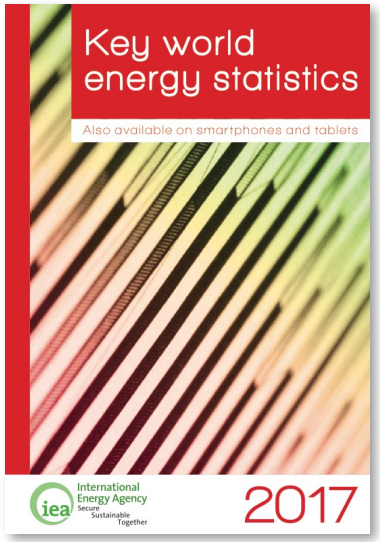
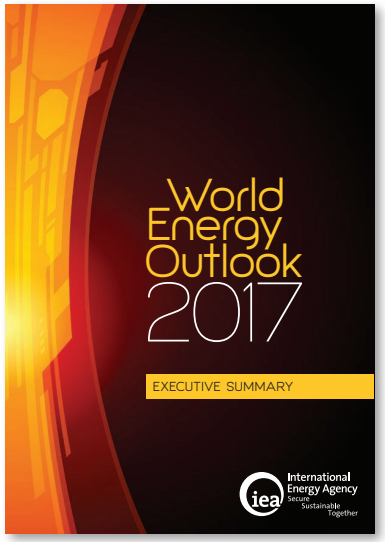
Energy: A Global Outlook

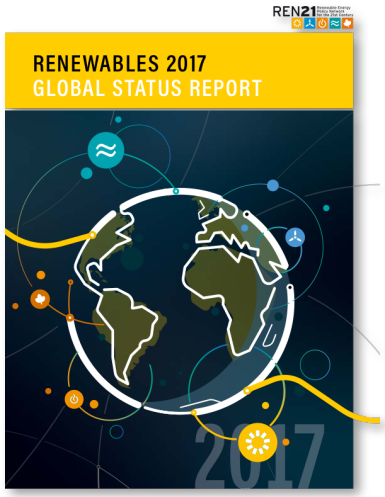
Laurent Dubus,
Expert Researcher, EDF R&D

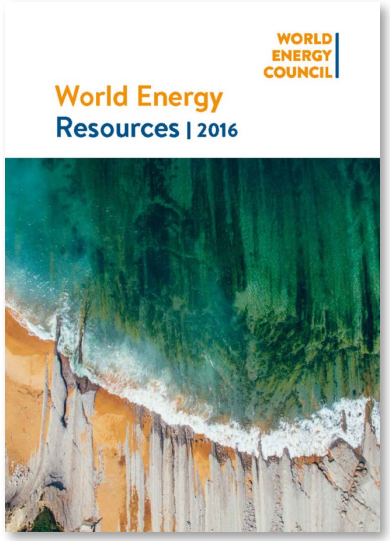
Many Information Sources

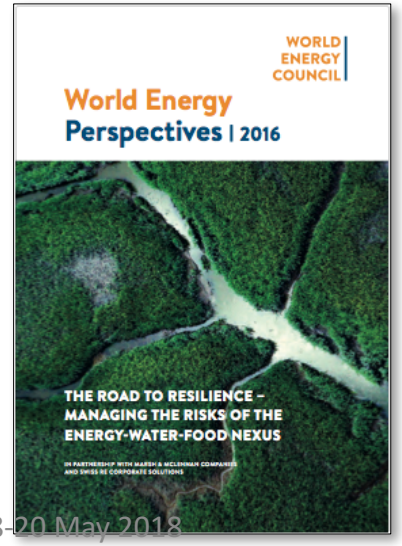
(click on images to access ressource)

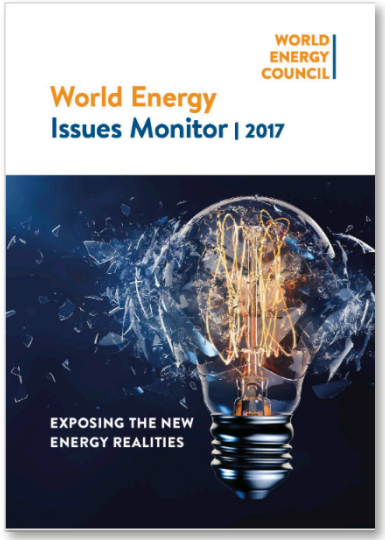












And many others …

WEMC
World Energy & Meteorology Council

Outline

1. **Some important aspects**
2. Global Energy Picture
3. Future scenarios
4. Challenges & Priorities

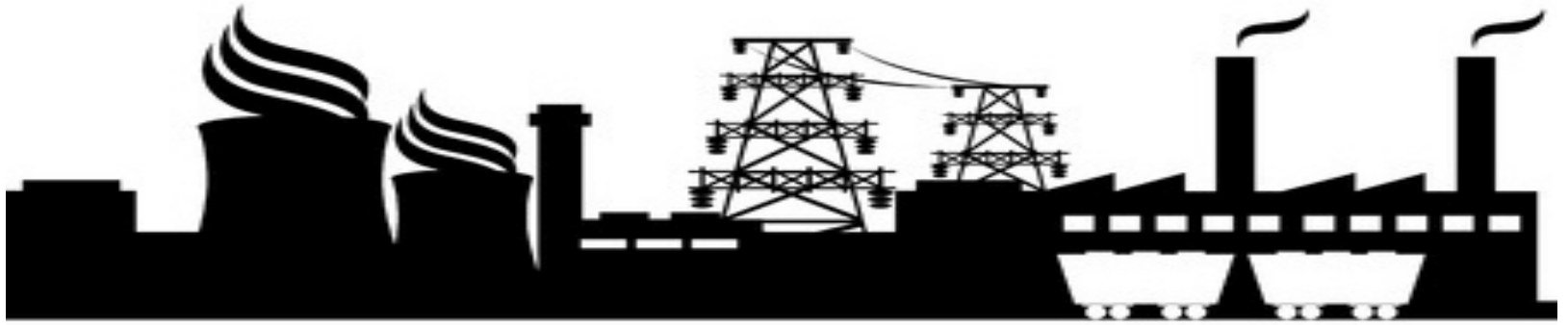
Energy is Key for Society

« Energy is the golden thread that connects economic growth, increased social equity and an environment that allows the world to thrive. Energy enables and empowers. Touching on so many aspects of life, from job creation to economic development, from security concerns to the empowerment of women, energy lies at the heart of all countries' core interests. »

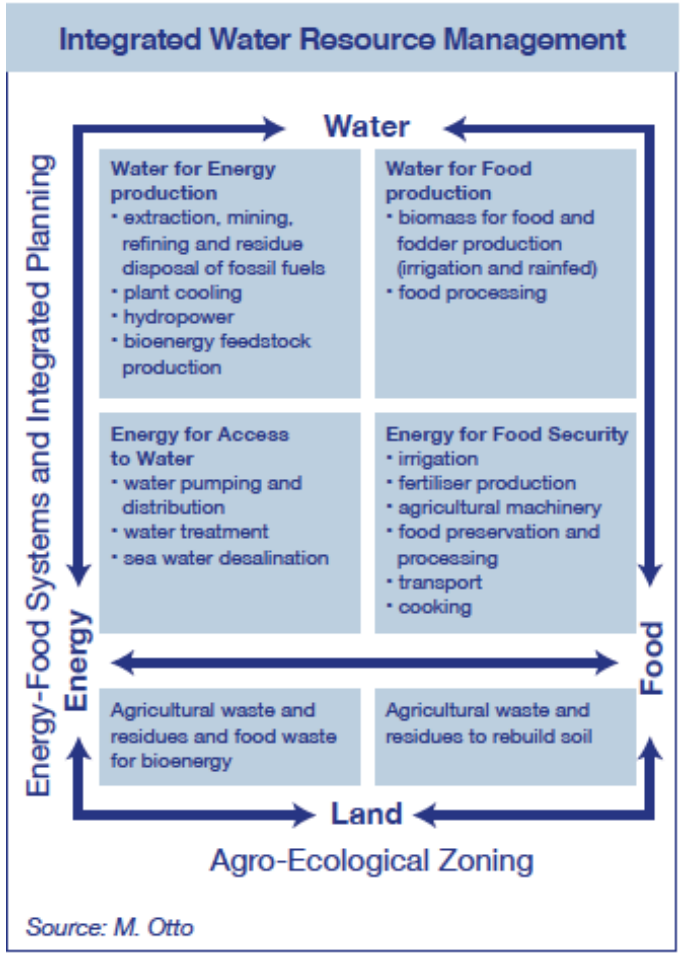
SE4ALL Annual Report, 2014

Peculiarities of Energy Systems

- **Capital intensive with long life cycles (~20-100 years)**
- **Diversity of sources – each with different emissions, efficiency, reliability, technical characteristics, costs, etc.**
- **National (fragmented) energy markets, sometimes compounded by security issues**



Cross-Sectoral Aspects



Quick facts on the interconnections between water, energy and climate change

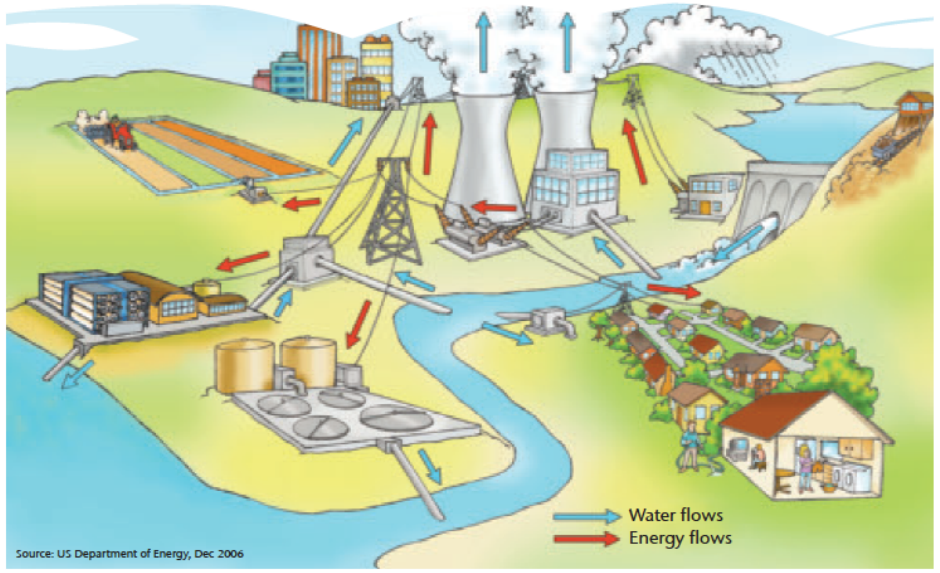
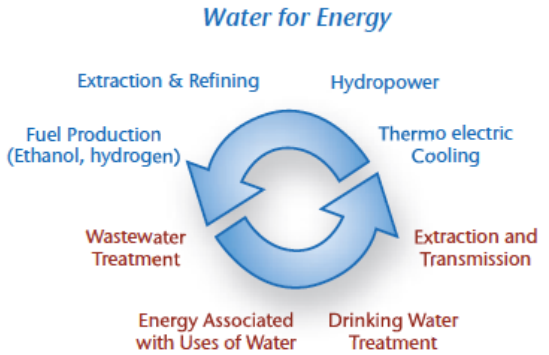


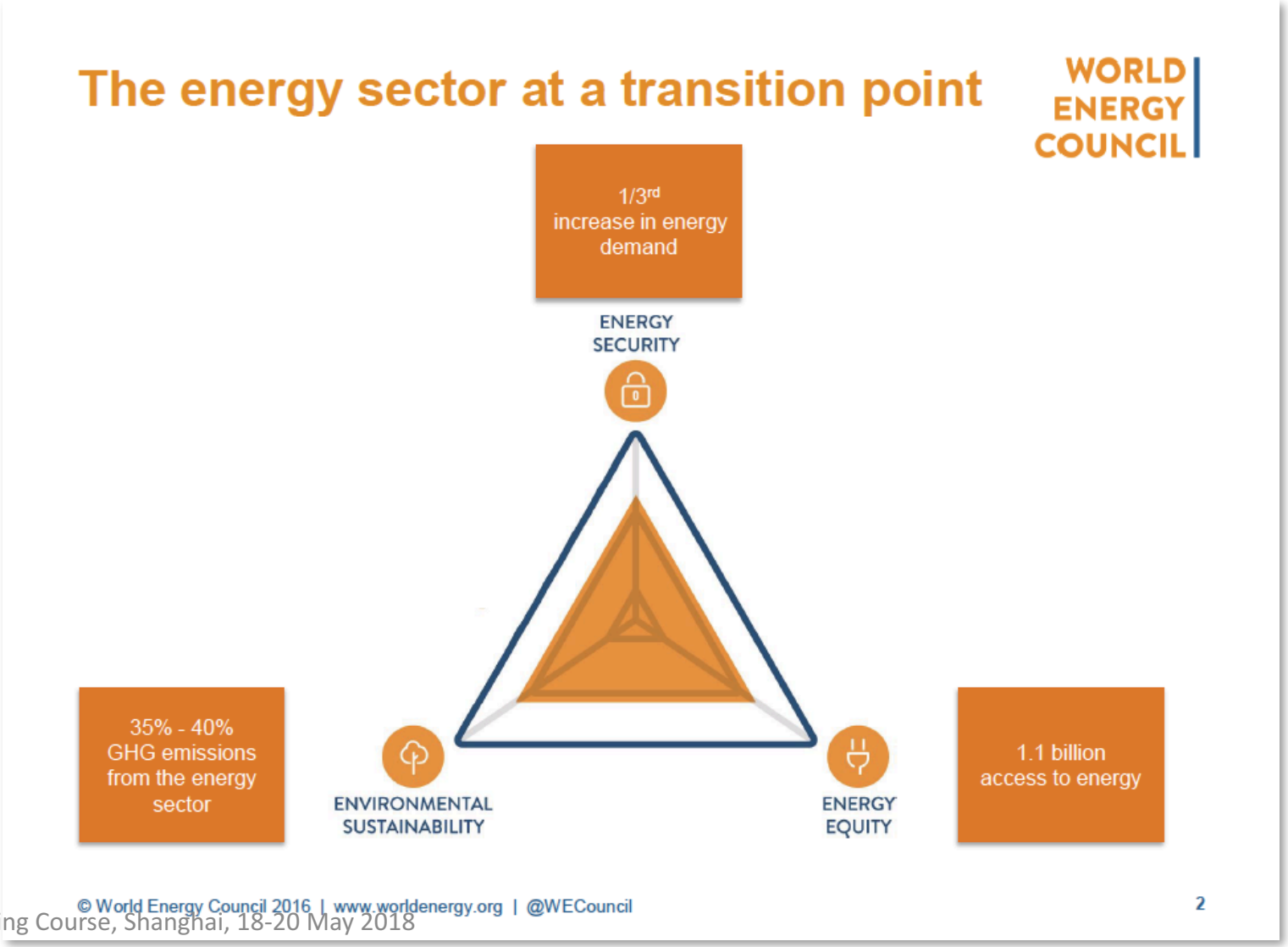
Figure 3: Examples of interrelationships between water and energy[7]



Source: Paul Reiter / International Water Association

Figure 4: Water for energy, energy for water

The Energy Trilemna (WEC)



Source: WEC

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Outline

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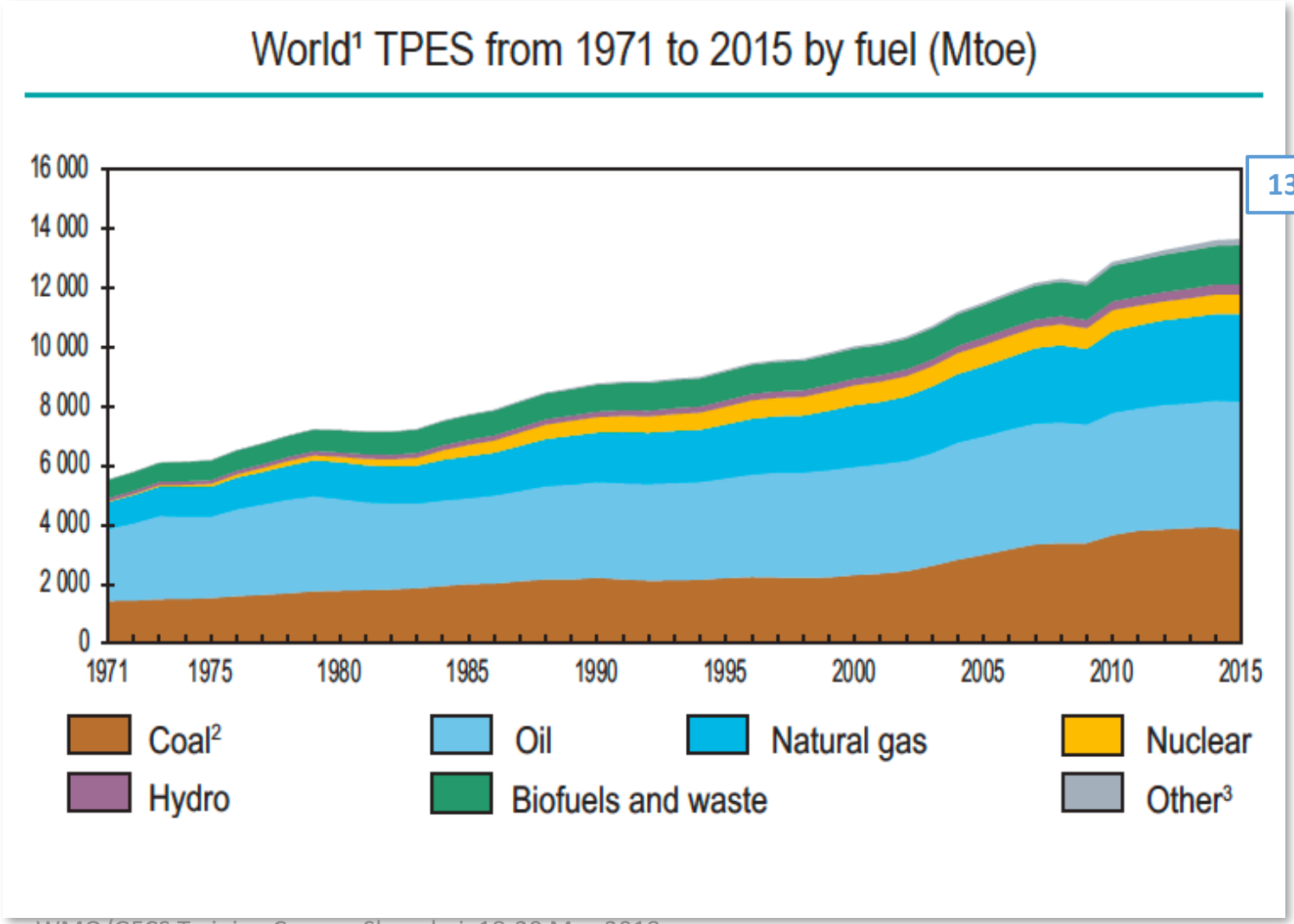
Total Primary Energy Supply



5 900 Mtoe

13 647 Mtoe

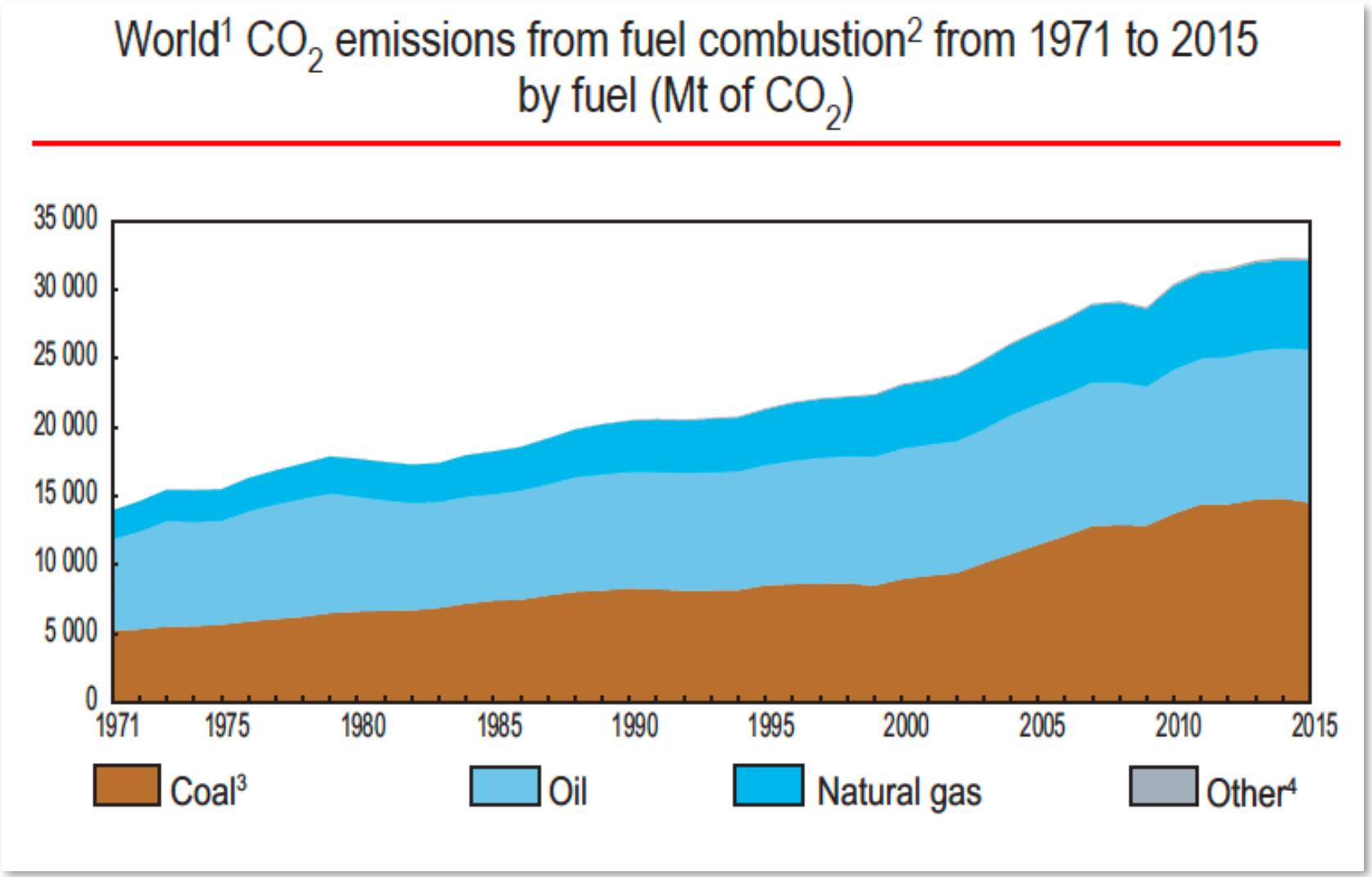
~ 80 % from Fossil Fuels

X 2 in 30 years

Stronger rate in BRICS

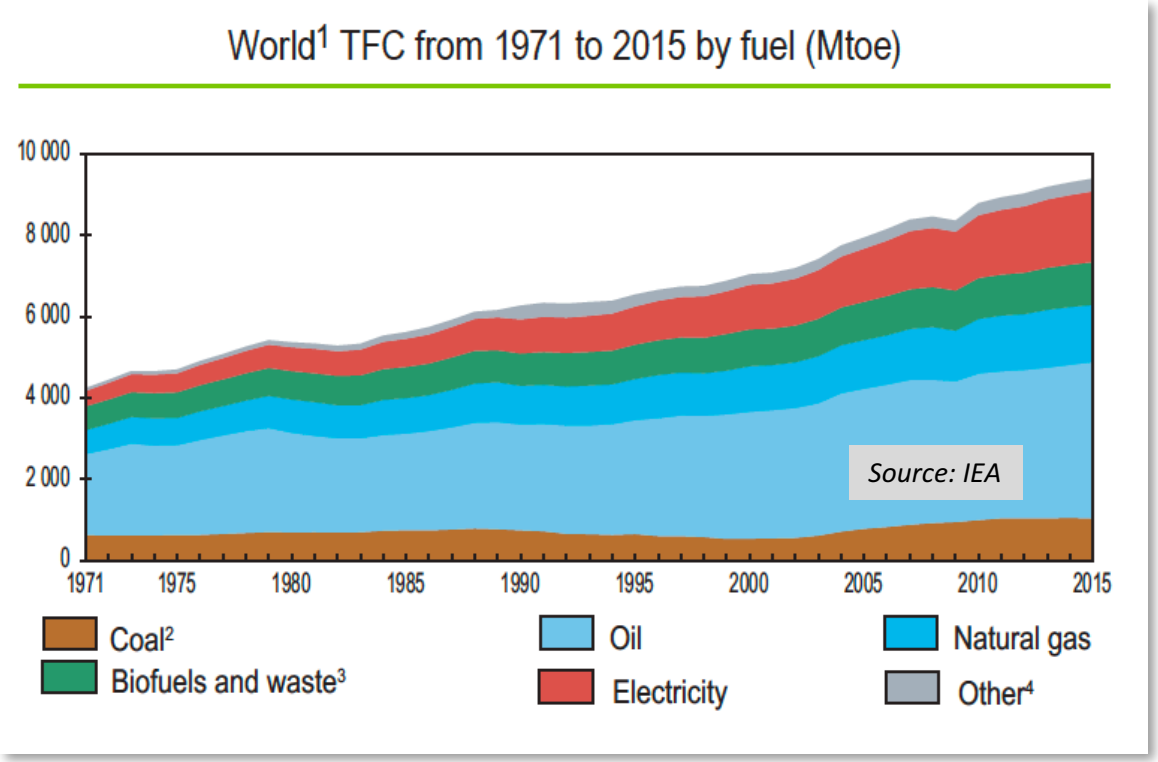
Source: IEA

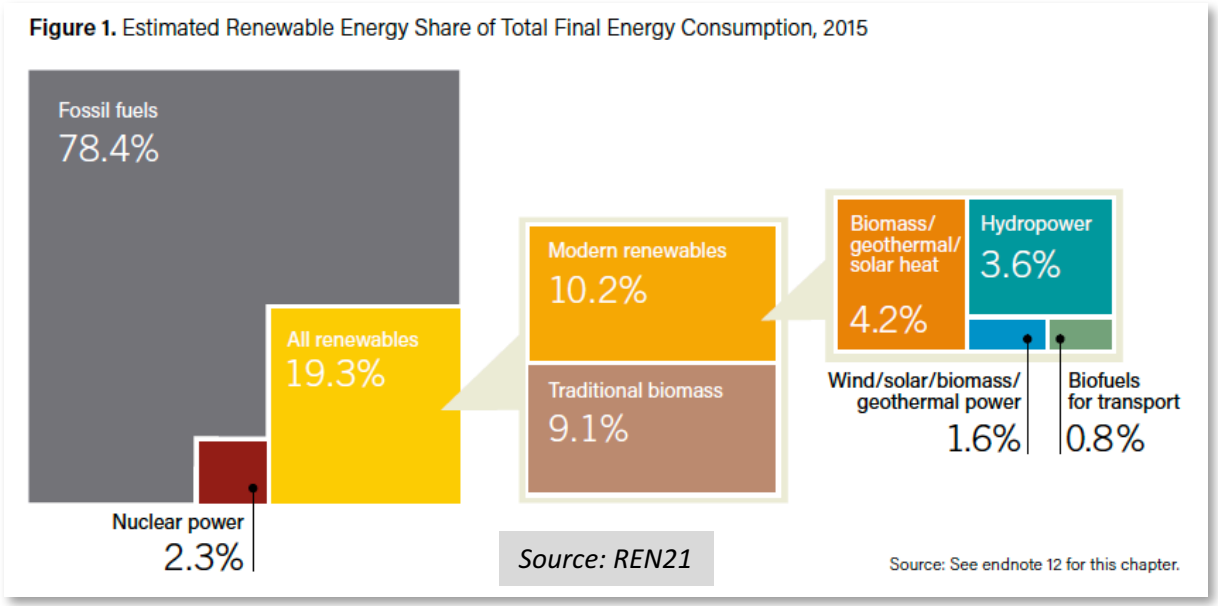
CO_2 Emissions



Source: IEA

Total Final Energy Consumption

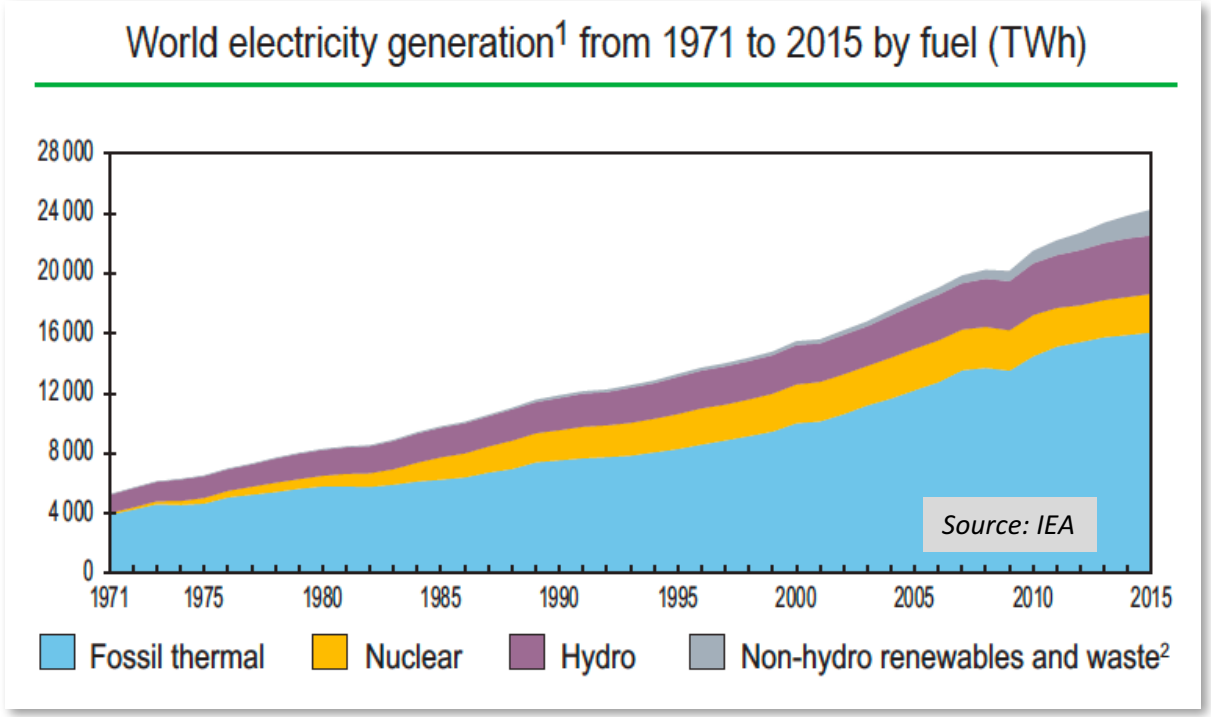


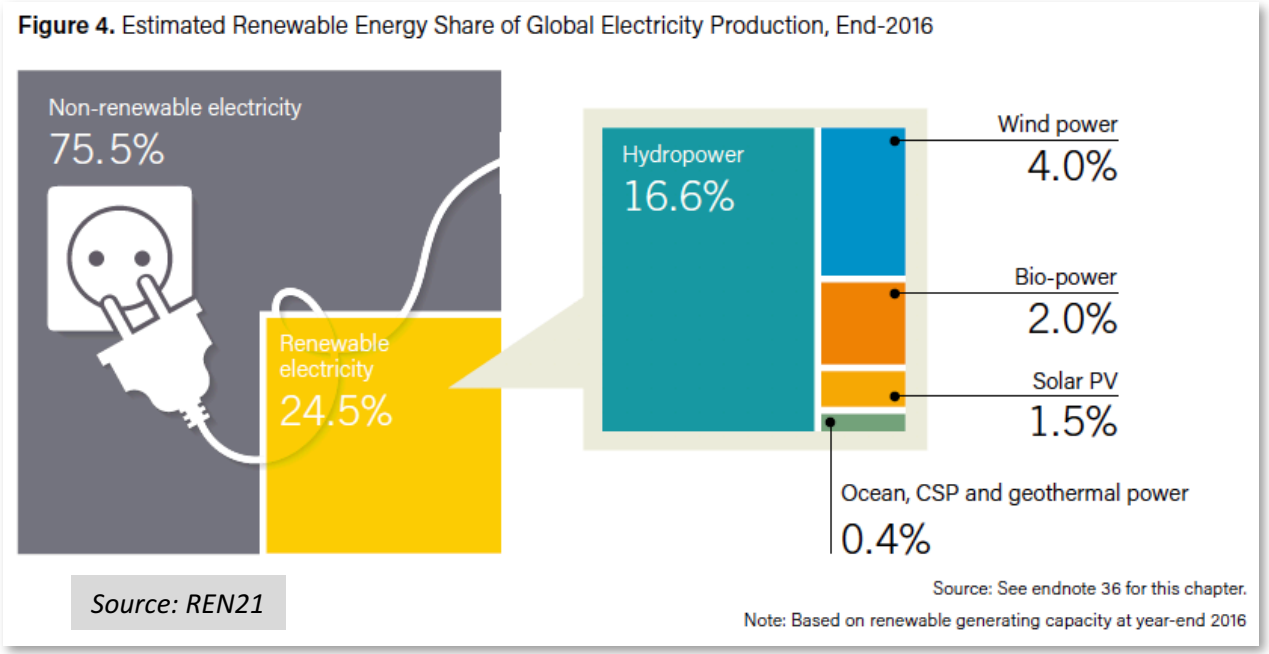


Fossil Fuels still dominate

Electricity rising

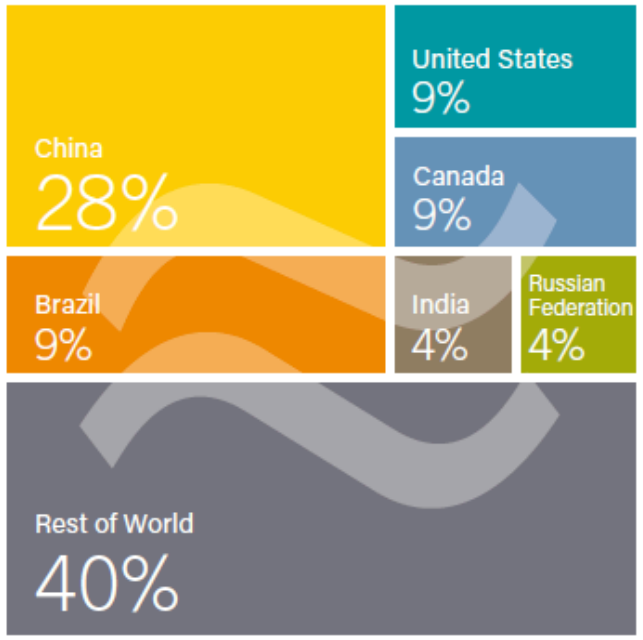
Electricity Generation





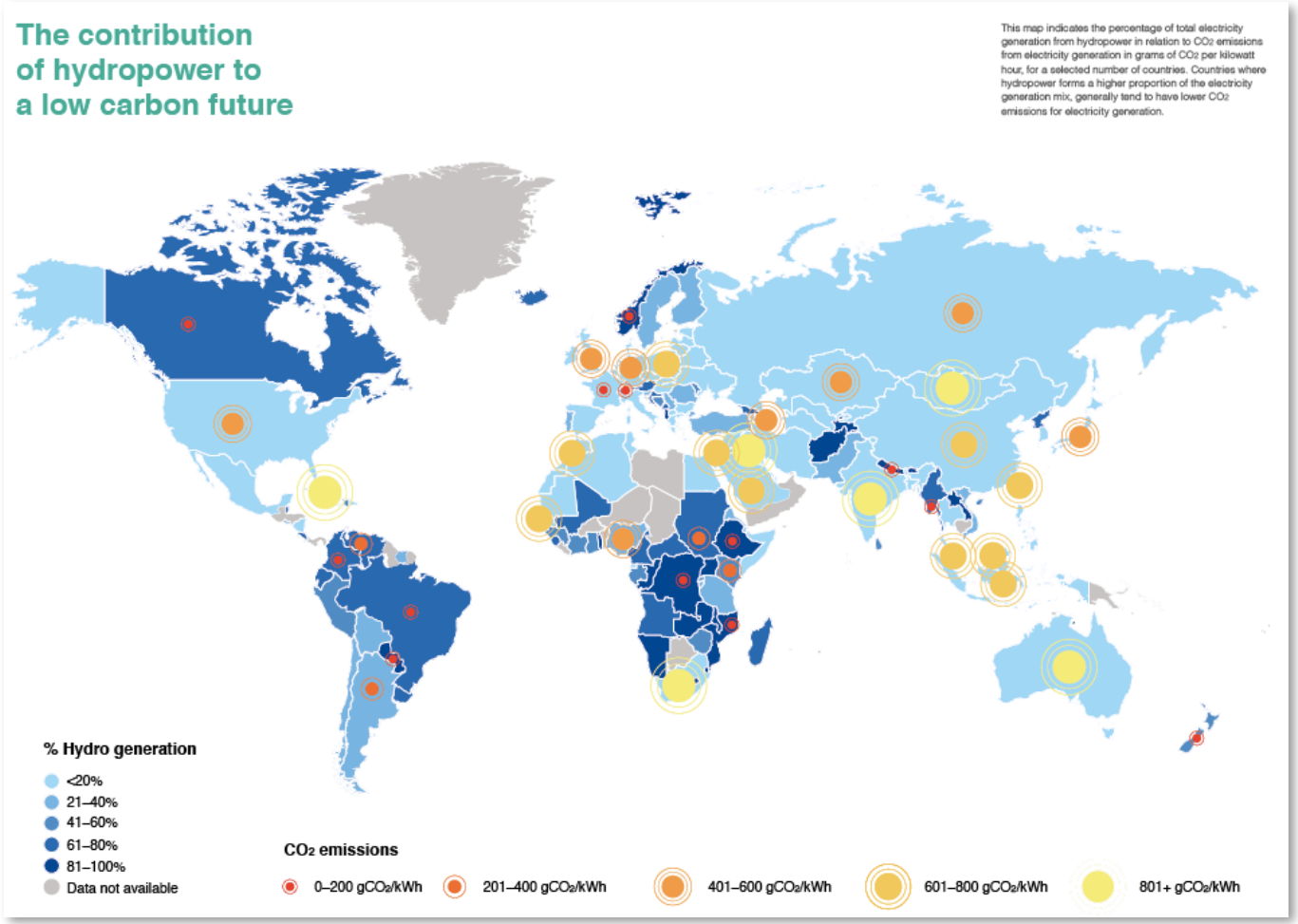
Hydropower

Figure 13. Hydropower Global Capacity, Shares of Top 6 Countries and Rest of World, 2016

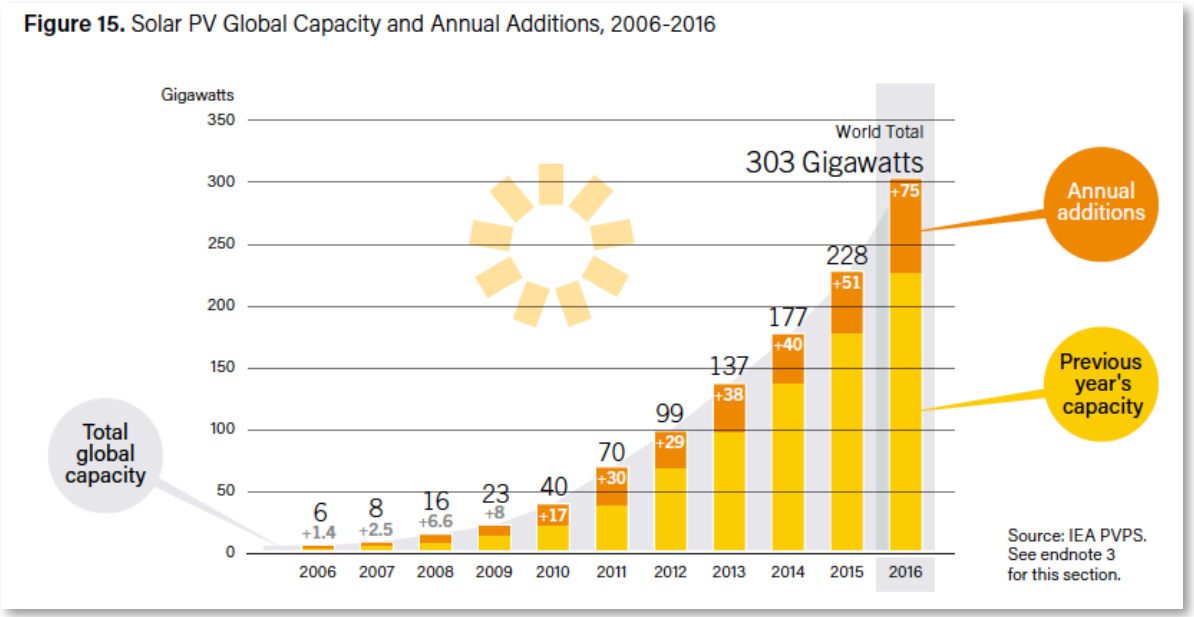


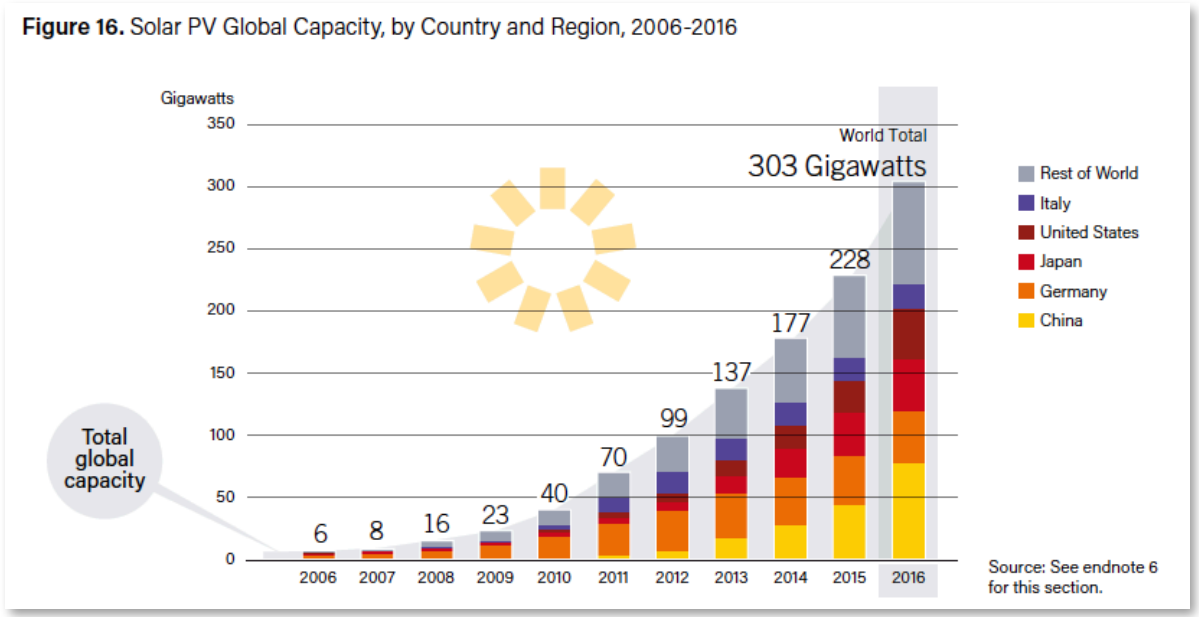
Source: See endnote 2 for this section.

Source: REN21



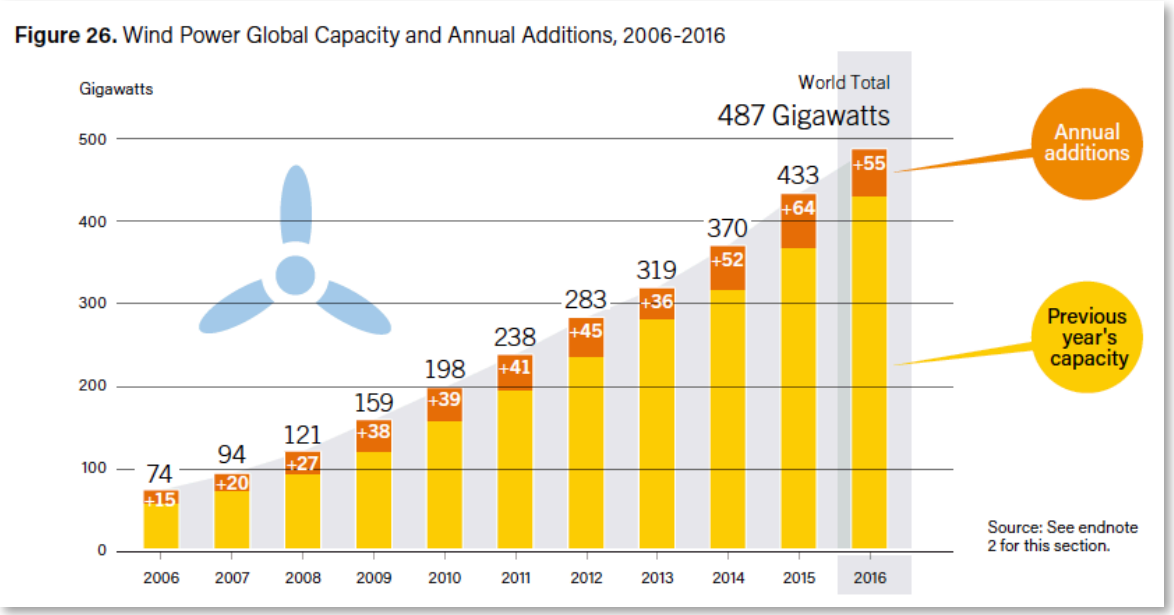
Solar PV Power

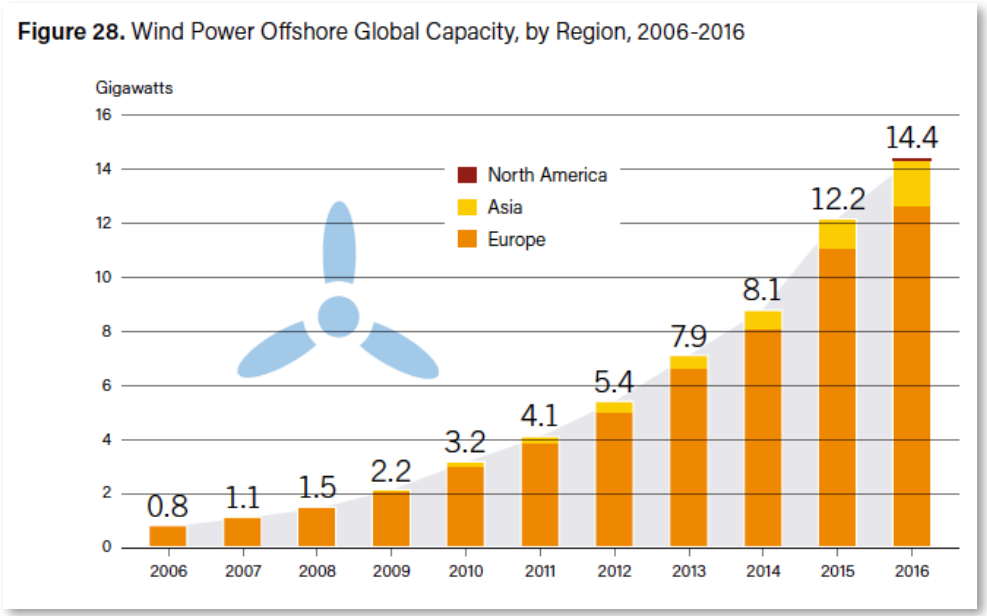




Source: REN21

Wind Power



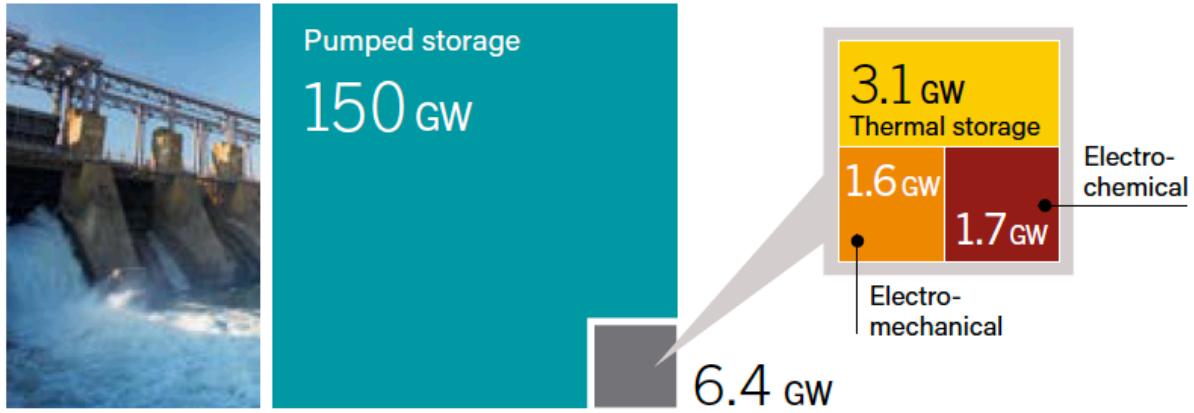


« Wind has become the LEAST-COST option for new power generating capacity in an increasing number of markets »

Source: REN21

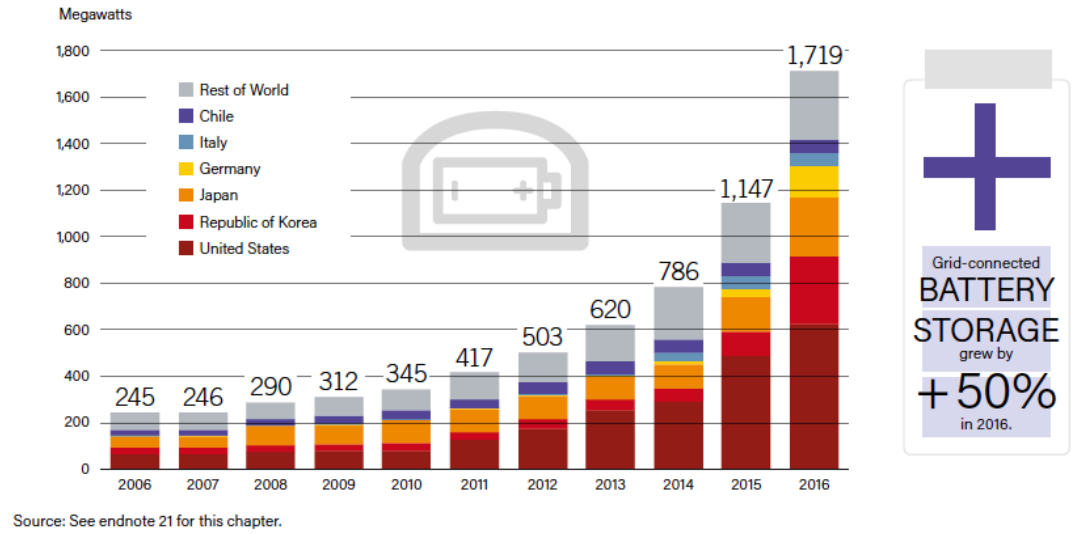
Storage Capacity is inscreasing

Figure 50. Global Grid-Connected Energy Storage Capacity, by Technology, 2016



Source: See endnote 13 for this chapter.

Figure 51. Global Grid-Connected Stationary Battery Storage Capacity, by Country, 2006-2016

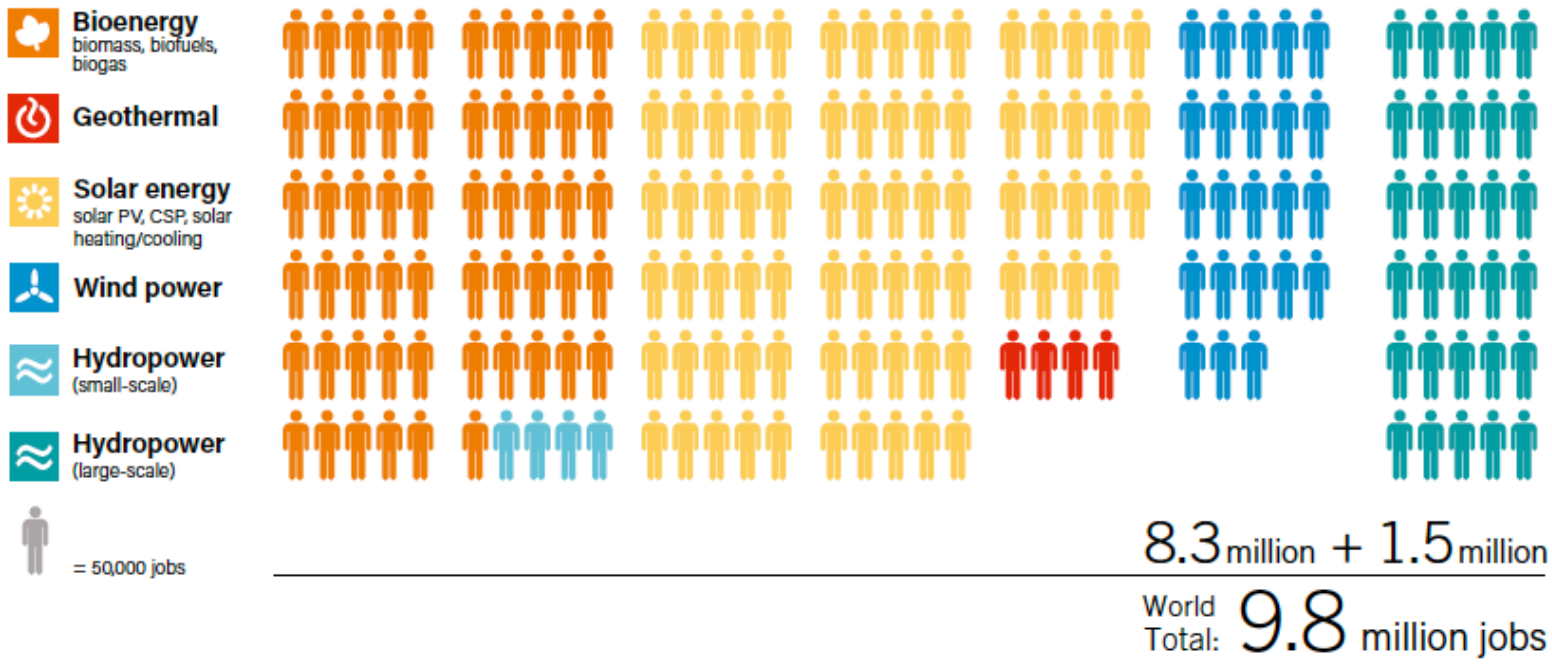


Source: See endnote 21 for this chapter.

Source: REN21

Jobs in RE

Figure 6. Jobs in Renewable Energy



Source: REN21

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Outline

1. Some important aspects
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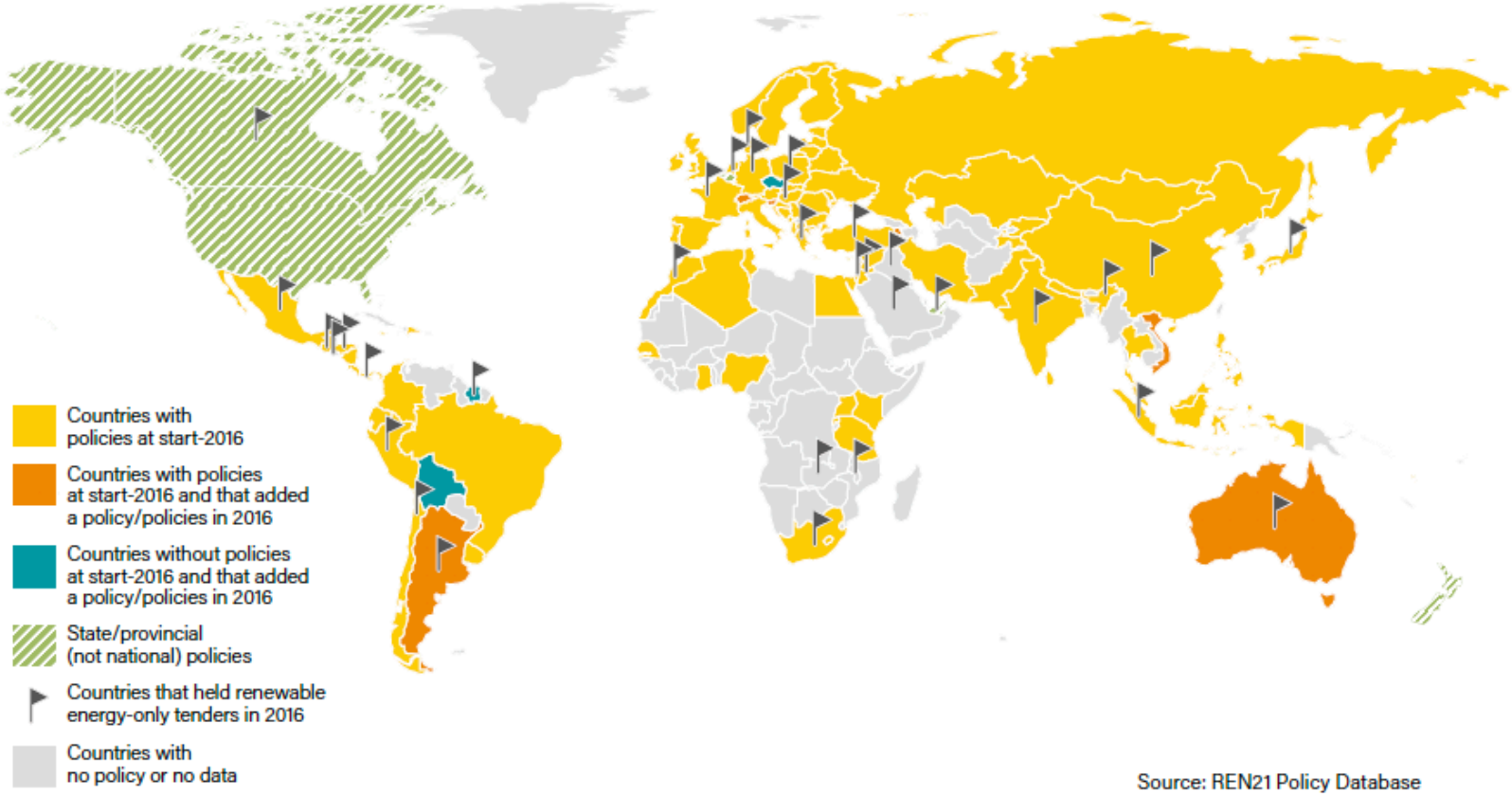
Renewables (almost) everywhere

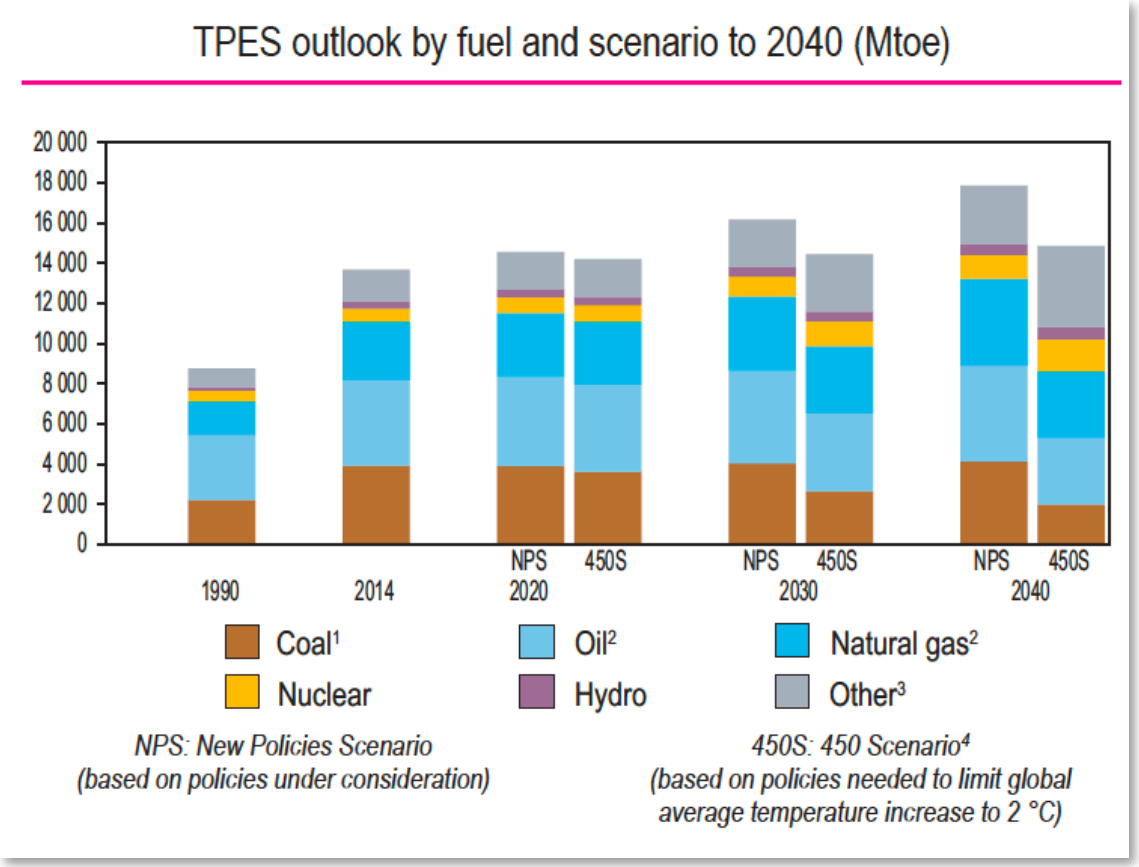
Figure 46. Countries with Renewable Energy Power Policies, by Type, 2016

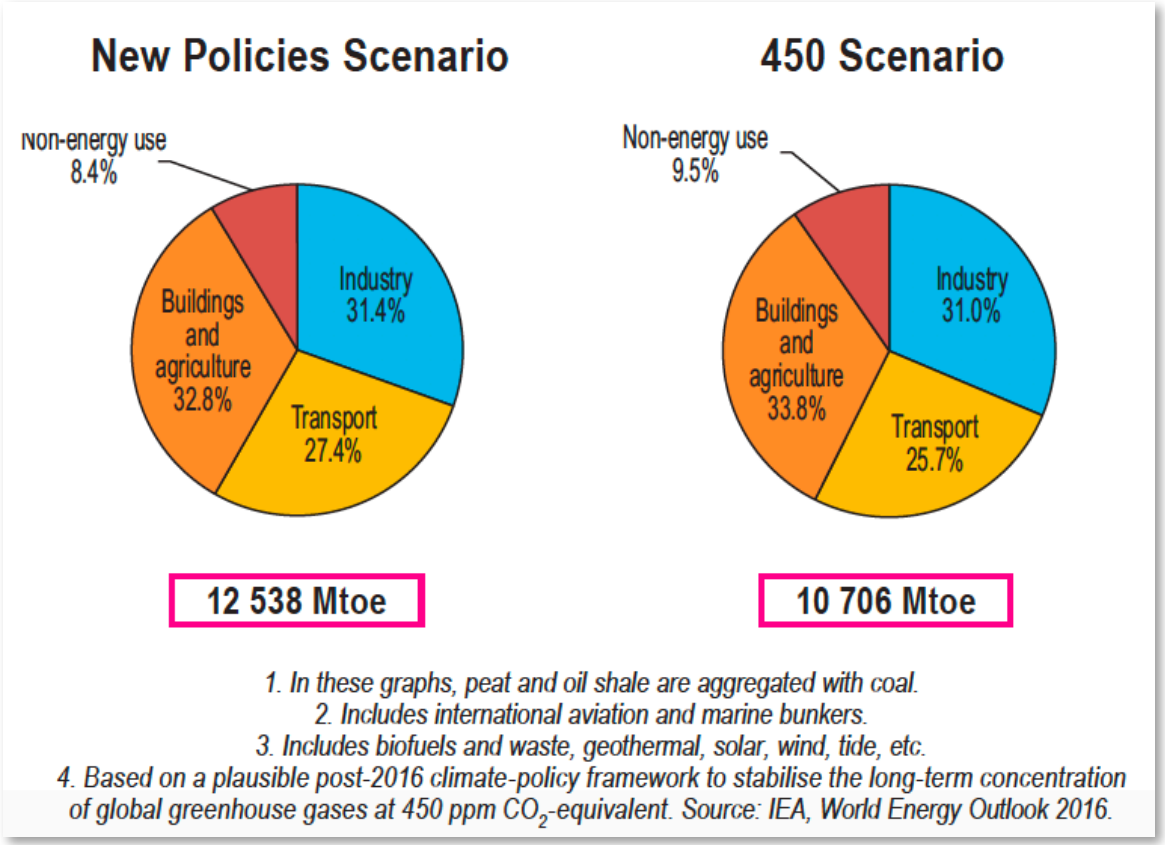


Note: Figure shows countries with Renewable Portfolio Standards, feed-in tariffs/premium payments and net metering policies. Countries are considered to have policies when at least one national-level policy is in place; these countries may have state/provincial-level policies in place as well. Diagonal lines indicate that countries have no policies in place at the national level but have at least one policy at the state/provincial level.

Source: REN21

IEA Scenarios





Source: IEA

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Tipping the energy world off its axis

World Energy Outlook 2017

- Four large-scale upheavals in global energy set the scene for the new *Outlook*:
  - The United States is turning into the undisputed global leader for oil & gas
  - Solar PV is on track to be the cheapest source of new electricity in many countries
  - China's new drive to "make the skies blue again" is recasting its role in energy
  - The future is electrifying, spurred by cooling, electric vehicles & digitalisation
- These changes brighten the prospects for affordable, sustainable energy & require a reappraisal of approaches to energy security
- There are many possible pathways ahead & many potential pitfalls if governments or industry misread the signs of change

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India takes the lead, as China energy growth slows

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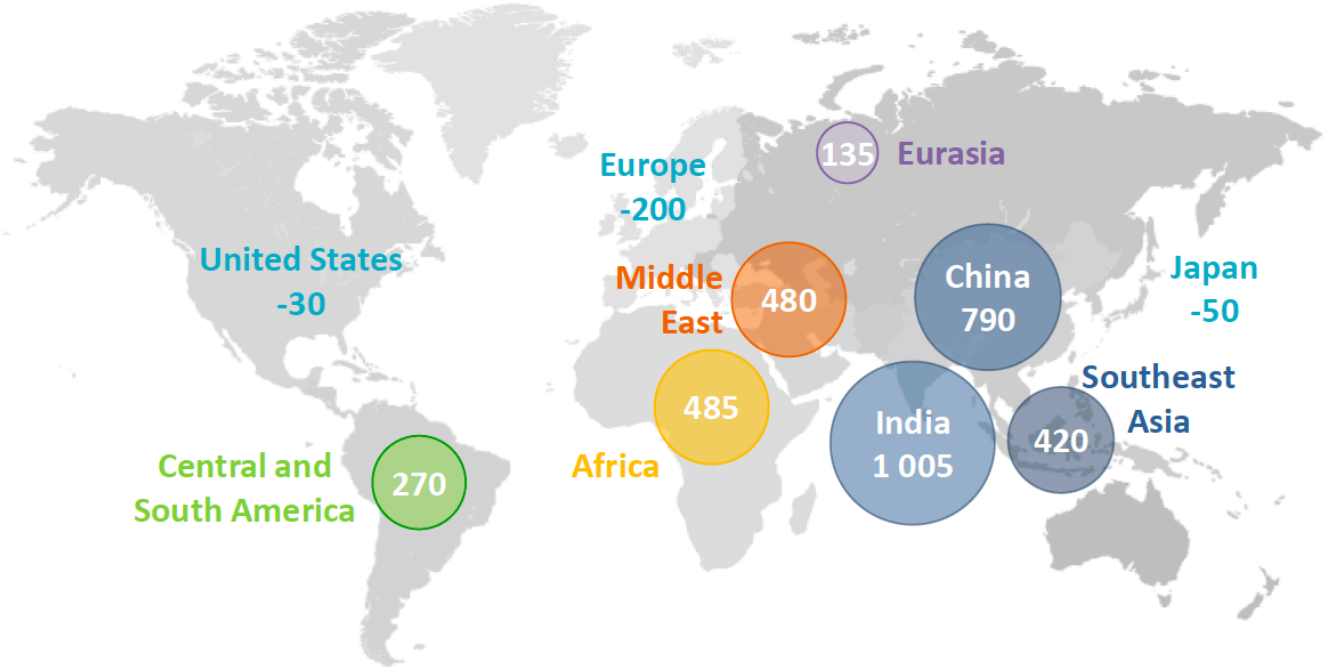
Change in energy demand, 2016-40 (Mtoe)



Old ways of understanding the world of energy are losing value as countries change roles: the Middle East is fast becoming a major energy consumer & the United States a major exporter

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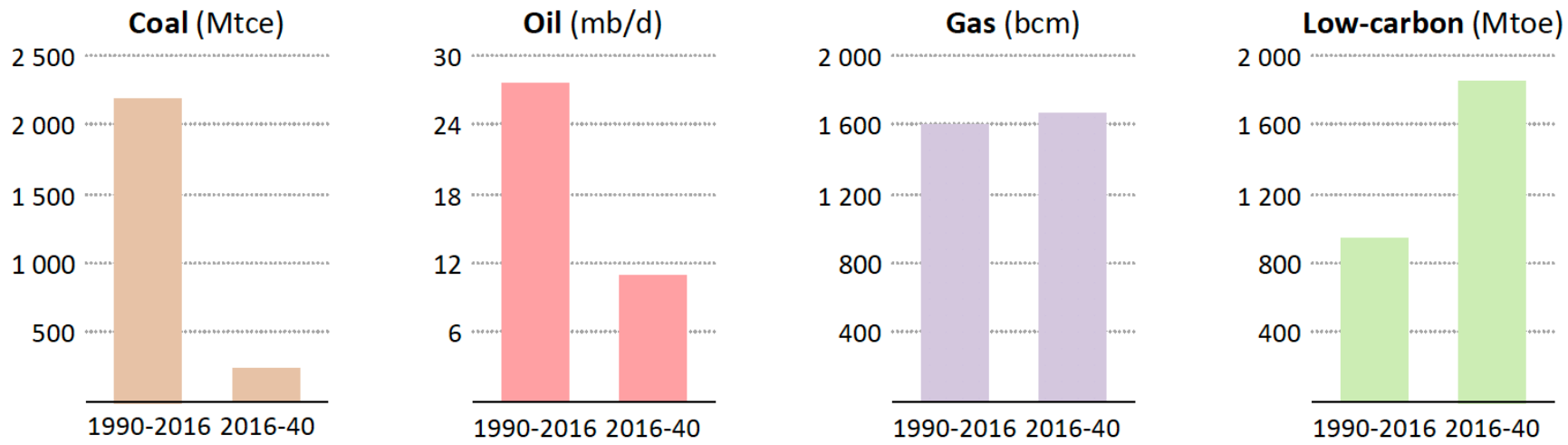
A world in motion..

World Energy Outlook 2017

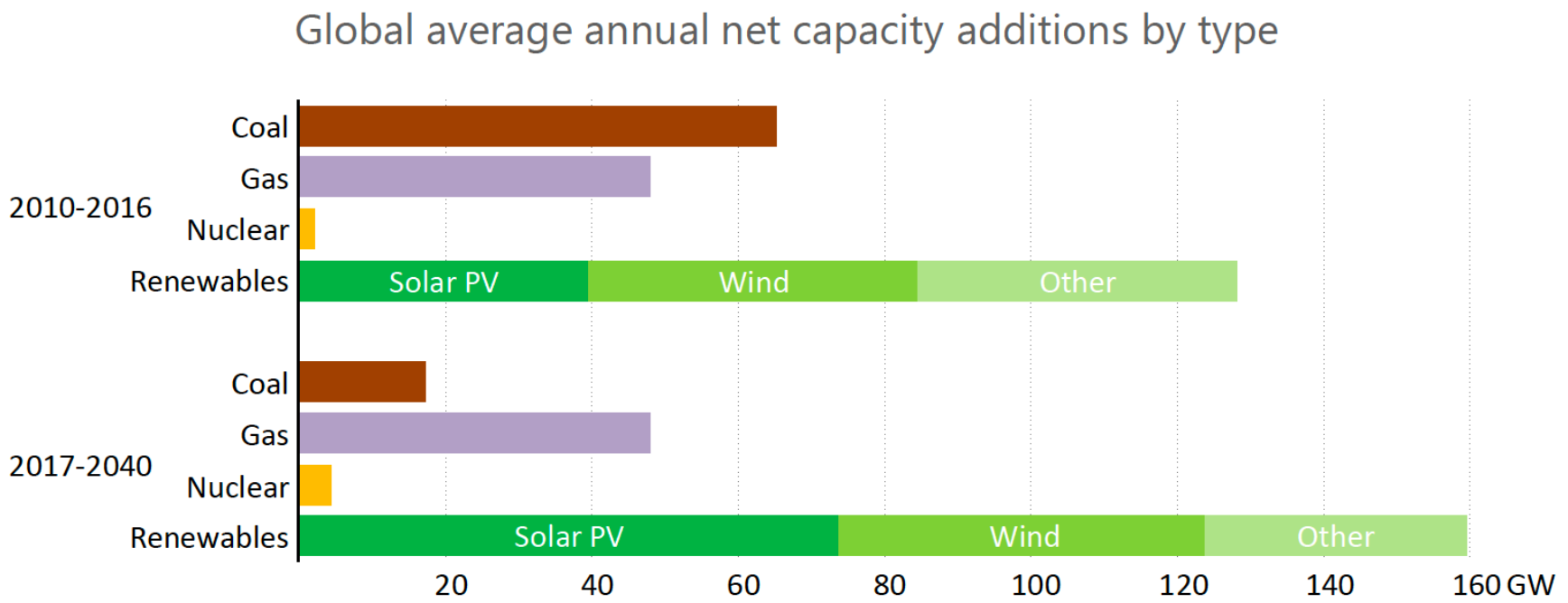
Change in world energy demand by fuel



Low-carbon sources & natural gas meet 85% of the increase in global demand:

Solar PV forges ahead in the global power mix

World Energy Outlook 2017



China, India & the US lead the charge for solar PV, while Europe is a frontrunner for onshore & offshore wind: rising shares of solar & wind require more flexibility to match power demand & supply

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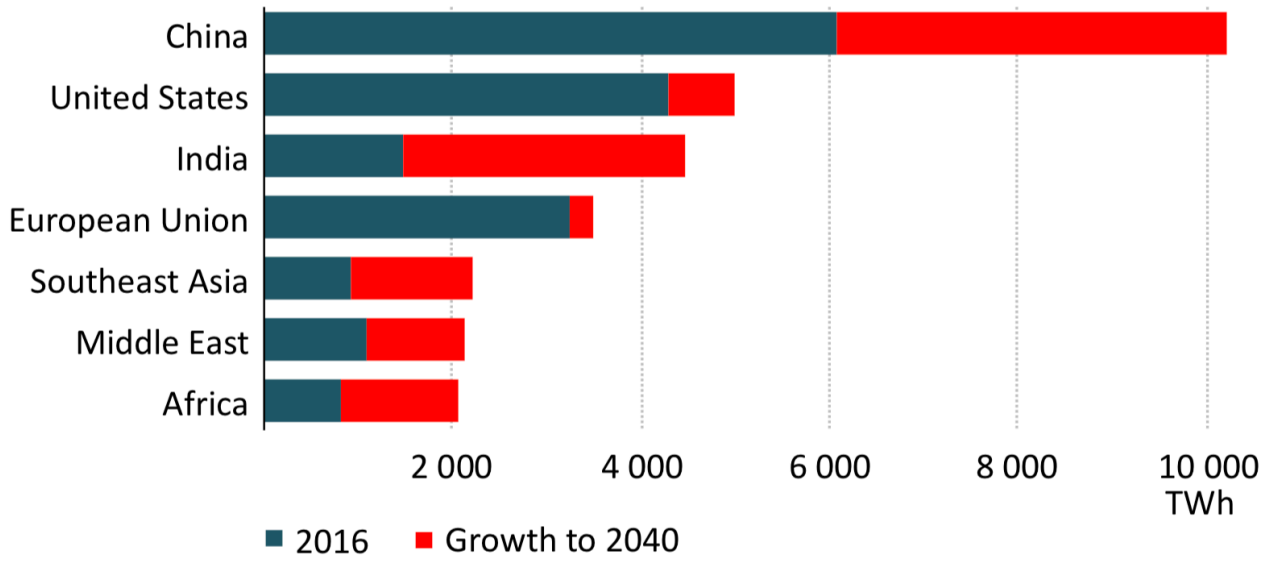
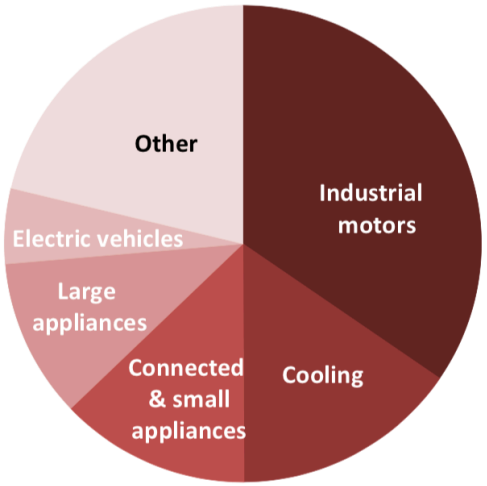
The future is electrifying

World Energy Outlook 2017

Electricity generation by selected region



Sources of global electricity demand growth



India adds the equivalent of today's European Union to its electricity generation by 2040, while China adds the equivalent of today's United States

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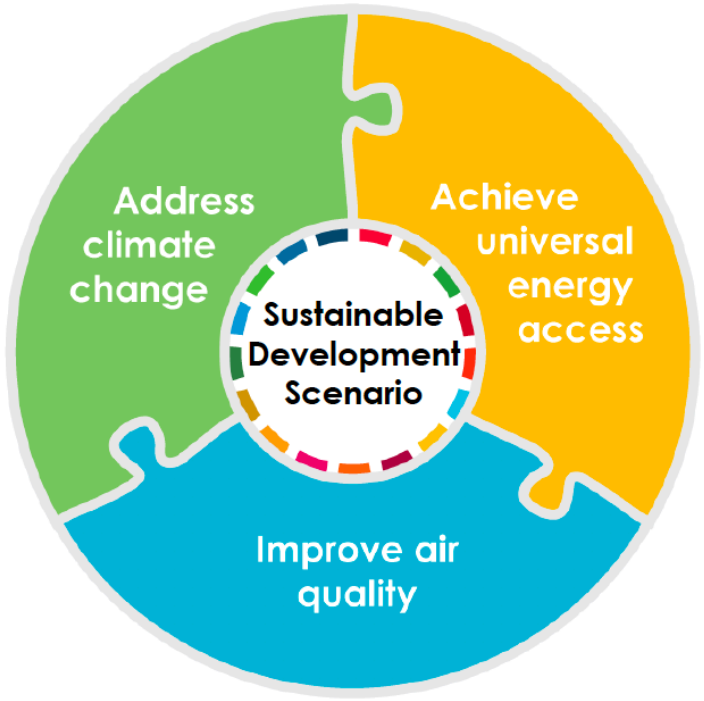
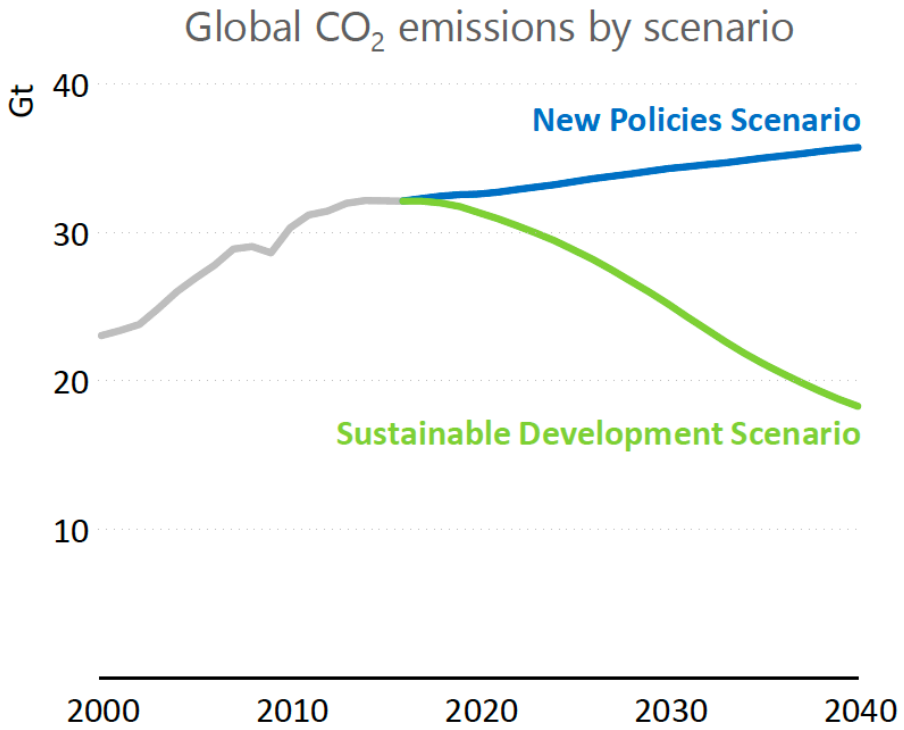
A new strategy for energy & sustainable development

World Energy Outlook 2017





The Sustainable Development Scenario reduces CO_2 emissions in line with the objectives of the Paris Agreement, while also tackling air pollution and achieving universal energy access

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Stronger policies for a more sustainable world

World Energy Outlook 2017

The Sustainable Development Scenario in 2040

875
million electric vehicles

2 times more efficient than today

3 250 GW
global solar PV capacity

580 bcm
additional gas demand

Only 15% additional investment is required to 2040 to achieve the Sustainable Development Scenario, with two-thirds of energy supply investment going to electricity generation & networks

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Conclusions

World Energy Outlook 2017

- The oil & gas boom in the United States is shaking up the established order, with major implications for markets, trade flows, investment & energy security
- The versatility of natural gas means that it is well placed to grow, but it cannot afford price spikes or uncertainty over methane leaks
- China continues to shape global trends, but in new ways as its "energy revolution" drives cost reductions for a wide range of clean energy technologies
- Our strategy for sustainable energy shows that concerted action to address climate change is fully compatible with global goals on universal access & air quality
- Electrification & digitalisation are the future for many parts of the global energy system, creating new opportunities but also risks that policy makers have to address

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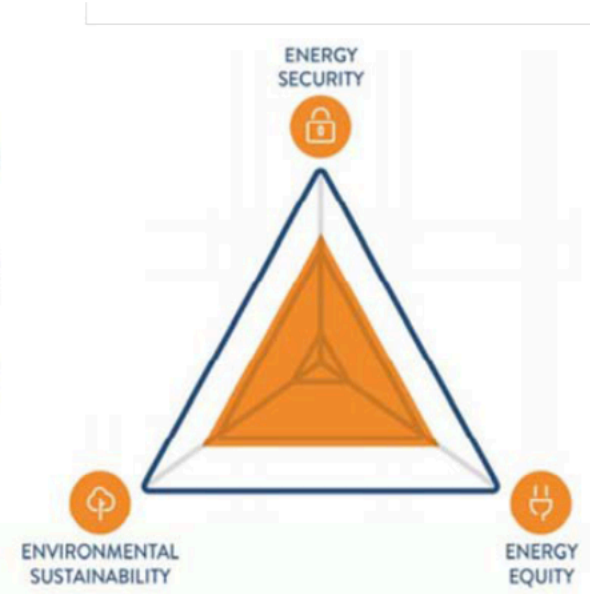
The Energy Trilemna (WEC)

Figure 7: The three dimensions of the Energy Trilemma

Energy security: Effective management of primary energy supply from domestic and external sources, reliability of energy infrastructure, and ability of energy provide to meet current and future demand.

Energy equity: Accessibility and affordabilit of energy supply across the population.

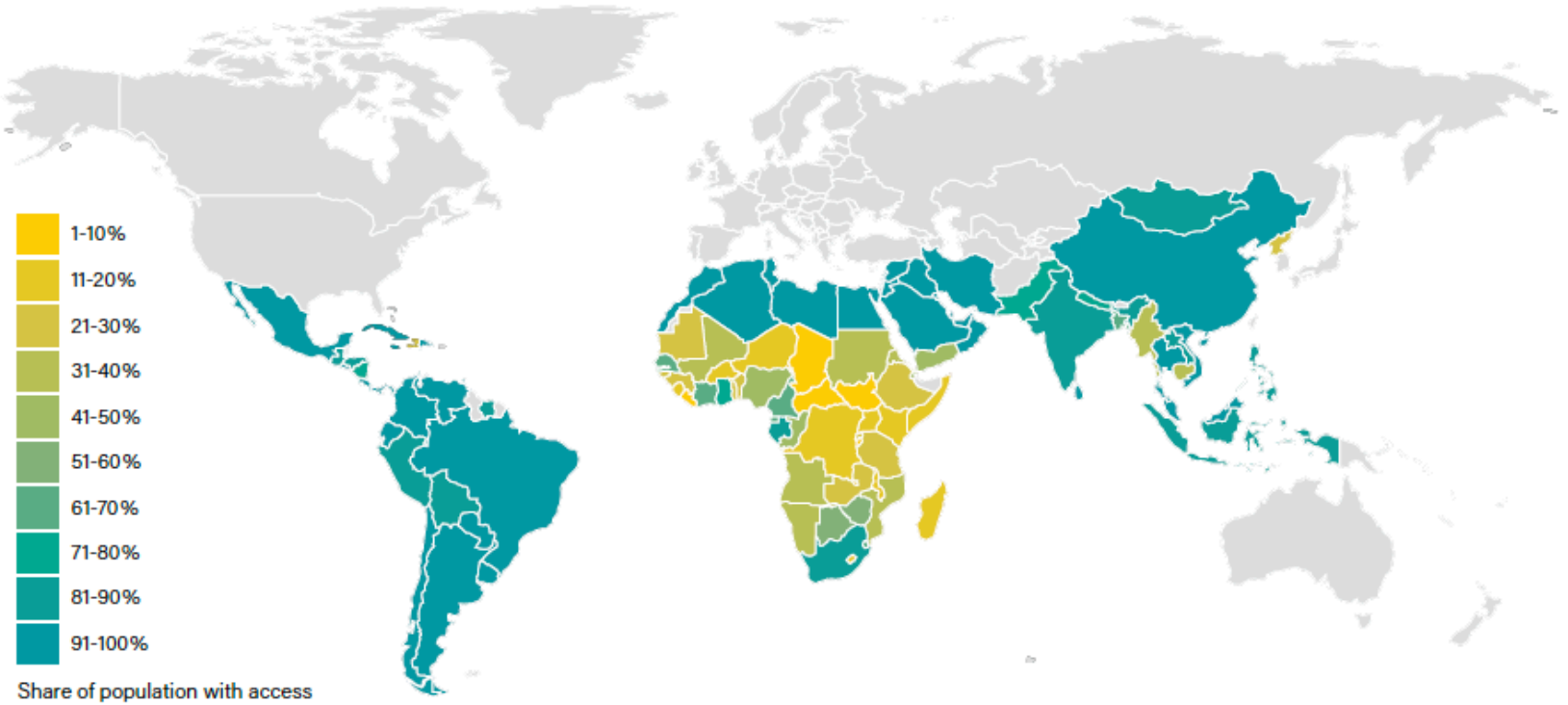
Environmental sustainability: Encompasses achievement of supply- and demand-side energy efficiencies and development of energy supply from renewable and other low-carbon sources.



Source: World Energy Council, Oliver Wyman, 2017

Challenges: Energy Access

Figure 31. Electricity Access in Developing Countries, 2014

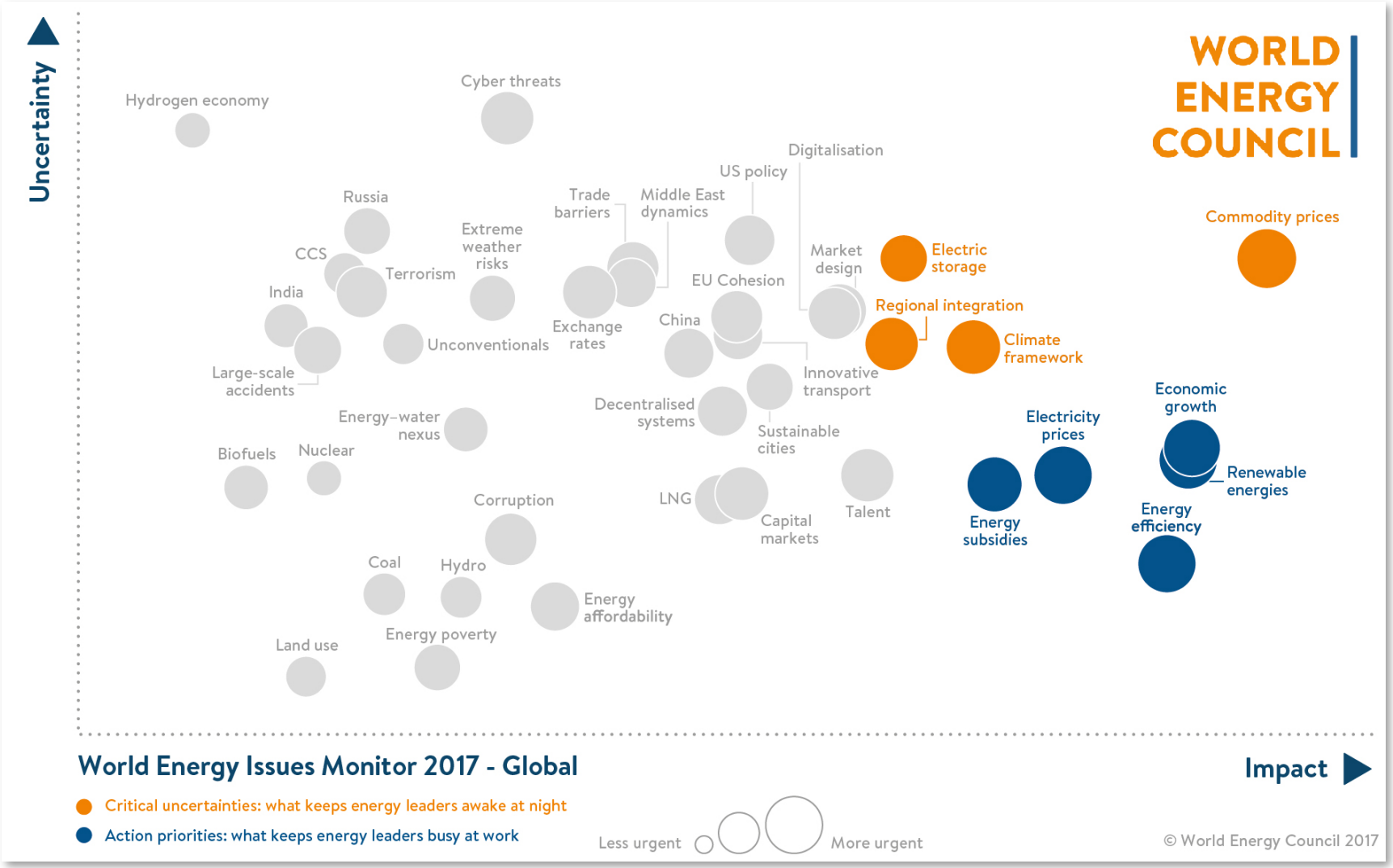


Source: See endnote 4 for this chapter.

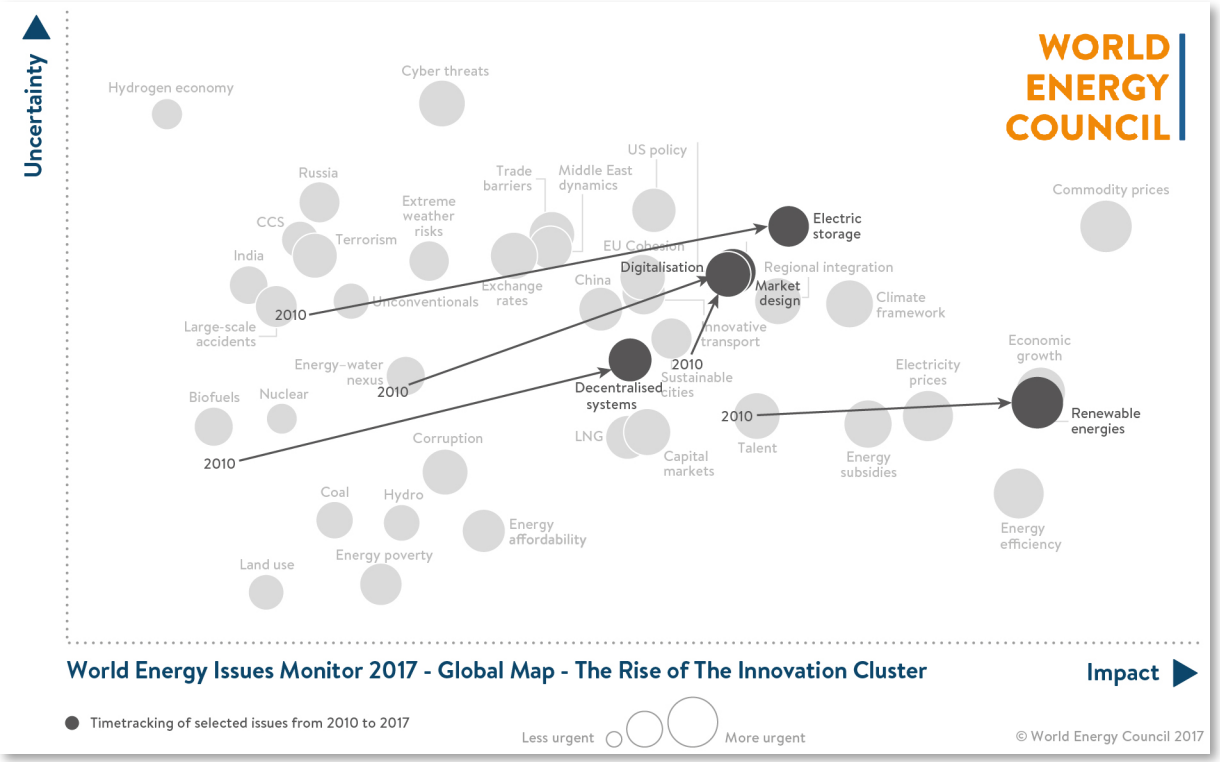
+ Similar map for clean cooking facilities

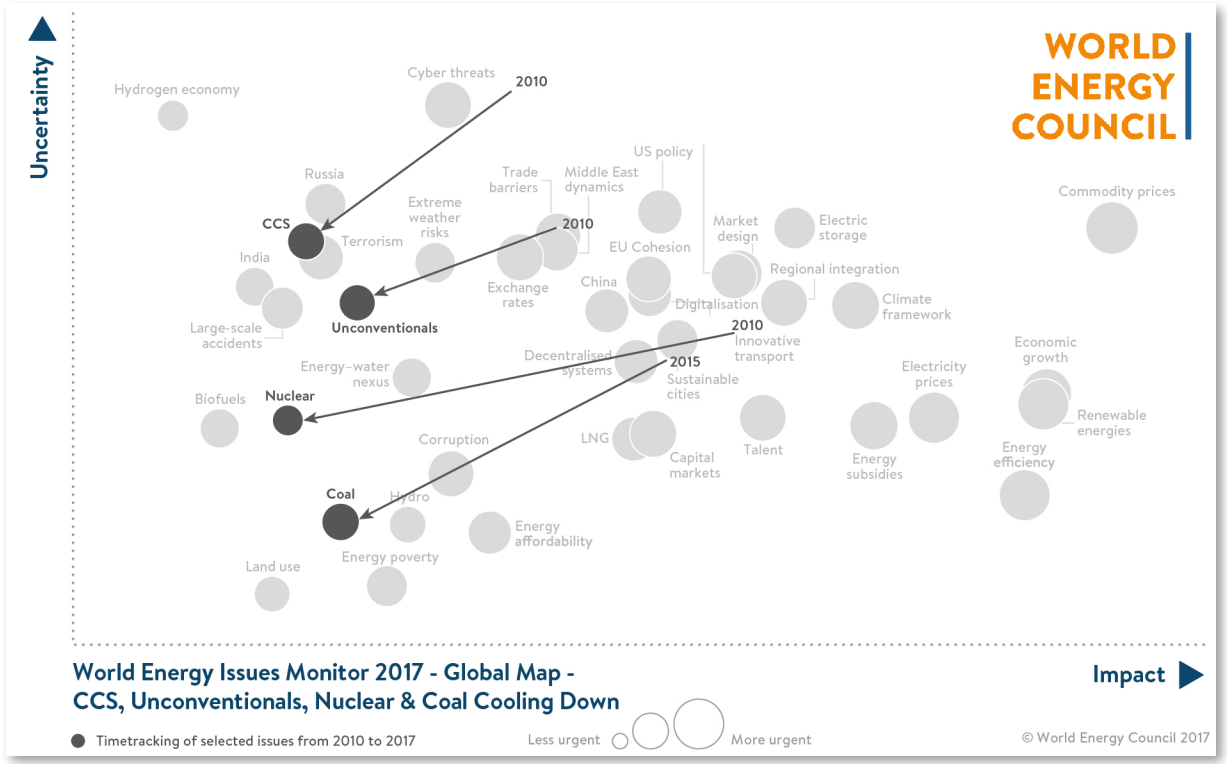
Source: REN21

Energy Leaders concerns



Source: WEC


Uncertainty
WORLD ENERGY COUNCIL
Hydrogen economy
Cyber threats
Russia
CCS
Terrorism
India
Extreme weather risks
Trade barriers
Middle East dynamics
US policy
Commodity prices
Electric storage
EU Cohesion
Digitalisation
Regional integration
Market design
Exchange rates
China
Unconventionals
Climate framework
Large-scale accidents
2010
Innovative transport
Energy-water nexus
2010
2010
Sustainable cities
Economic growth
Biofuels
Nuclear
Decentralised systems
Electricity prices
2010
Renewable energies
Corruption
LNG
Capital markets
Talent
Energy subsidies
2010
Coal
Hydro
Energy affordability
Energy efficiency
Energy poverty
Land use
World Energy Issues Monitor 2017 - Global Map - The Rise of The Innovation Cluster
Impact
Timetracking of selected issues from 2010 to 2017
Less urgent
More urgent
© World Energy Council 2017


Uncertainty
WORLD ENERGY COUNCIL
Hydrogen economy
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Trade barriers
Middle East dynamics
US policy
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2010
EU Cohesion
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Regional integration
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China
Digitalisation
Climate framework
Large-scale accidents
Unconventionals
2010
Innovative transport
Energy-water nexus
Decentralised systems
2015
Sustainable cities
Electricity prices
Economic growth
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Nuclear
Renewable energies
Corruption
LNG
Capital markets
Talent
Energy subsidies
Energy efficiency
Coal
Hydro
Energy affordability
Energy poverty
Land use
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CCS, Unconventionals, Nuclear & Coal Cooling Down
Impact
Timetracking of selected issues from 2010 to 2017
Less urgent
More urgent
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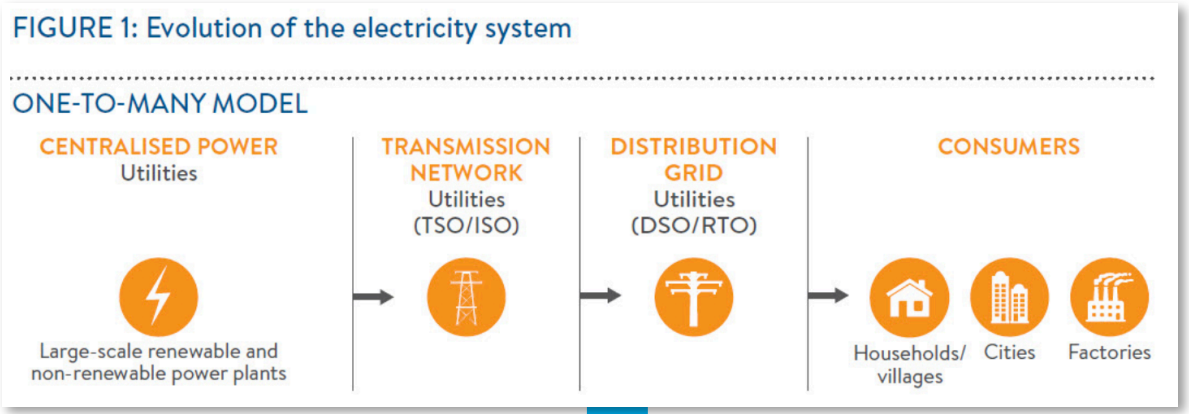
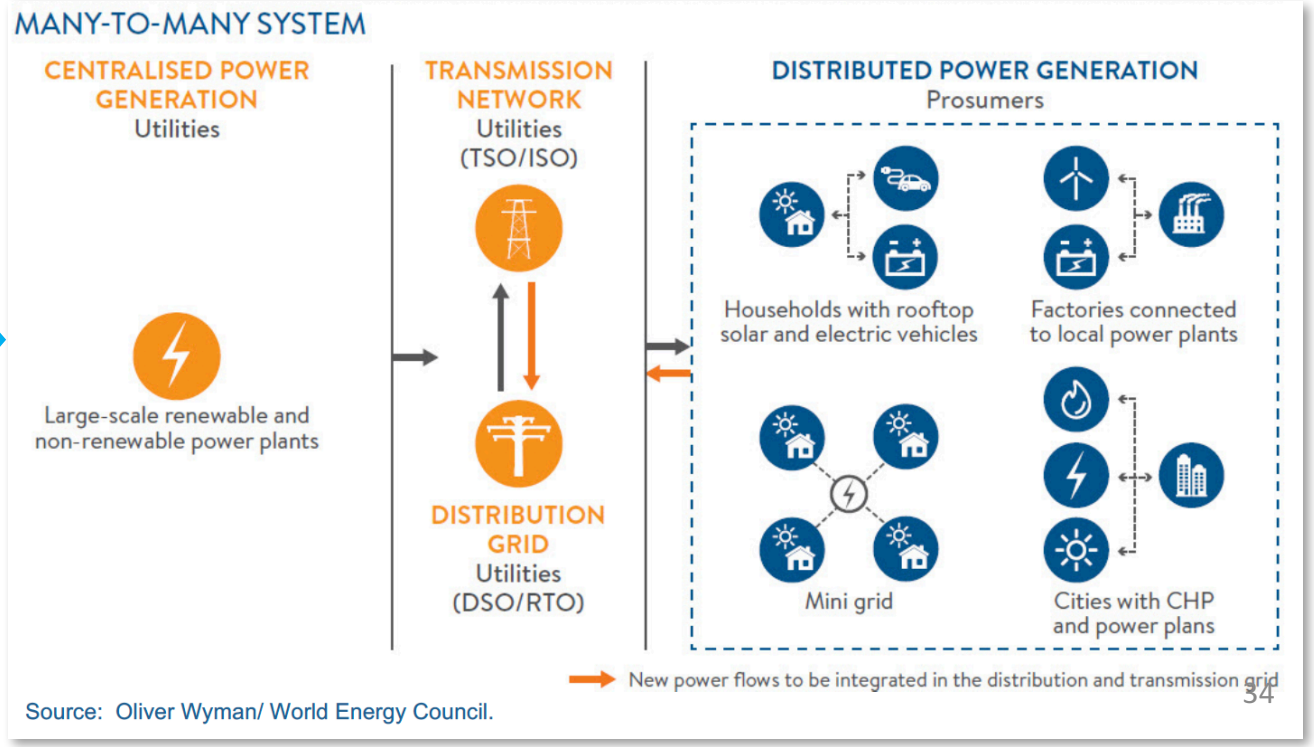
Source: WEC

Transitioning to new Energy Models





Source: WEC

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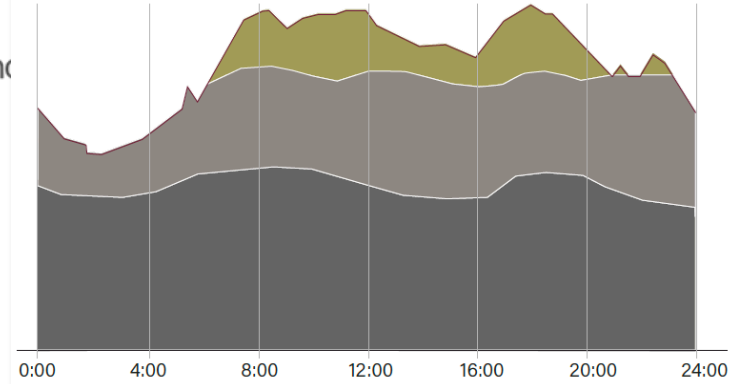
Target?

Figure 59. Conceptual Progression from the Baseload Paradigm to a New Paradigm of 100% Renewable Electricity

A) The Baseload Paradigm

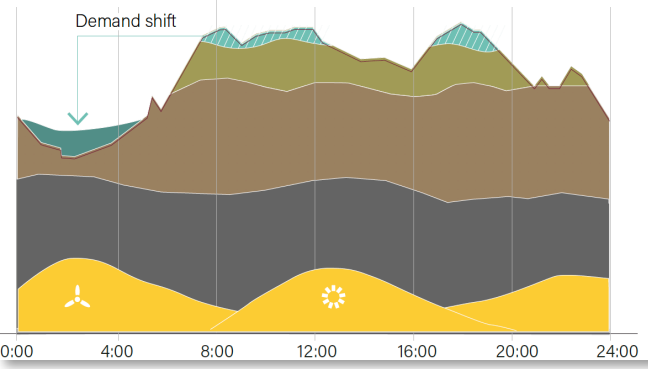


	Power generation
Peak	
Intermediate and dispatchable	
Baseload	

Source: REN21

In the early stages of progression to larger shares of variable renewable generation, power systems make some adjustments in their grid operations, develop forecasting systems for renewable energy production, and introduce improved control technology and operating procedures for efficient scheduling and dispatch.

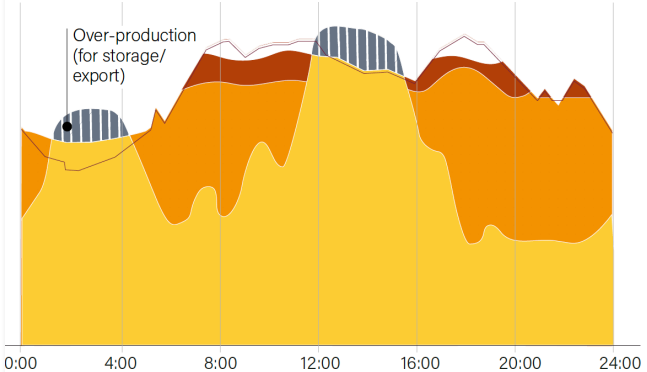
B) The Early Transition



	Power generation
Demand shift	→ to early morning lows
Peak	
Intermediate and dispatchable	
Baseload	
Variable renewable energy	

In the late stages of progression towards fully renewable power systems, variable renewable power will be integrated through advanced resource forecasting, grid reinforcements and strengthened interconnections, improved information and control technologies for grid operations, widespread deployment of storage technologies, greater efficiency and scope of demand response, and coupling of electricity, heating and cooling, and transport sectors.

C) A New Paradigm



	Power generation
Over-production	→ for storage or trade
Storage or import/trade	from solar and wind peaks
Dispatchable	*
Variable renewable energy	

* CSP with thermal energy storage

Coal-fired · Oil-fired · Diesel generator · Nuclear · Natural gas-fired · Hydro-power · Bio-power · Solar PV and CSP · Geothermal power · Wind power

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World Energy &
Meteorology Council

@WEMCouncil

Thank You

www.wemcouncil.org

info@wemcouncil.org

+44 (0)20 3286 3250

The Enterprise Centre, University Drive, University of East Anglia, Norwich NR4 7TJ. UK