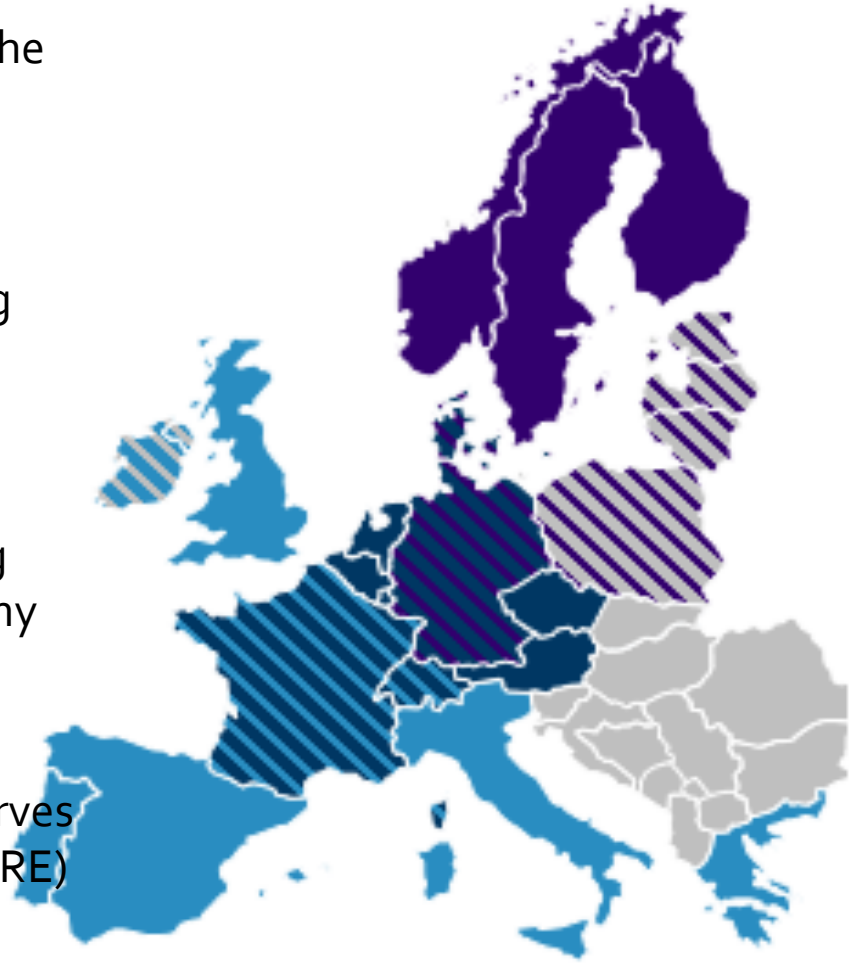
Benefits Case #2: Integrate Balancing Markets

Annual benefits:

~ 220 M€	Replacement reserves in the Nordics since 2003
~ 260 M€	Common reserves, netting and common merit order implemented across TSO-areas in Germany
~ 80 M€	Pilot on imbalance netting within and around Germany (IGCC)
~ 120 M€	Pilot on replacement reserves across the Continent (TERRE)



Theoretical benefits of full integration of balancing markets

Up to 3 Bn€

POWER SECTOR RESPONSE

eurelectric
ELECTRICITY FOR EUROPE

VISION FOR THE EUROPEAN ELECTRICITY INDUSTRY

- the sector association representing the common interests of the electricity industry at pan-European level
- represents 3,500 companies in Europe with an aggregate turnover of €200 bln

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In light of the Paris Agreement and the urgency to address climate change, air pollution and depletion of natural resources;

In the midst of a deep transformation driven by technology, digitalisation and more active European customers;

In recognition of the importance of cost-efficiency and the need to deliver secure and affordable energy while modernising our infrastructure;

WE, THE EUROPEAN ELECTRICITY INDUSTRY, COMMIT

to playing a key role to enable and sustain:

- A vibrant, competitive European economy, reliably powered by clean, carbon-neutral energy
- A smart, energy efficient and truly sustainable society for all citizens of Europe

WE BELIEVE THAT ELECTRICITY IS THE KEY

- **To customer value.** More than a century after the introduction of electric light bulbs and motors, the potential of electricity continues to grow. Electricity has already brought us light, appliances, telecommunications, computers and many other tools that have enabled and improved modern living. It will soon deliver enhanced user experience through new digital energy services, enable zero-emission mobility and living comfort, and resource-efficient industrial processes;

- **To competitiveness.** The combination of integrated and well-functioning energy markets, fully optimised industrial value chains and decreasing exposure to volatility of commodities will make electricity the preferred option to power the economy and sharpen Europe's competitive edge;

- **To energy security.** After decades of dependence on fossil fuels in the power, transport and industrial sectors, domestically produced clean electricity will improve our balance-of-trade and reduce dependence on fuel imports from outside the EU.This is a much-needed shift from a resource-based to a European technology-based economy;

- **To social and environmental sustainability.** Switching to electricity will bring immediate and tangible improvements for cities, communities and rural areas in the form of cleaner air and better health. Electricity is already the most versatile climate-friendly energy carrier today.

WE WILL LEAD THE COST-EFFECTIVE ENERGY TRANSITION

which we see as a unique opportunity. In particular, we will:

- **INVEST** in clean power generation and transition-enabling solutions, to reduce emissions and actively pursue efforts to become carbon-neutral well before mid-century, taking into account different starting points and commercial availability of key transition technologies;
- **TRANSFORM** the energy system to make it more responsive, resilient and efficient. This includes increased use of renewable energy, digitalisation, demand side response and reinforcement of grids so they can function as platforms and enablers for customers, cities and communities;
- **ACCELERATE** the energy transition in other economic sectors by offering competitive electricity as a transformation tool for transport, heating and industry;
- **EMBED** sustainability in all parts of our value chain and take measures to support the transformation of existing assets towards a zero carbon society;
- **INNOVATE** to discover the cutting-edge business models and develop the breakthrough technologies that are indispensable to allow our industry to lead this transition.

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WE CALL UPON POLICYMAKERS AND STAKEHOLDERS

- **To recognise** the key role of increasingly clean and climate-friendly electricity in achieving Europe's climate and energy commitments under the Paris Agreement and actively support measures that accelerate the shift towards competitively priced electricity for European consumers;
- **To promote a cost-effective energy transition** supported by a strong carbon market that delivers a meaningful price and channel climate and energy financing towards transition-enabling technologies;
- **To accelerate electrification** through smart and better regulation, and promote the take-up of clean heating and cooling in residential and industrial buildings, clean electric mobility and more efficient industrial processes;
- **To promote the digitalisation** of the entire value chain. Make smart grids a reality so as to integrate centralised and decentralised technologies, promote customer participation in a secure, flexible and cost-effective manner;
- **To ensure a well-functioning, fully integrated power market** at the heart of the European energy system, giving the right signals to attract investments, boost innovation and reduce costs, while ensuring security of supply;
- **To support a fair transition,** by actively managing social and geographical impacts, ensuring a fair effort sharing and guarding data protection, privacy and freedom of choice for customers.

Ørsted

Creating a world that runs entirely on green energy

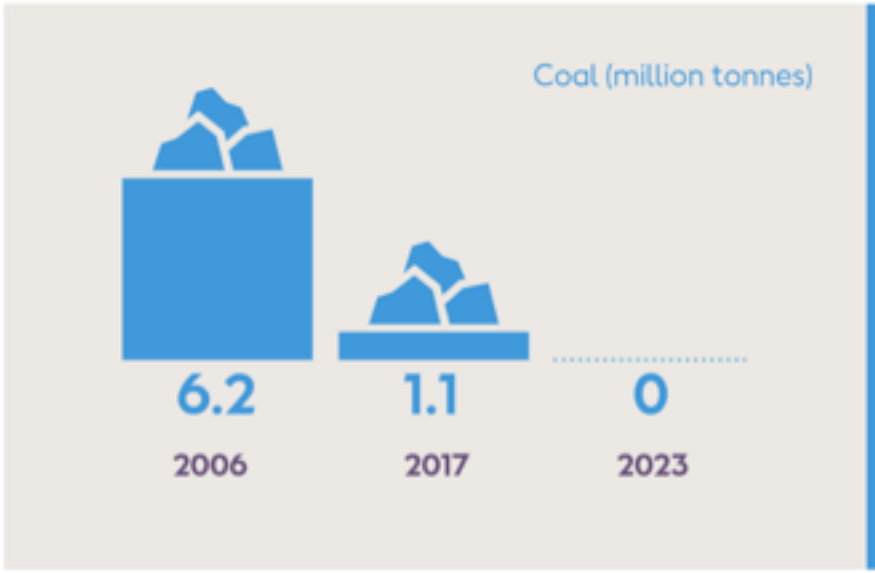
We believe that it is time to take real action to create a world that runs on green energy. Renewable energy holds the key to a cleaner future, and the planet needs to act now to reduce the effects of climate change.

Keeping the global temperature down

Since the Paris agreement took effect in 2016, the international community has begun a common path to address climate change, working towards keeping the global temperature rise below 2°C.

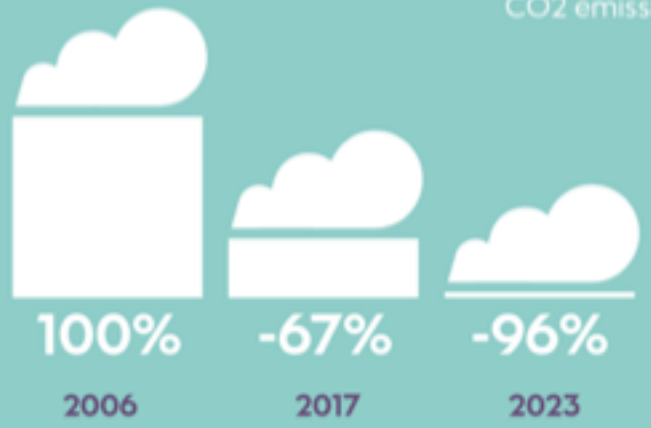
From black to green

Despite the positive progress being made, we believe that more can be done to reduce the effects of climate change. More than a third of global CO2 emissions come from power production. One third. This huge number is in part what made us completely rethink our business strategy a decade ago, causing us to initiate our transformation from a black to a green energy company.



We say goodbye to coal in 2023

...and saying goodbye to CO_2



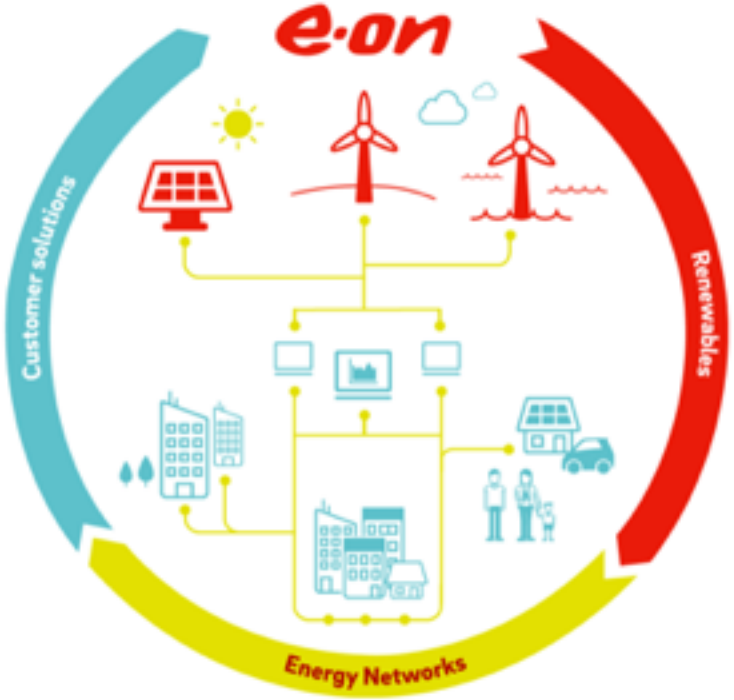
Enel's Strategic Plan 2019-2021: the renewable future

Published on Saturday, 24 November 2018

There's a new energy in the world. It's a renewable energy which consists of **digitalisation**, **technology** and **customer centricity** that makes the **creation of sustainable value** possible. And Enel is undoubtedly a leader when it comes to this new energy, which is no longer simply a product for generation and distribution, but a development facilitator. Not only that, Enel works to maintain this leadership on a daily basis, in every country where the Group has a presence.

Goals and business areas

Our portfolio comprises energy networks, renewable energy and individual customer solutions. With these three areas as our core competencies, we are well-positioned for the changes the future will bring.



Wrap-up

- The global energy framework has changed
  - Decarbonisation
  - Markets
  - Distributed generation and digitalisation
  - RE becomes competitive with fossil-fuel technologies
- The power industry is responding proactively to these changes
- Power market (and comprehensive grid planning) have big advantages for economy, security, integration of RE, environment

Key drivers for energy transition

Energy efficiency in the end-use sectors

Electrification as means to energy efficiency and fossil-fuel reduction

Actively push RE energy costs down through scale-up and innovative incentives

Create a level playing-field for RE by including external costs (carbon pricing) and remove subsidies for fossil fuels

Use power markets as the major tool for cost-efficient energy transformation

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Total Primary Energy Consumption

Fuel shares in the IEA SDS scenario in 2040

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Electricity production on fuels in the IEA SDS scenario in 2040

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