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The future trends for Power & Utilities

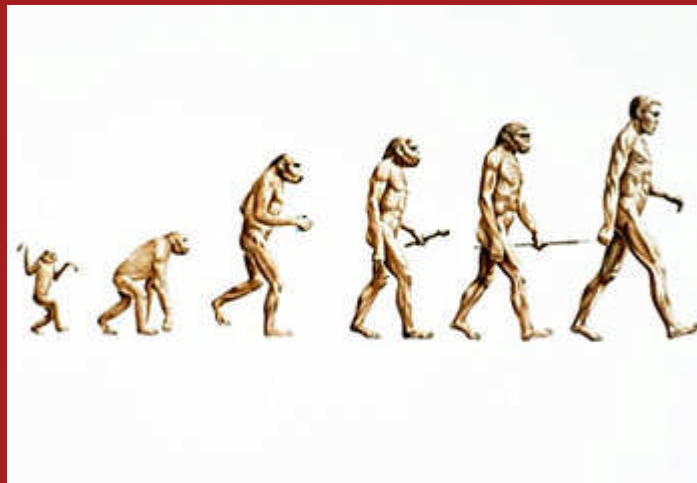
Norbert Schwieters
Global Power & Utilities Leader



Global Power & Utilities – evolution or revolution?

“It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change.”

Author unknown, commonly misattributed to Charles Darwin



A closer look at the drivers of global change

Global drivers

War for natural resources

- Growing demand for natural resources and the impact of climate change are of growing economic concern.

Demographic change

- With a global population that has recently passed 7 billion, demographic change is a key consideration across all industries.

Social and behavioural change

- The behaviour of individuals and communities is changing as a result of the combined impact of urbanisation, increasing personal wealth, migration, digital communication.

Rise and interconnectivity of emerging markets

- Opportunity extends for South America, Africa, Asia and the Middle East. These regions have growing consumer markets, manufacturing capabilities and access to labour. Also they have significant liquid investable capital incl. 78% of the world's sovereign wealth funds.

Impact of new technology

- For the last 200 years, technology has changed society in unpredictable ways.

What does it mean for P&U?

1

Demand for energy and water consumption is forecast to increase. Yet, 1.4 bn people have no access to electricity (mainly in sub-Saharan Africa and Asia).

2

For the P&U sector, population growth will continue to drive the demand for energy of all types.

3

For P&U companies these changes have a profound impact through a changing role of the consumer.

4

For P&U companies, these regions hold more than 50% of global gas reserves and are the future growth markets.

5

P&U sector technological breakthroughs like shale gas, renewables, power-to-gas, CCS will have a profound impact on our future.

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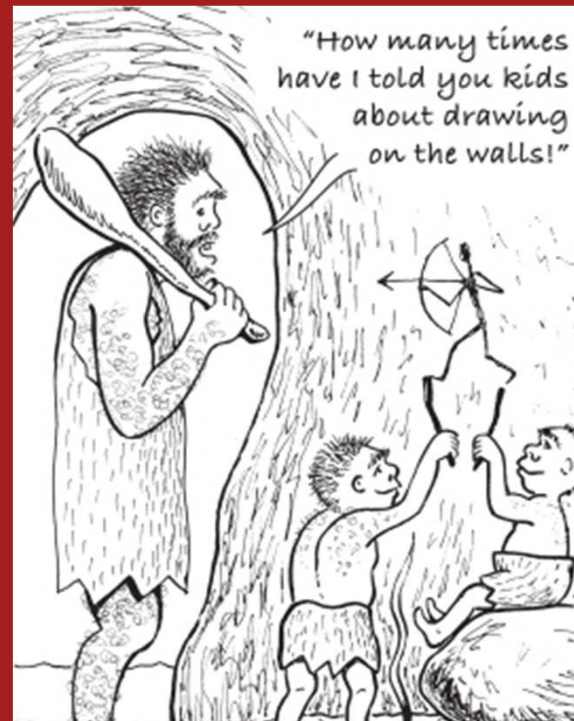
Driver of change #1:

The war for natural resources

“He who rejects change is the architect of decay. The only human institution which rejects progress is the cemetery.”

~Harold Wilson

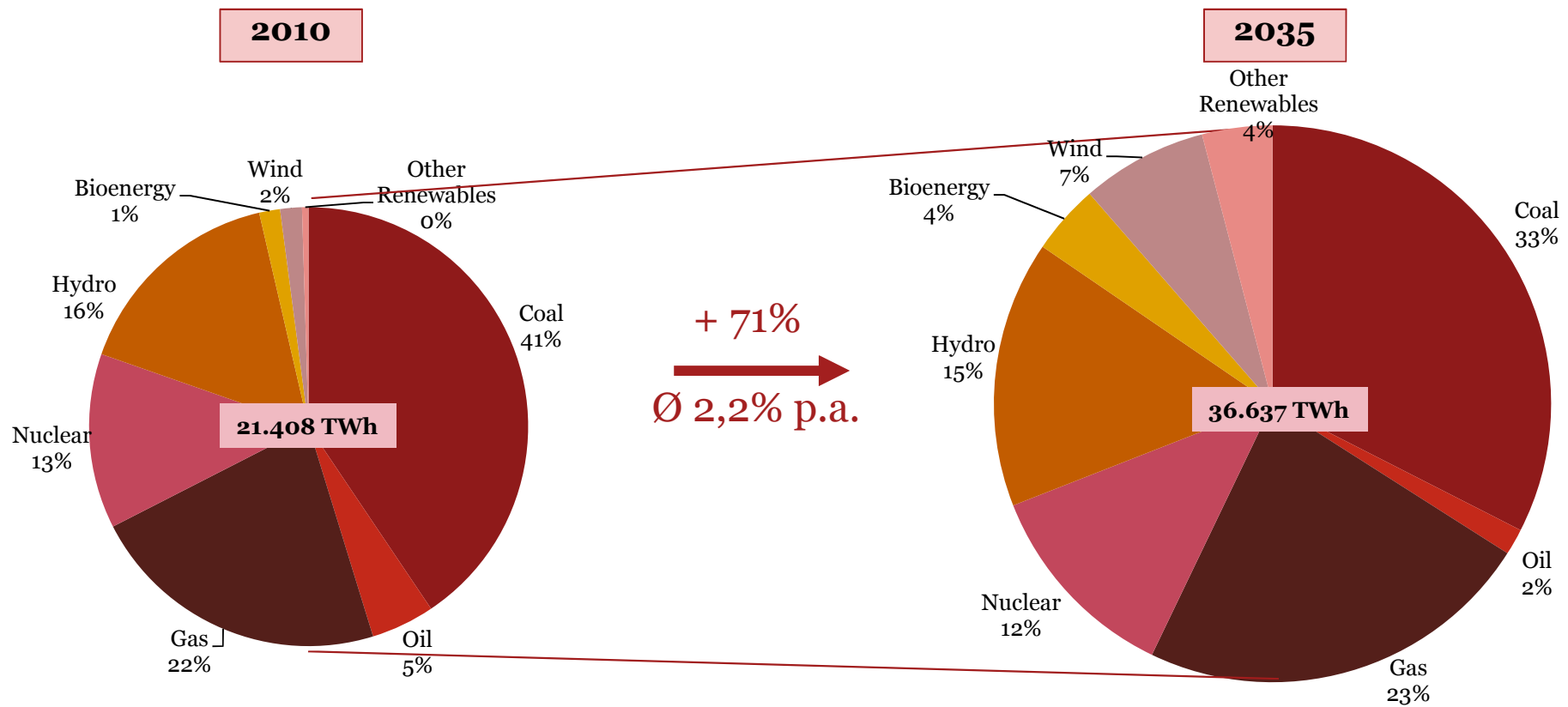
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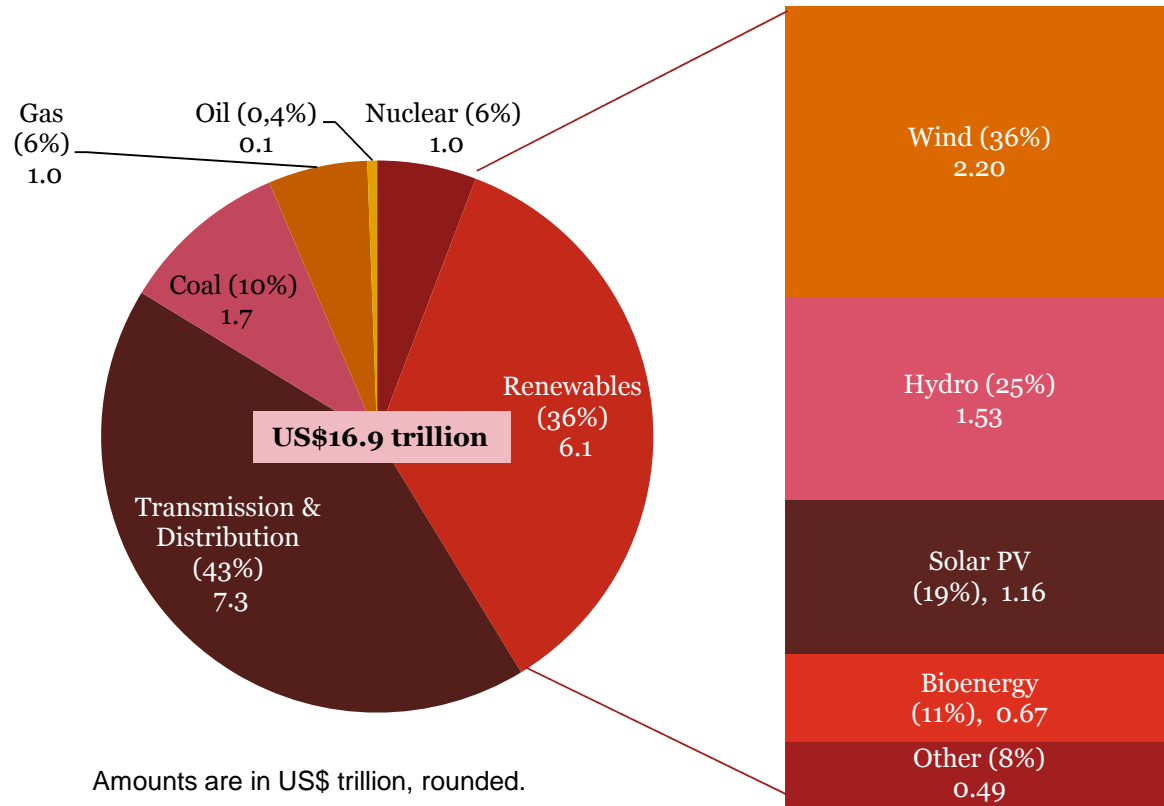
" THE GOOD NEWS IS WE'VE DISCOVERED A VAST NEW OIL RESOURCE. THE BAD NEWS IS WE NEED A SPACE SHIP TO GET THERE. "

Global power generation fuel mix



Profound changes in global fuel mix by 2035 due to substantial drop of fossil fuels (mainly coal by -8%) and growth of renewables (+11%).

Power sector cumulative investment needs: US\$16.9 trillion investment by 2035

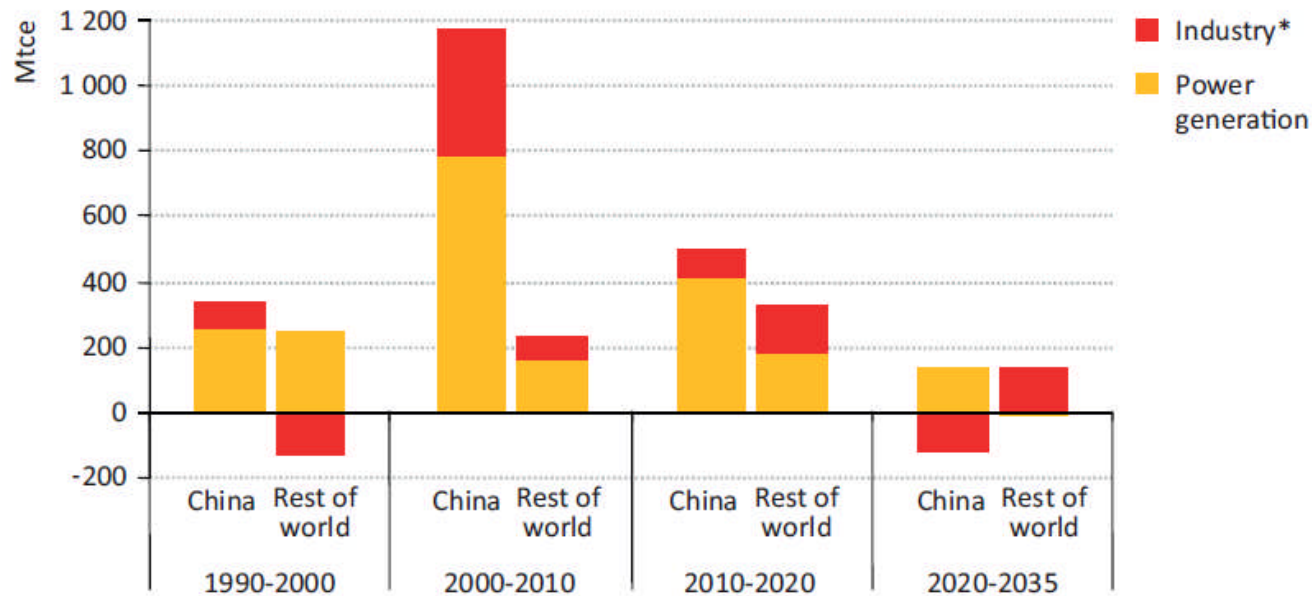


- Cumulative investment needed by 2035 is roughly equivalent to the GDP of the entire European Union in 2011
- Investment in power plants accounts for 57% of the power sector total, over 60% of it for renewables.
- Investment is greatest in China, where total power sector spending is \$3.7 trillion, followed by the European Union, United States, and India.

Other includes geothermal, concentrating solar power and marine

Global coal: drop in coal-fired generation in OECD offset by big increase in China

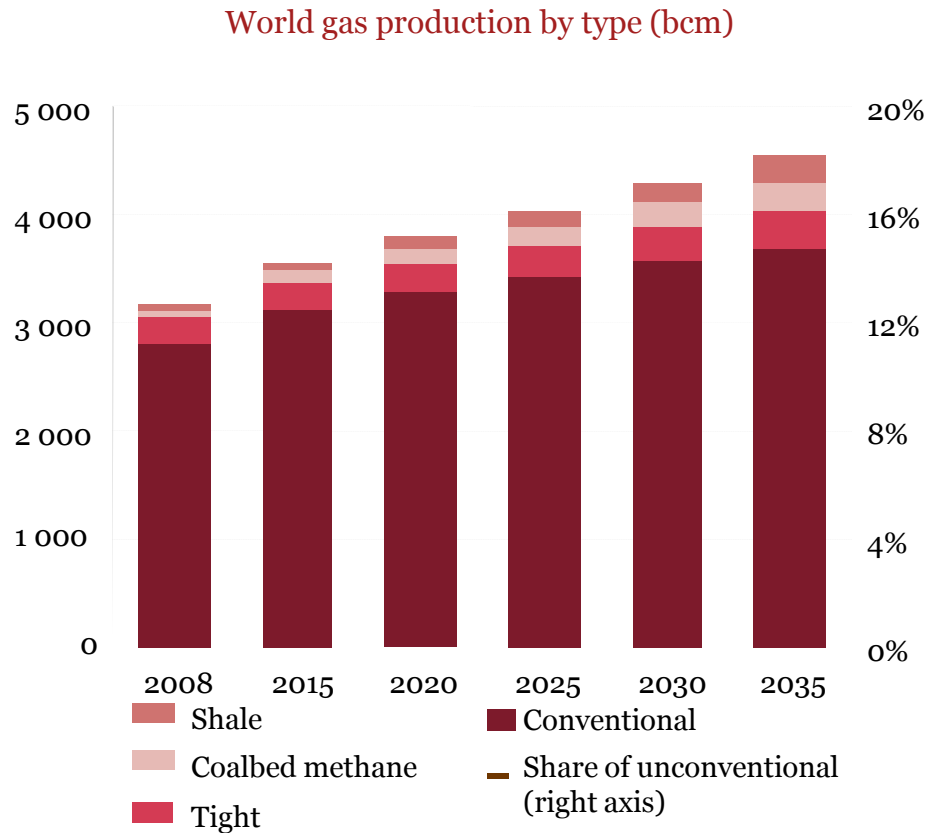
Incremental coal demand in China and the rest of the world by major sector



* Includes blast furnace, coke oven transformation, and own use.

In 2010, nearly 80% of China's power output was coal-fired. China's share in international coal markets increased by a colossal 18% over 2001-2011, accounting for 80% of coal demand growth. With China holding large unconventional gas resources, there is potential for gas to start playing a much bigger role in meeting the country's rising power needs.

A golden age for gas

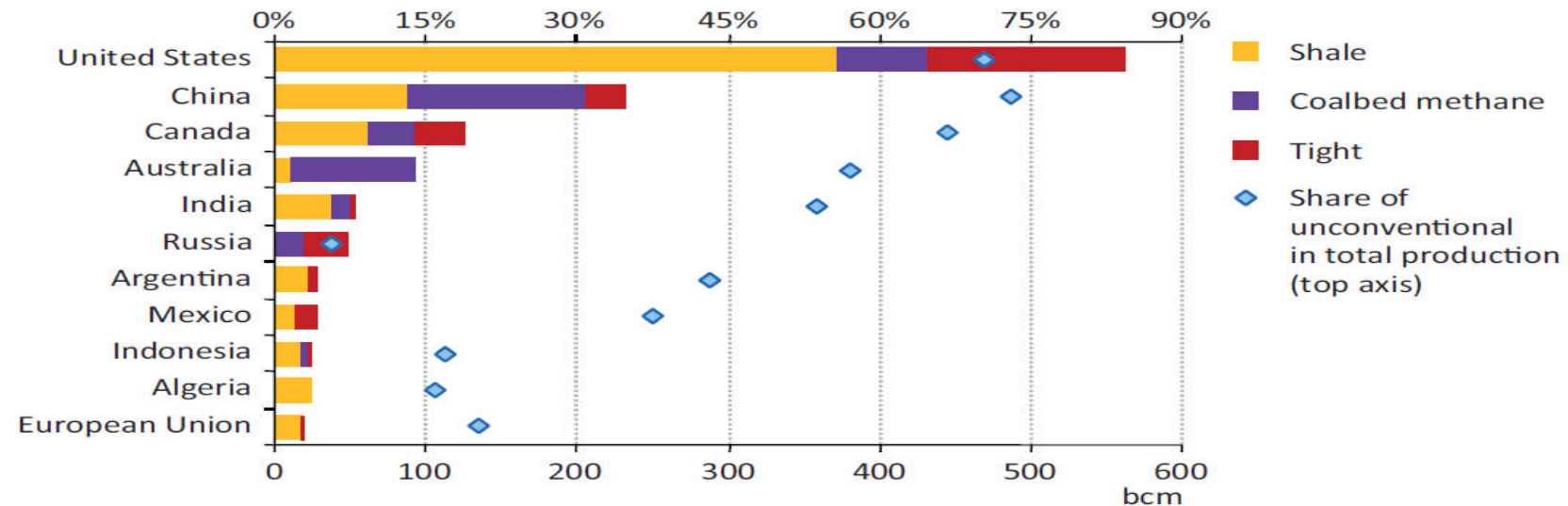


- Gas is set to play a key role in meeting the world's energy needs
- ... demand rises by 44%, led by China & Middle East
- Unconventional gas accounts for 35% of the increase in global supply to 2035, with new non-US producers emerging
- Gas glut is peaking up, keeping up the pressure on gas exporters to move away from oil-price indexation, notably in Europe
- Lower prices could lead to stronger demand for gas, backing out renewables & coal in power generation

Shale gas boom

Unconventional gas production in leading countries

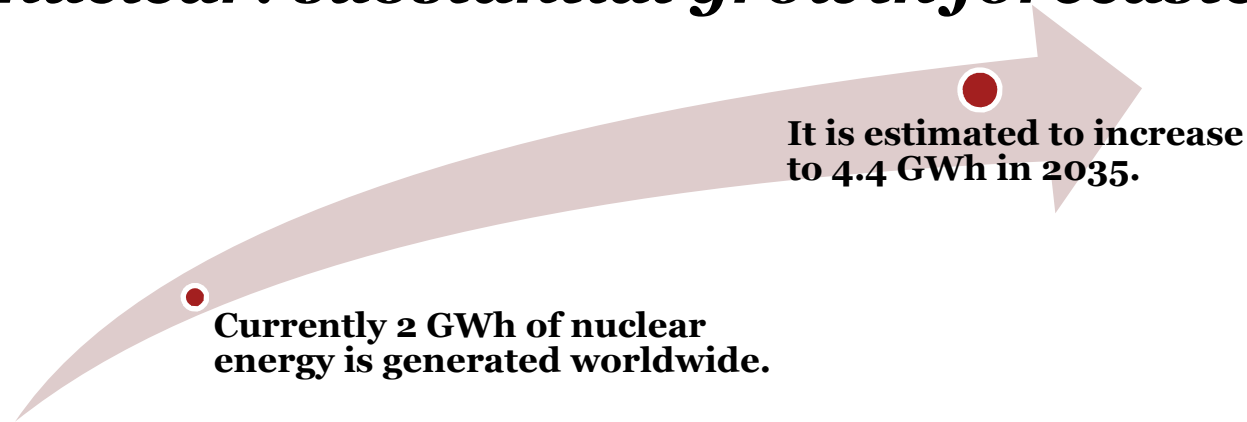
Source: IEA World Energy Outlook 2012, New Policies Scenario, 2035



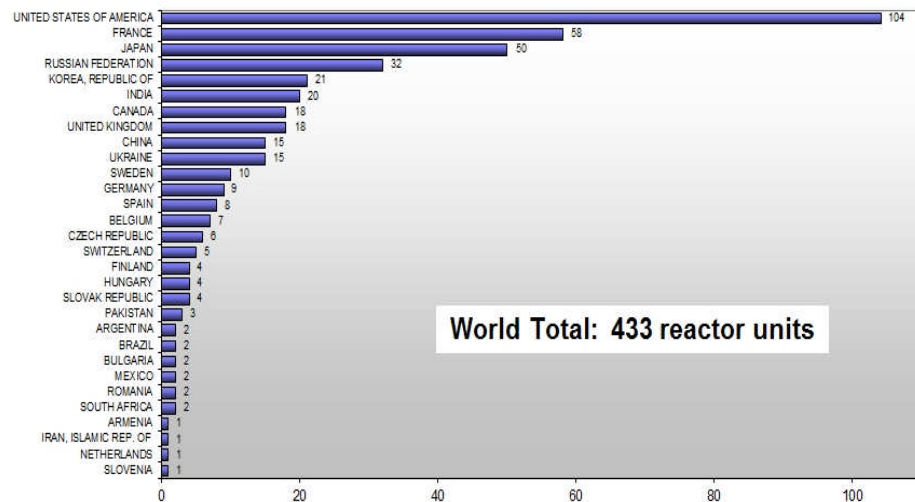
Above ground risks could slow shale boom

- **Government risks:** level of government support for the development of unconventional resources varies by nation and region.
- **Market risks:** access to markets for production will depend on pricing reform and in many markets could face export restrictions.
- **Environmental risks:** public discomfort with hydraulic fracturing, wastewater management and earthquakes contribute to moratoria risk in some markets.

Global nuclear: substantial growth forecasted...

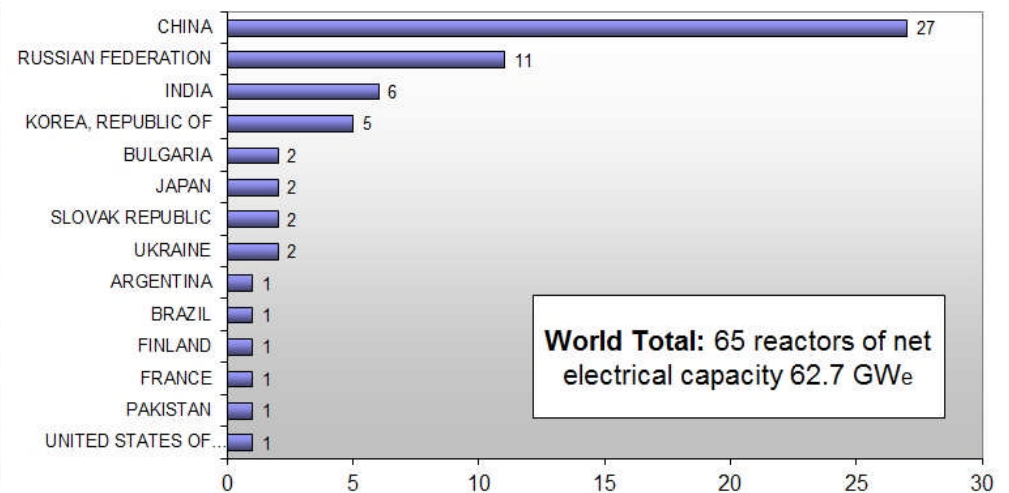


Operational nuclear reactors



Note: Long-term shutdown units (5) are not counted

Reactors under construction

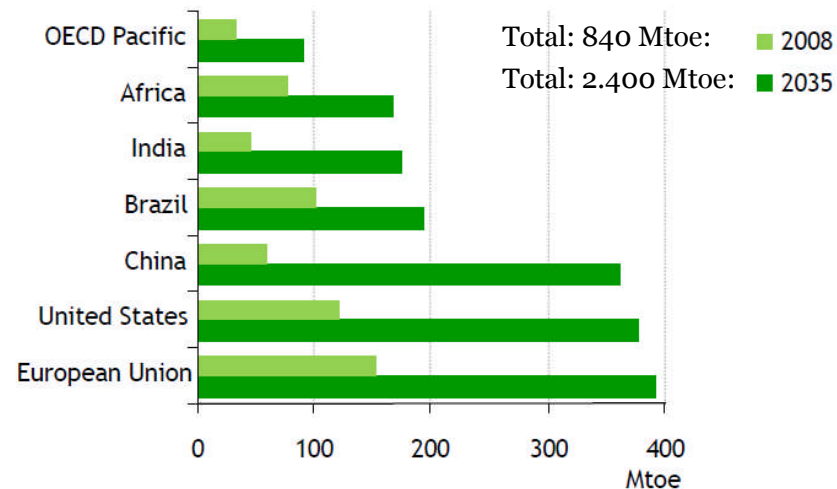


Note: The World Total includes also 2 reactors under construction in Taiwan, China.

Source: BP Statistical Review 2012; International Atomic Energy Agency

Renewables enter the mainstream ...

Renewable primary energy demand

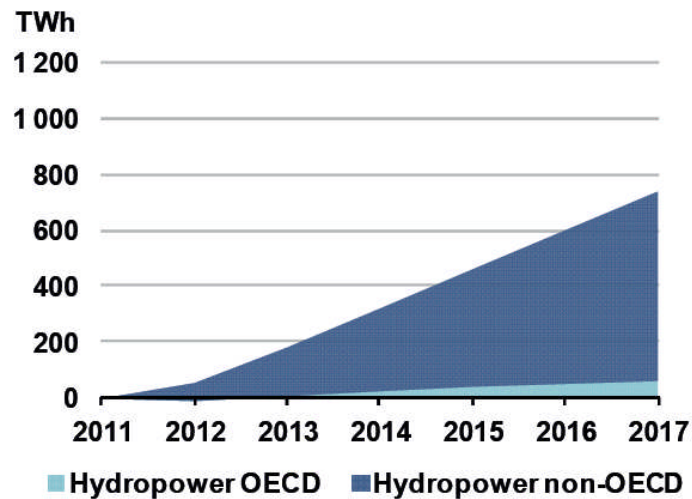


The use of renewables triples by 2035, driven by the power sector: share in electricity mix rises to 32% in 2035

- Renewable energy is growing at double-digit rates but still only comprises about 16% of global energy production.
- The main challenge with renewable energy is producing it at a cost that is comparable to other energy sources.
- Economies of scale have yet to be achieved, but with the global investment in renewables, continued progress is expected.
- By 2030, it is expected that 20-30% of the global energy supply will come from renewables.

Renewables: hydro remains the main source

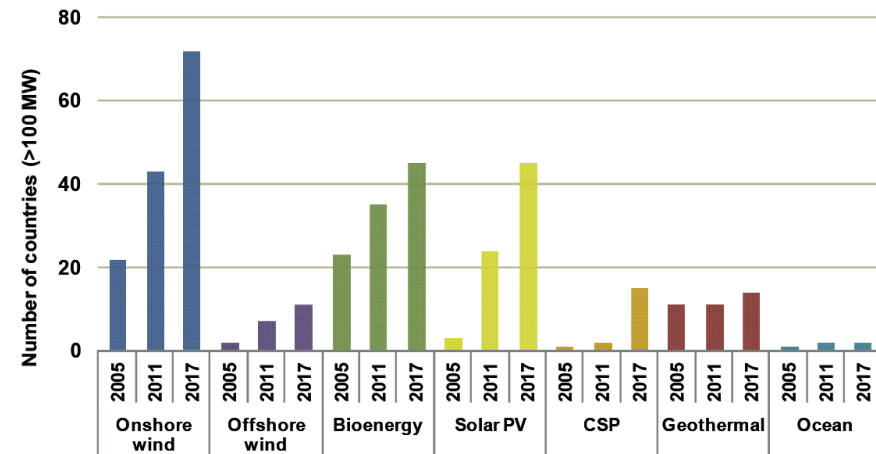
Global hydropower forecast cumulative additions (2011-17)



Hydropower production in 2011 accounted for 80% of total renewable generation.

Source: IEA Medium-Term Renewable Energy Market Report 2012

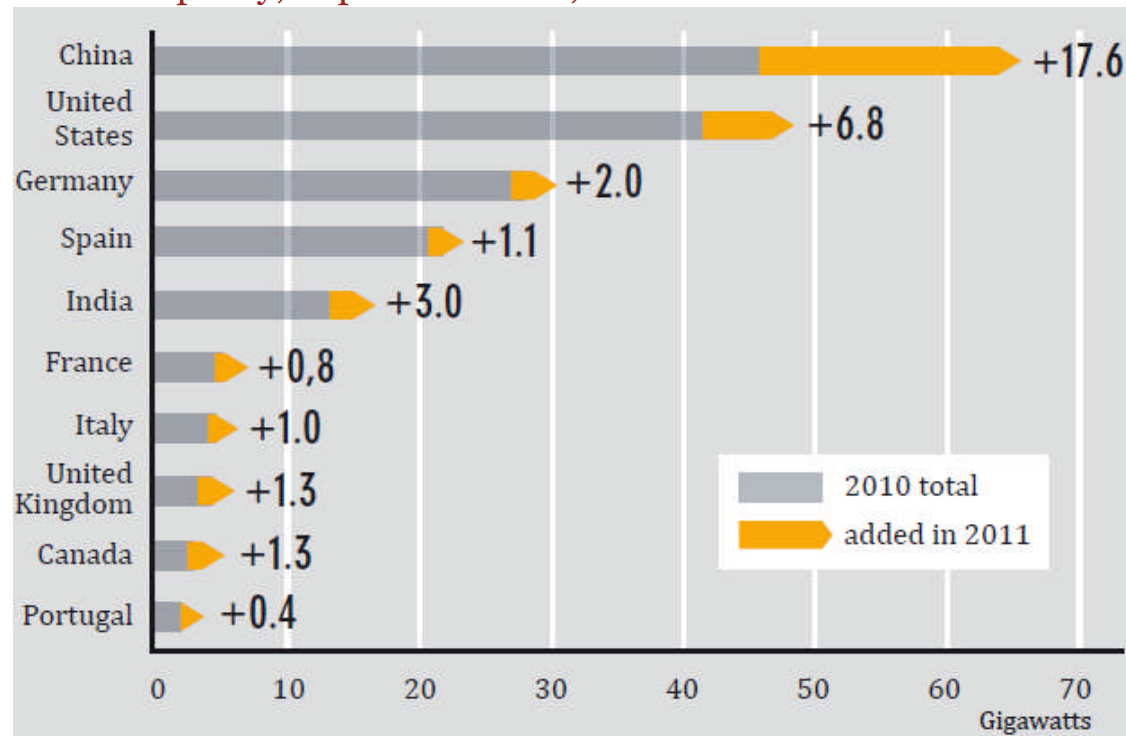
Number of countries with non-hydro renewable capacity above 100 MW



- In 2017, the number of countries with cumulative renewable electricity capacities above 100 MW increases significantly for most non-hydro technologies.
- China accounts for almost 40%, or 270 GW of the global renewables market, followed by the United States, India, Germany and Brazil.

Onshore wind energy

Global Wind Power Capacity, Top 10 countries, 2011

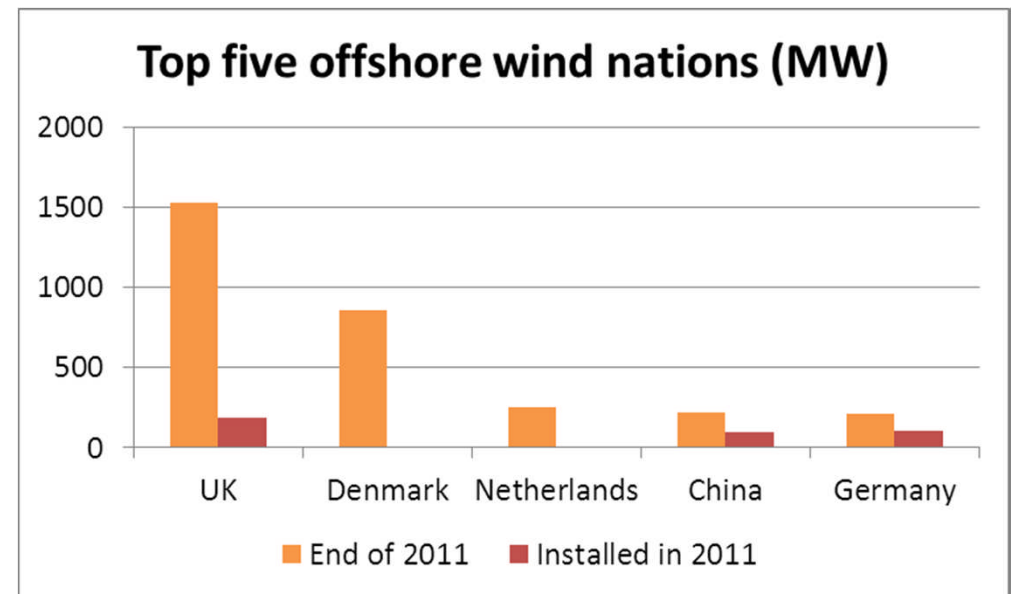


Wind energy will grow in the global fuel mix from 2% to 7% by 2035, with onshore wind still remaining the proven technology with less risk (in comparison to offshore).

Source: REN21. 2012. Renewables 2012 Global Status Report

Offshore wind power – large potential

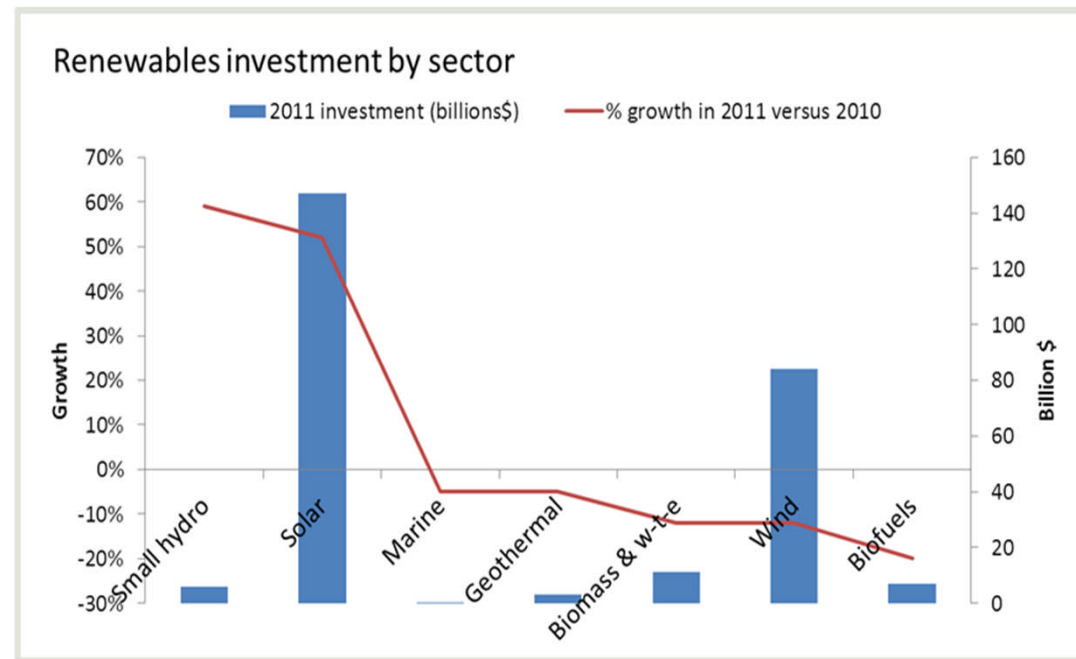
- Better wind resource than onshore (load factors > 35 %)
- Maturing technology/industrial scale projects
- High generation rate/limited track record of best practices
- Growth areas: Europe, especially UK and Germany
- Tight supply situation across value chain for suppliers with proven technologies Vestas and Siemens Wind > 90% of markets for turbines
- High generation cost per MWh
- Attractive support policies
- High maintenance risks



Source: GWEC – Global Wind Power Market Potential, RWE Innogy Factbook Renewable Energy

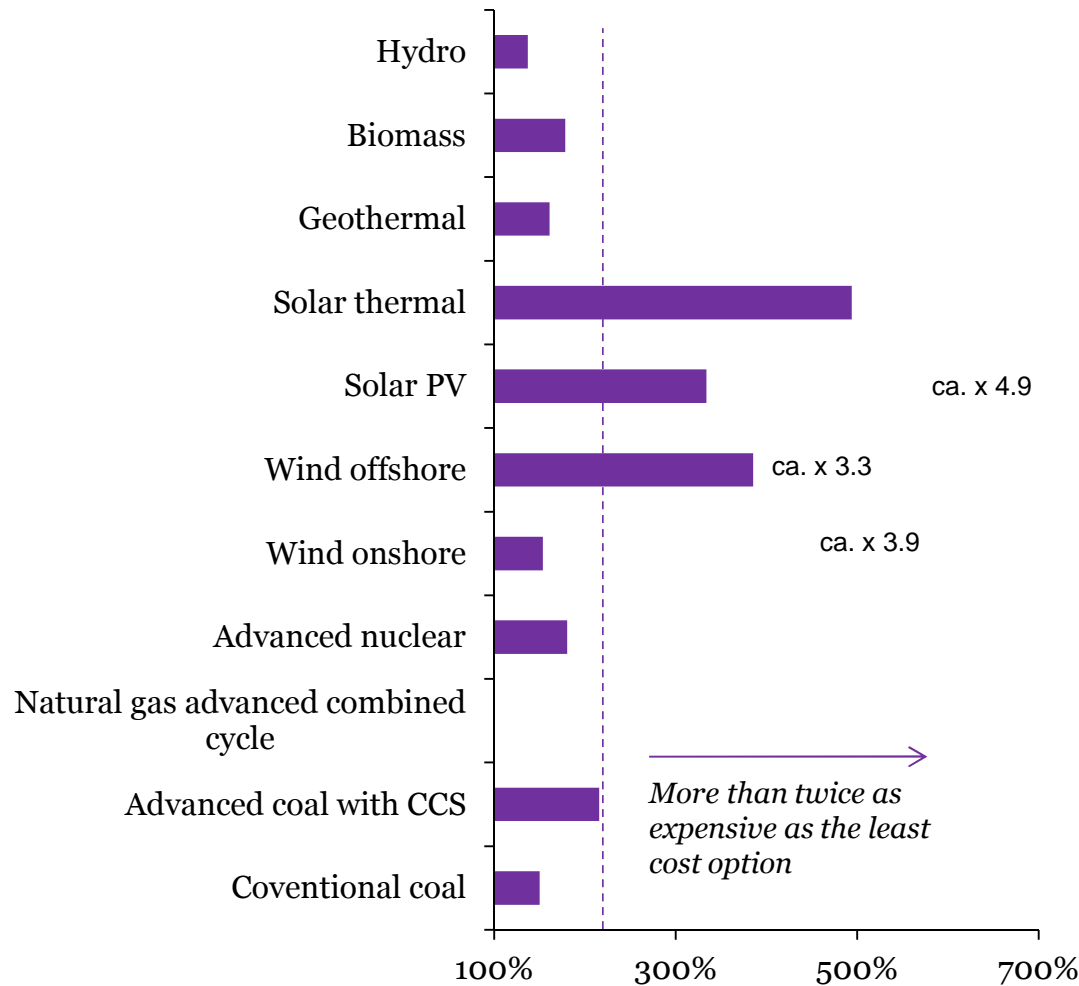
Solar energy: soaring despite market risks

- Solar investment dominated the renewables sector in 2011
- Governments in Europe have been transitioning from solar due to price tag and rising dominance of China
- China's impressive growth targets as part of 12th FYP may indicate reaction to glut rather than long-term support.
- ME emerges with an ambition to invest into solar
- Beyond the solar PV bubble: in recent years, manufacturing capacity of PV solar panels in OECD countries and China has expanded much more quickly than actual demand



Source: IEA, World Energy Outlook, RWE Innogy Factbook Renewable Energy

Commercial maturity of renewables

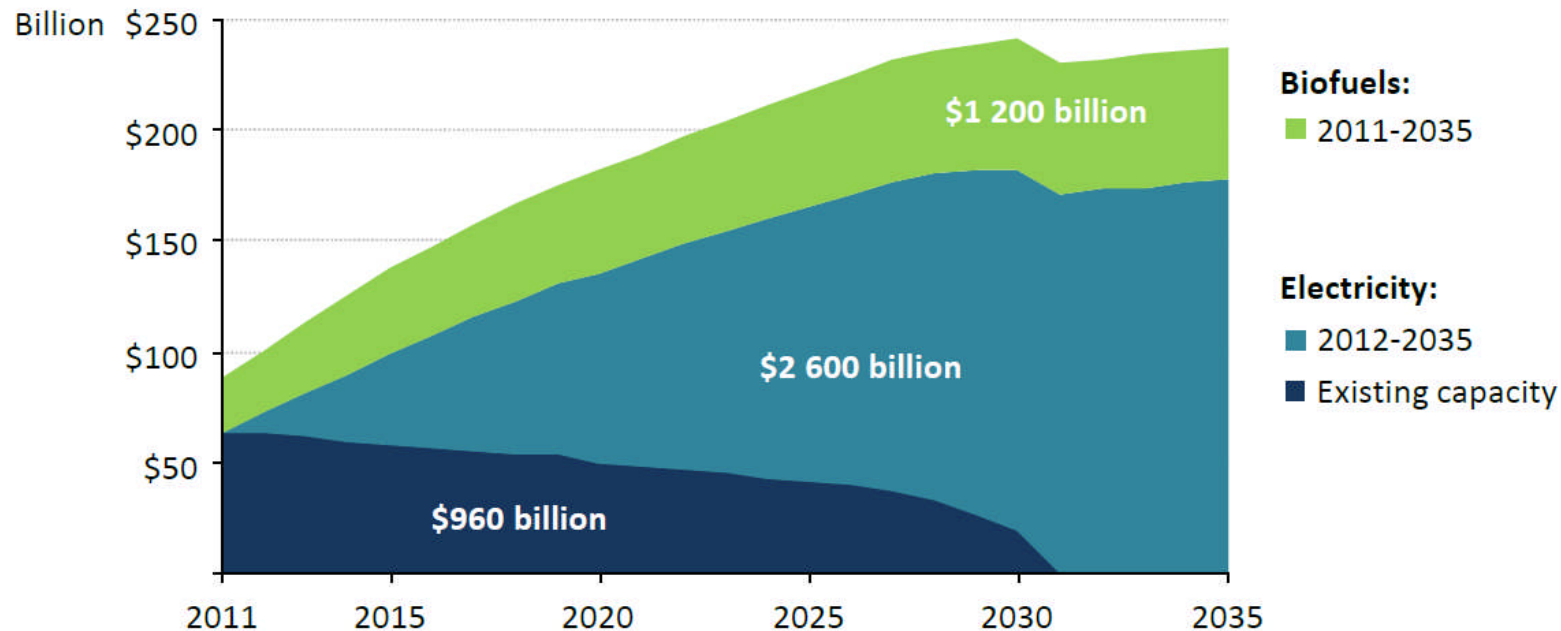


- Nearly all renewable technologies are more expensive than gas combined cycle turbine.
- Electricity costs from offshore wind, solar (thermal & PV) are up to almost five times more expensive than current electricity costs from fossil fuels.
- Geothermal and hydro have low scalability due to location restrictions.
- Wind onshore is almost at par with conventional coal.

Source: PwC analysis

Renewables subsidies: the multiple benefits of come at a cost

Global renewable energy subsidies



Renewable subsidies were \$88 billion in 2011; over half the \$4.8 trillion required to 2035 has been committed to existing projects or is needed to meet 2020 targets

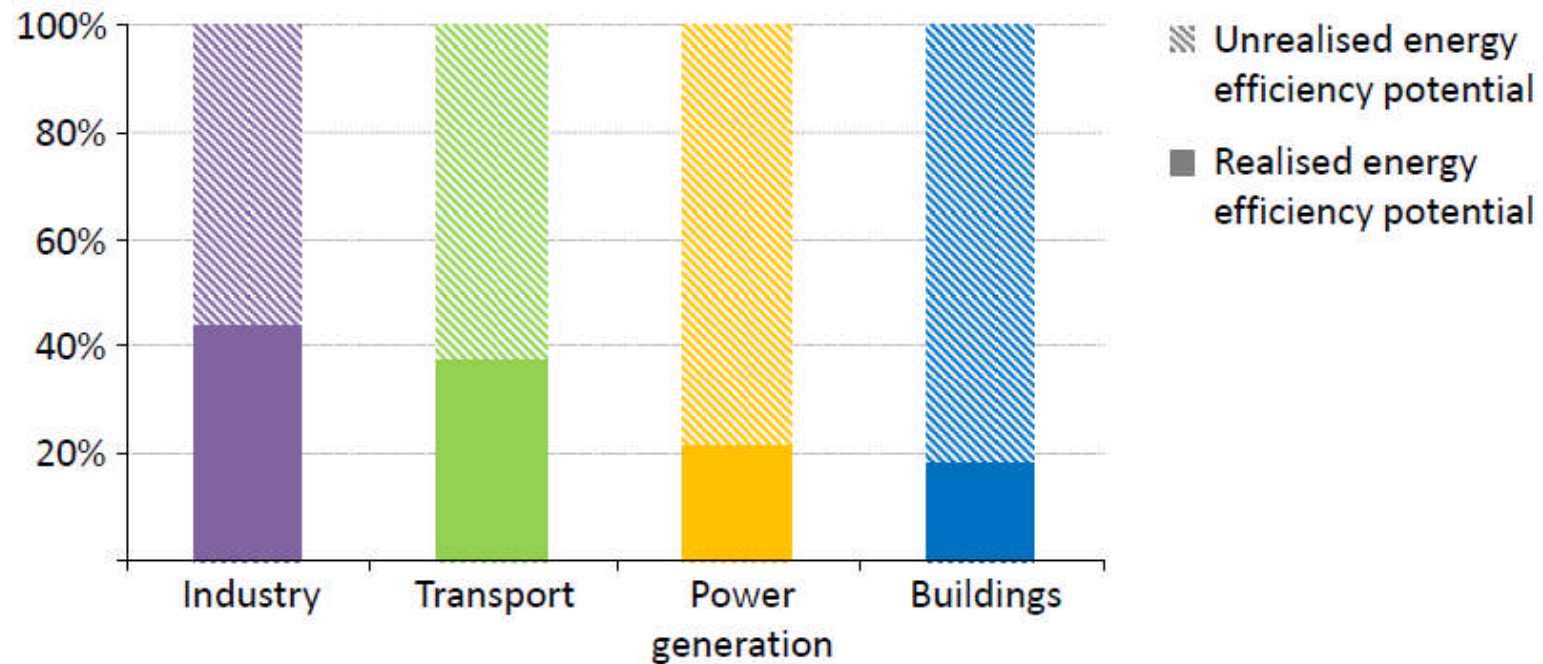
Source: IEA World Energy Outlook 2012, New Policies Scenario

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Energy efficiency: a new fuel?

Energy efficiency potential used by sector



Two-thirds of the economic potential to improve energy efficiency remains untapped in the period to 2035

Source: IEA World Energy Outlook 2012, New Policies Scenario

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Driver of change #3 and #5

Social and behavioural change + New Technology

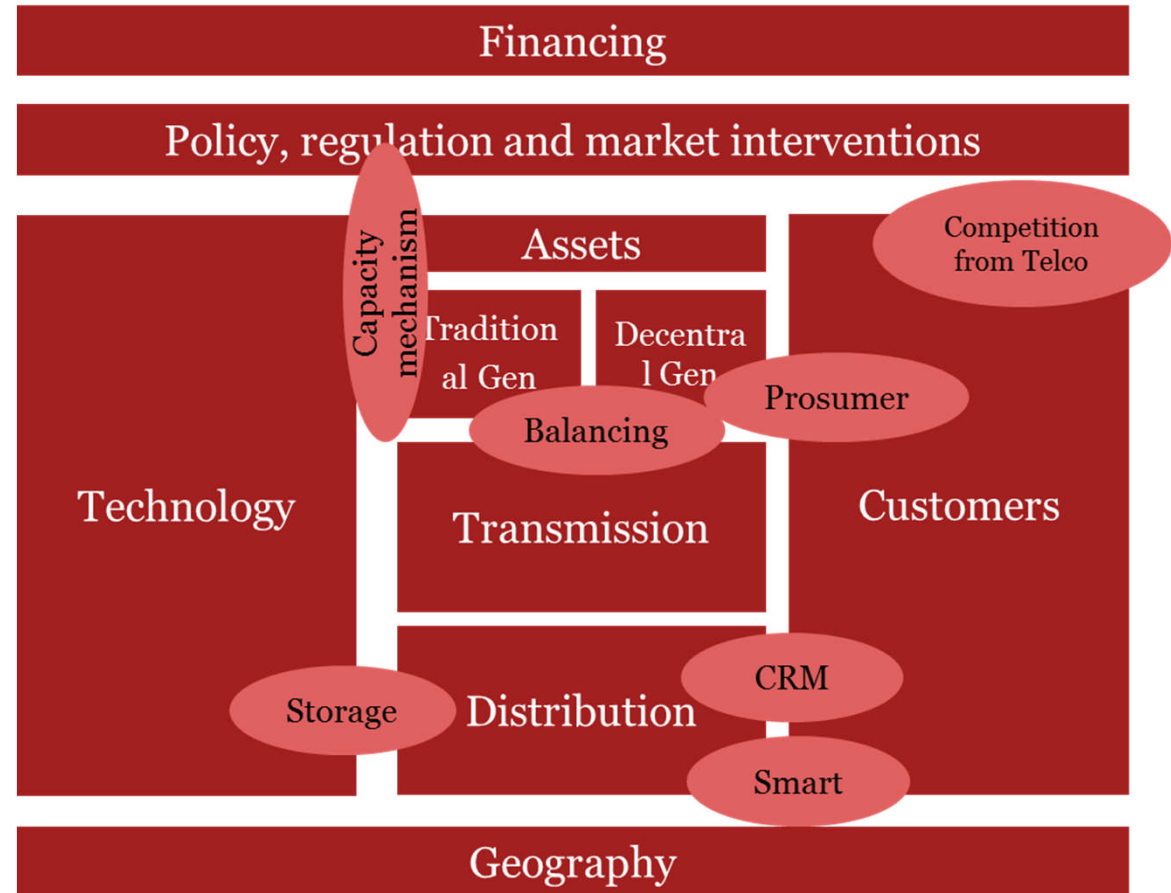
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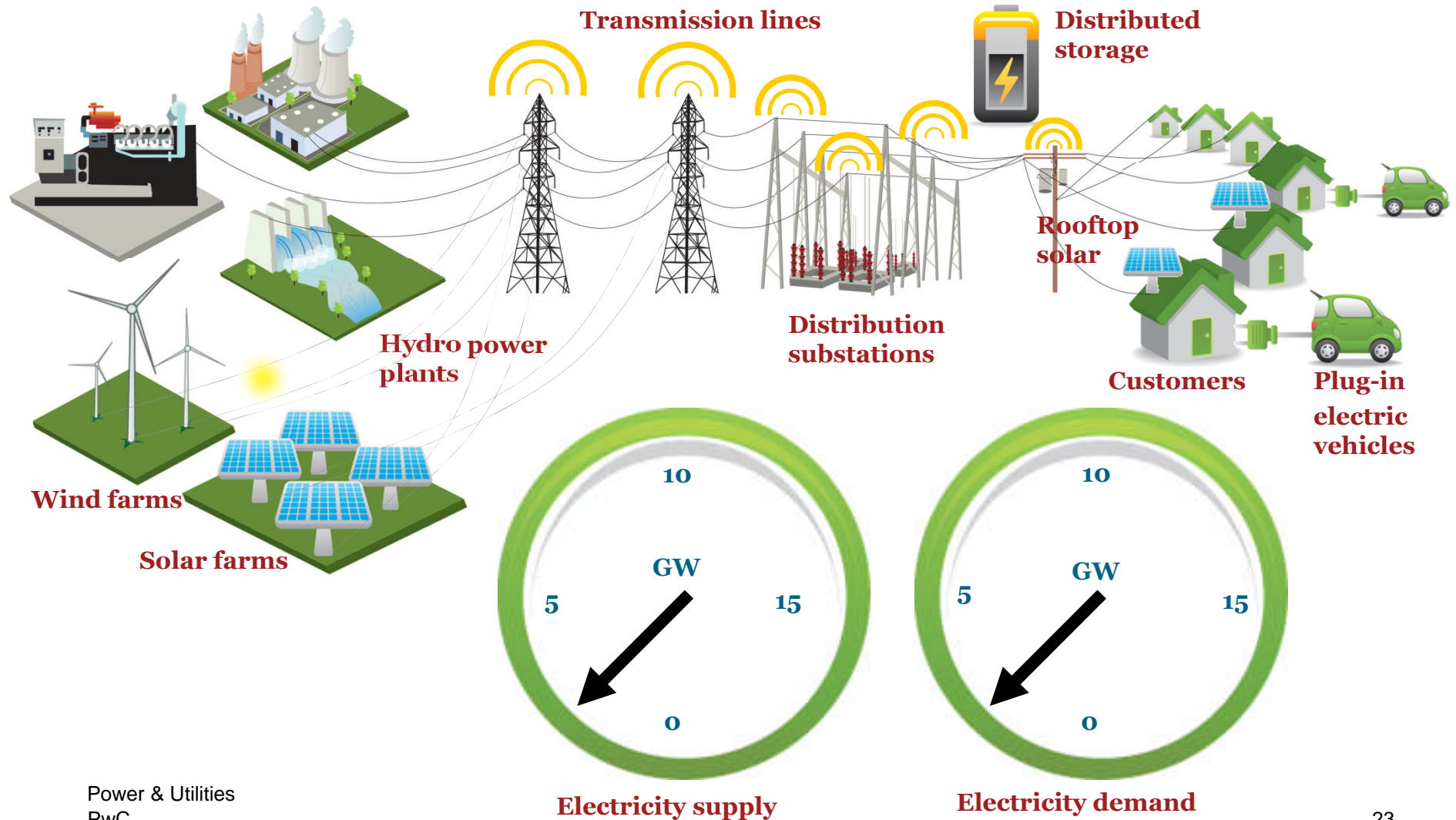
New global Power & Utilities 'biosphere'

- Renewables are adding volatility to the system and enable distributed generation as a key driver of the future business model of a P&U company
- Role of the customer is changing from consumer to prosumer
- Growing number of different stakeholders
- Demand has to follow supply
- New financing models will emerge
- The energy transformation will occur at different time and pace in various markets - ***BUT IT WILL IMPACT ALL P&U COMPANIES GLOBALLY***

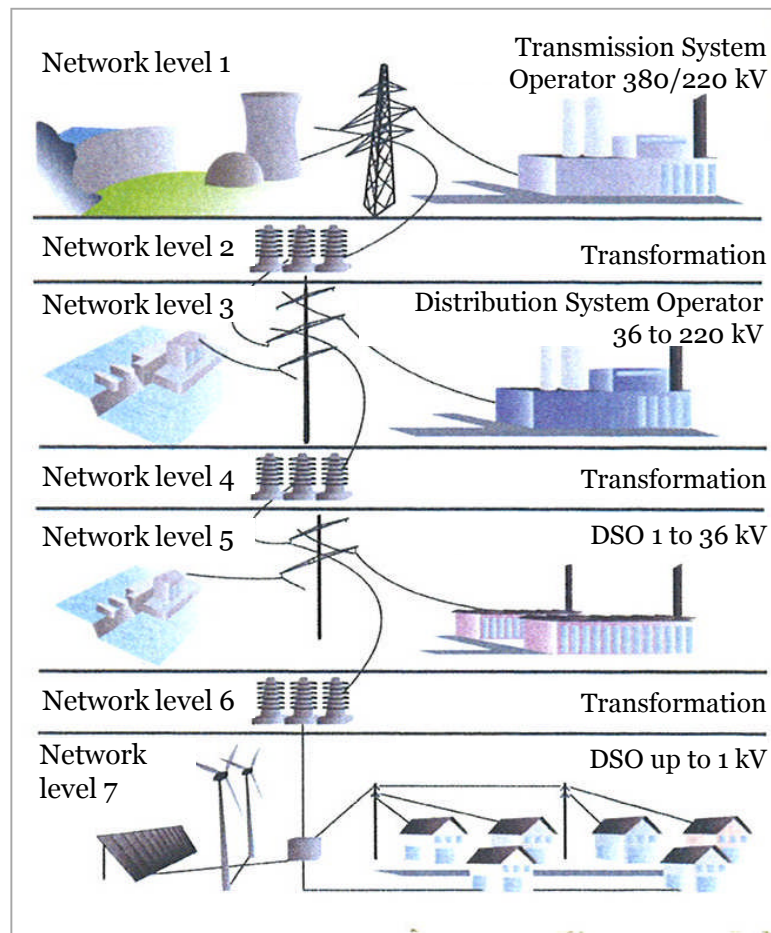
- ➔ need for back up capacity
- ➔ need for management of big data flows bidirectionally
- ➔ need for balancing of a complex system with many players
- ➔ need for a smart demand side management to ensure a reliable energy supply



With Smart Grid, the balance between electricity supply and demand can be restored



The impact of the components depends on the grid level – e.g. Smart Grid



- Smart Grid has different effects – in particular depending on the grid level (transmission grid or distribution grid)
- The transmission grid connects huge, central power generation plants (e.g. wind farms) with urban centres
- In the distribution grid Smart Grid leads to an increasing decentralized balancing of power generation and consumption
- The result is a growing number of (regional) markets which have to be managed
- DSOs will be existing on various levels

Source: Arosa Energie, Switzerland

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Smart Metering increases transparency for the consumer

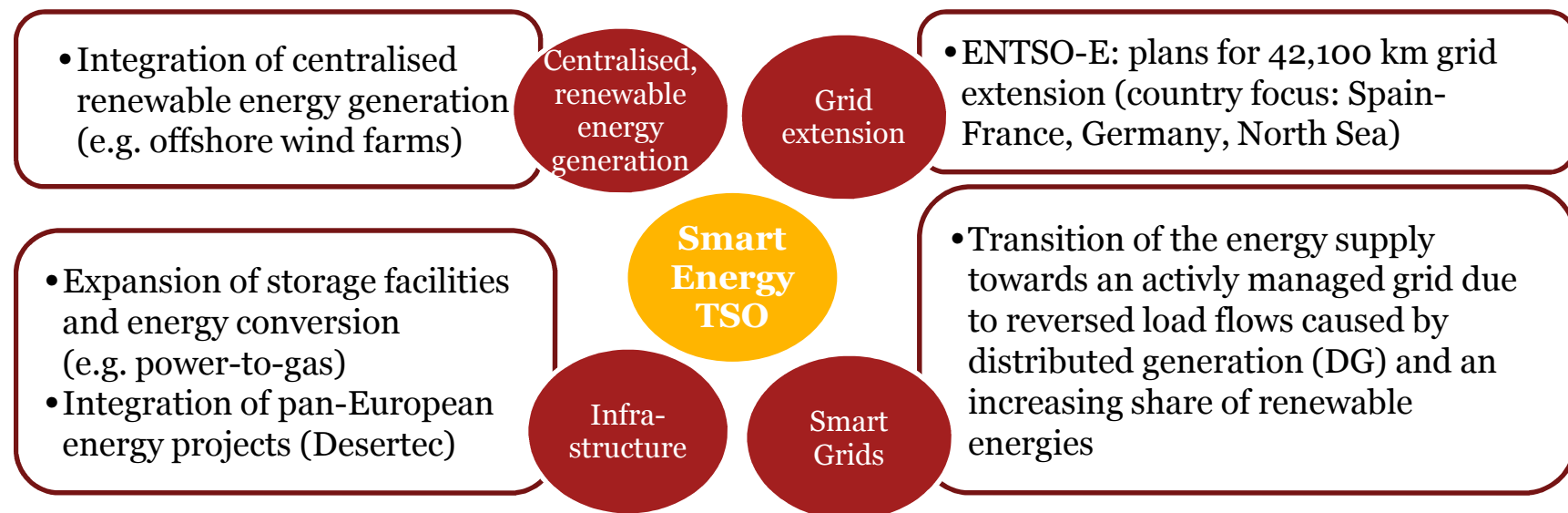
Examples for Smart Metering:



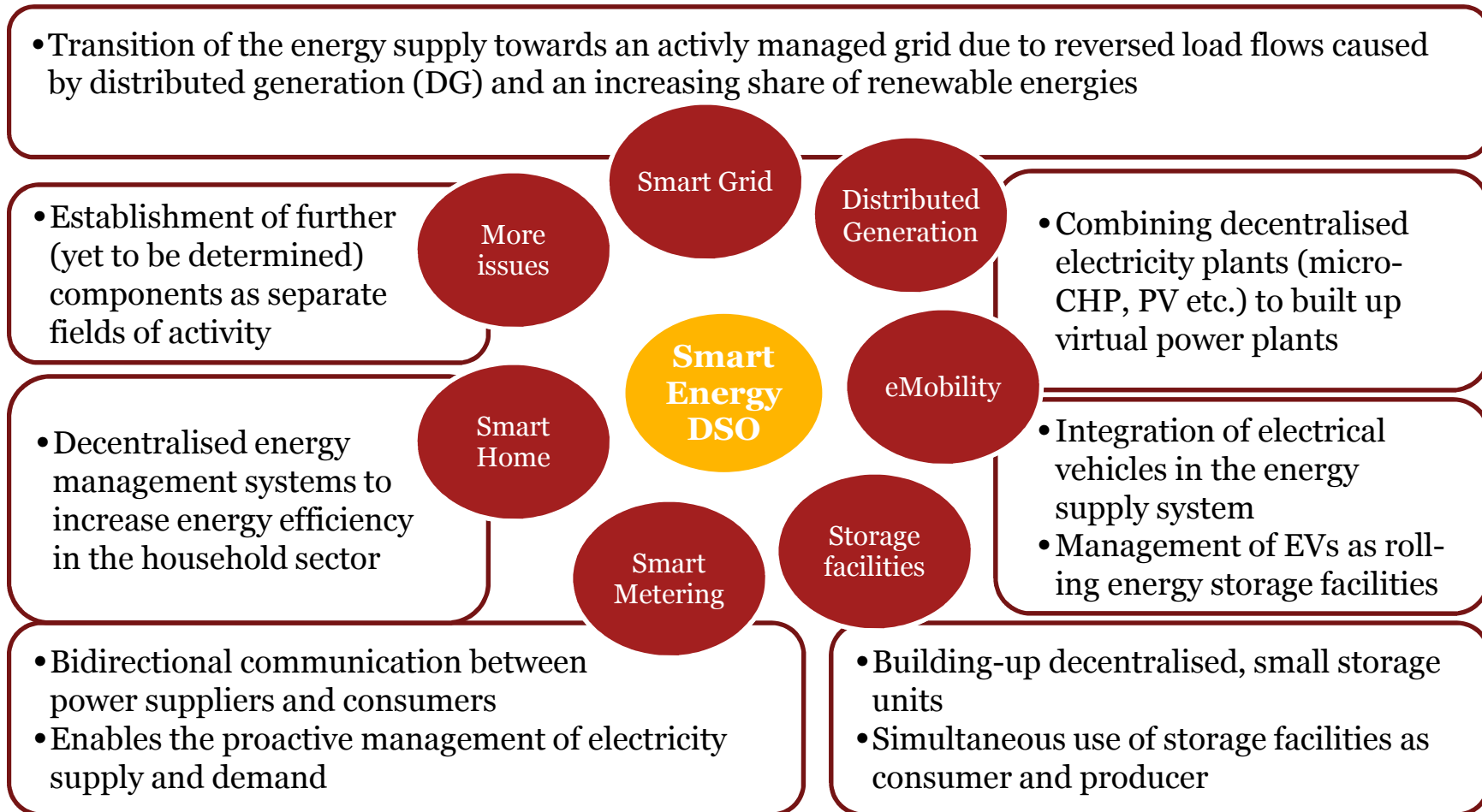
- By the exchange of mechanical meters with Smart Meters, various benefits can be generated:
 - Visualisation of energy consumption increases the consumer's benefit and can be used as feedback system
 - Active consumption controlled by price signals
 - Further services, such as building monitoring and surveillance
 - Real time usage and pricing information
- However: Someone has to take care of, collect, analyse and secure the data for an efficient management of the system

The grid integration of new generation hubs is a key task of Transmission System Operators (TSOs)

- The extension of the transmission grid and the integration of transnational grid services becomes a challenging task for all participants in this grid level
- Beyond this, the integration of huge renewable energy plants tends to overload the current transmission grid
- Hence, Smart Grid becomes a topic also for TSOs



In the future, DSOs operate more self-sufficient, but still require the connection to the TSOs



Smart Energy is not only an issue for the energy industry

Smart City and eMobility

- Battery charging systems
- Telematics
- Intermodal mobility
- Shared Spaces/ parking space management
- Car sharing

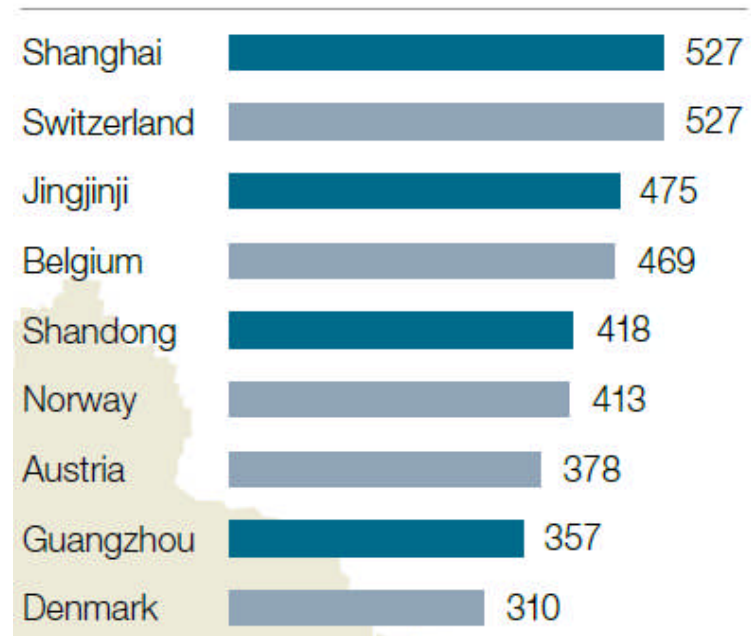
- Smart Cities can prospectively connect all existing infrastructure components – and beyond
- Smart Grids interlink the energy sector with the infrastructure of urban centres
- The driving forces are the increasing number of regional energy markets as well as the expansion of ICT
- Smart Cities integrate further components, such as the expansion of broadband, eBusiness and eGovernment



Smart cities

- Over the next 15 years, just 440 emerging market cities will generate nearly half of global GDP growth and 40 percent of global consumption growth.
- Some Chinese cities already now are economically larger than entire European countries.

2010 GDP for urban clusters in China vs selected countries, \$ billion



Source: McKinsey 2012, Winning the \$30 trillion decathlon: Going for gold in emerging markets

Cities around the world are reshaping their urban and rural communities



Green-field

- Skolkovo, Russia
- Dontang, China
- Eco-Tianjin, China
- KAEC, Saudi Arabia
- Lavasa, India
- Masdar City, United Arab Emirates
- Nanjing Ecocity, Nanjing, China
- SmartCity, Malta
- Songdo IBD, South Korea



Re-generation

- Porto Maravilha, Brazil
- Dockside Green, Victoria, Canada
- Hafencity, Hamburg, Germany
- Île Séguin-Boulogne Billancourt, Paris, France
- King's Cross, London, United Kingdom
- Portu Nuova, Milan, Italy
- Fujisawa, Japan
- Christchurch, New Zealand



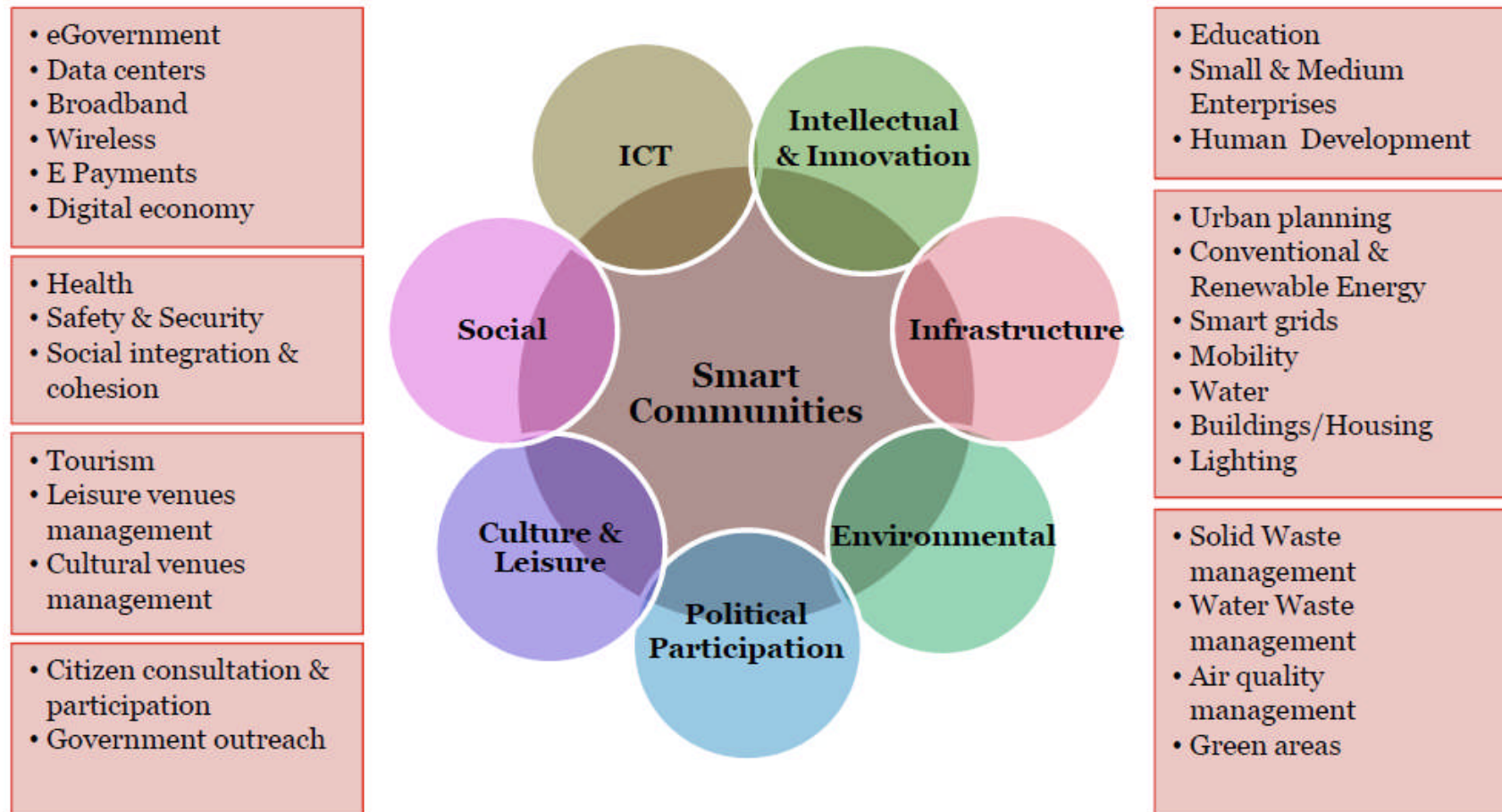
Retrofitting

- Amsterdam, Netherlands
- Copenhagen, Denmark
- Curitiba, Brazil
- London, United Kingdom
- Mexico City, Mexico
- Newcastle, Australia
- New York, United States
- Stockholm, Sweden
- Vancouver, Canada


Technology enabled Services

A Smart City is a holistic ecosystem

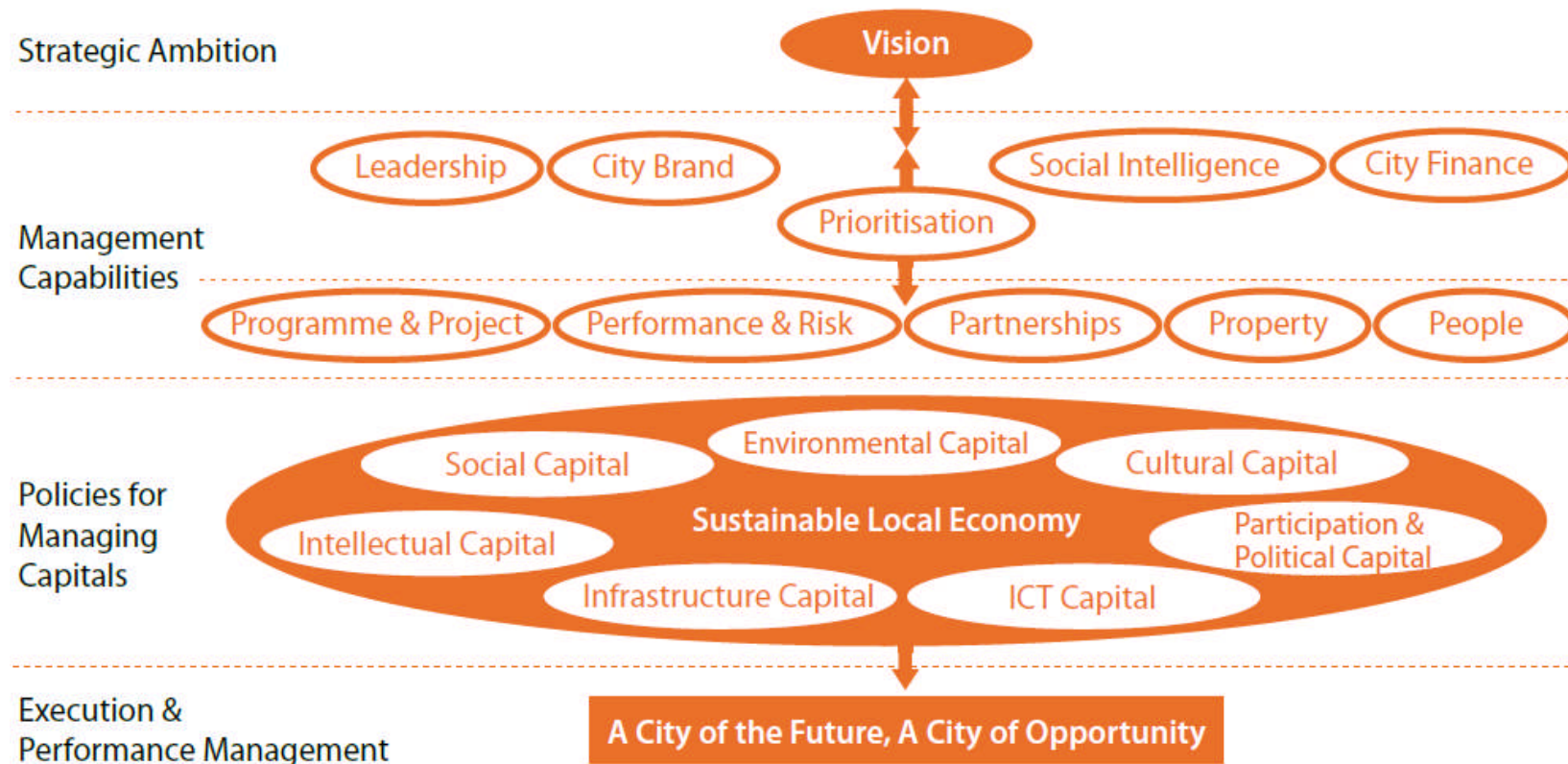
Where people are interconnected and contributing towards a common vision, creation of knowledge and exchange of ideas



Industry convergence around Smart Cities

- For a utility provider
 - How to make my grids smarter and smooth the peaks in my network to serve smart homes?
 - How much to invest in renewable sources?
 - For a telecom operator
 - How to configure my network to carry all the new traffic?
 - What value added services can I provide for a smart community?
 - For a technology provider
 - Which are my opportunities as a solution provider?
 - Which technology standards will prevail?
 - For a city manager:
 - How will developing a smart community enhance living quality for citizens, strengthen the economy and generate jobs?
 - How will smart initiatives be prioritized, funded and implemented?
 - For an automotive producer
 - Are my vehicles becoming obsolete?
 - How much to bet on the electric vehicles market?
 - For a financial institution
 - How to become the payment platform of choice?
 - What are my opportunities in infrastructure financing?
 - For an electronics goods producer
 - What are my customers needs as citizens in a smart community?
 - Which platforms will win?
 - For a health care provider
 - How can I leverage technology to provide universal health care?
 - How to deal with privacy issues?
 - For a media provider
 - What is my digital content strategy?
- 
- The diagram consists of three interlocking gears. The top gear is labeled 'New business models'. The bottom-left gear is labeled 'Conversing value chains'. The bottom-right gear is labeled 'Expectations for smarter products and services'. Arrows indicate a clockwise flow between the gears, suggesting a cyclical relationship between these three concepts.

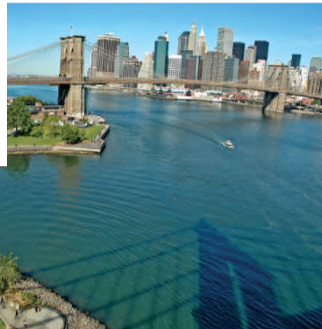
A holistic approach to visioning and execution of city strategy



PwC's thought leadership



Cities of Opportunity



Cities of Opportunity



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Smart cities

From earthen walls to smart grids

October 2012

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Smart specialization for cities

A roadmap for city intelligence and excellence

By Jan Sturesson, Hazem Galal and Laurent Probst



How to build an intelligent city
The broad view of holistic development should nevertheless be coupled with a deepening of strategy and positioning. This is pursued in part by developing clear leadership and leadership.

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"We need new perspectives of cities, their visions, knowledge, creativity and motivation in order to find new ways to develop strategic city management."

The growing importance of cities
The OECD estimates that 70% of the world's population will live in urban areas by the year 2020. UNDECO projects that by 2015, there will be 26 megacities (cities with more than 10 million people), with more than 10% of the world's population living in these cities. Clearly, city perspectives, strategies and governance have become key focus points on national government agendas, with cities around the world increasingly seen as engines for growth.

What will define one city from another, however, is whether it can manage its potential growth effectively and sustainably, or it will be swept away by the unintended consequences of a rising wave

of urban cities in areas in which it is not making the most of its capital and opportunities.

Global trends

12th PwC Annual Global Power & Utilities Survey

26 The World Financial Review

The shape of power to come

Investment, affordability and security in an energy-hungry world



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