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GRAND TRANSITION, DIGITAL REVOLUTION & NEW ENERGY REALITIES

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Three Scenarios Stories

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MODERN JAZZ

Market-driven approach to achieving individual access and affordability of energy through economic growth

- Market mechanisms
- Technology innovation
- Energy access for all

UNFINISHED SYMPHONY

Government-driven approach to achieving sustainability through internationally coordinated policy and practices

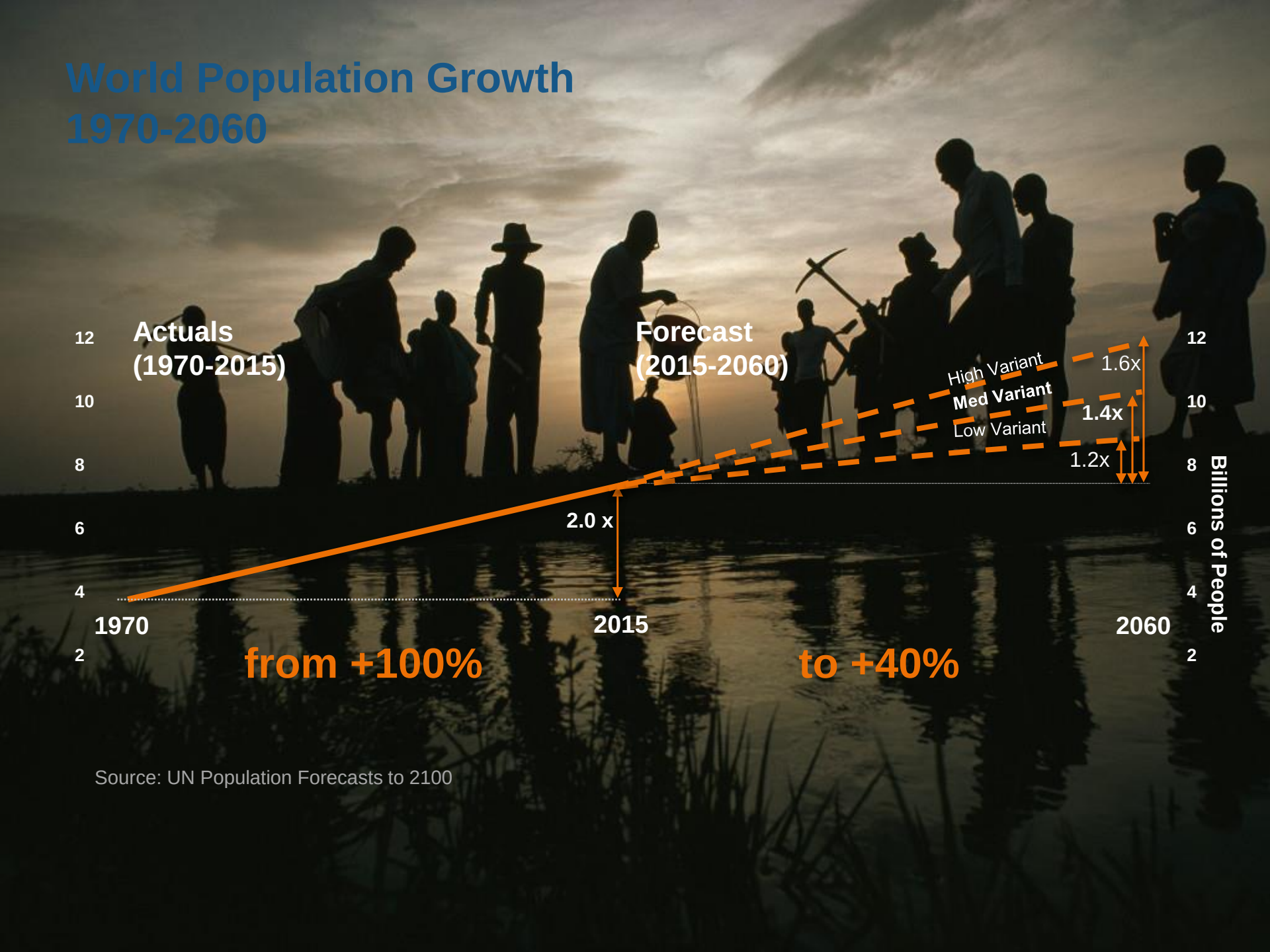
- Strong policy
- Long-term planning
- Unified climate action

HARD ROCK

Fragmented approach driven by desire for energy security & independence in a world with low global cooperation

- Fragmented policies
- Local content
- Best-fit local solutions

World Population Growth 1970-2060



Source: UN Population Forecasts to 2100

Carbon Intensity Reduction 1970-2015

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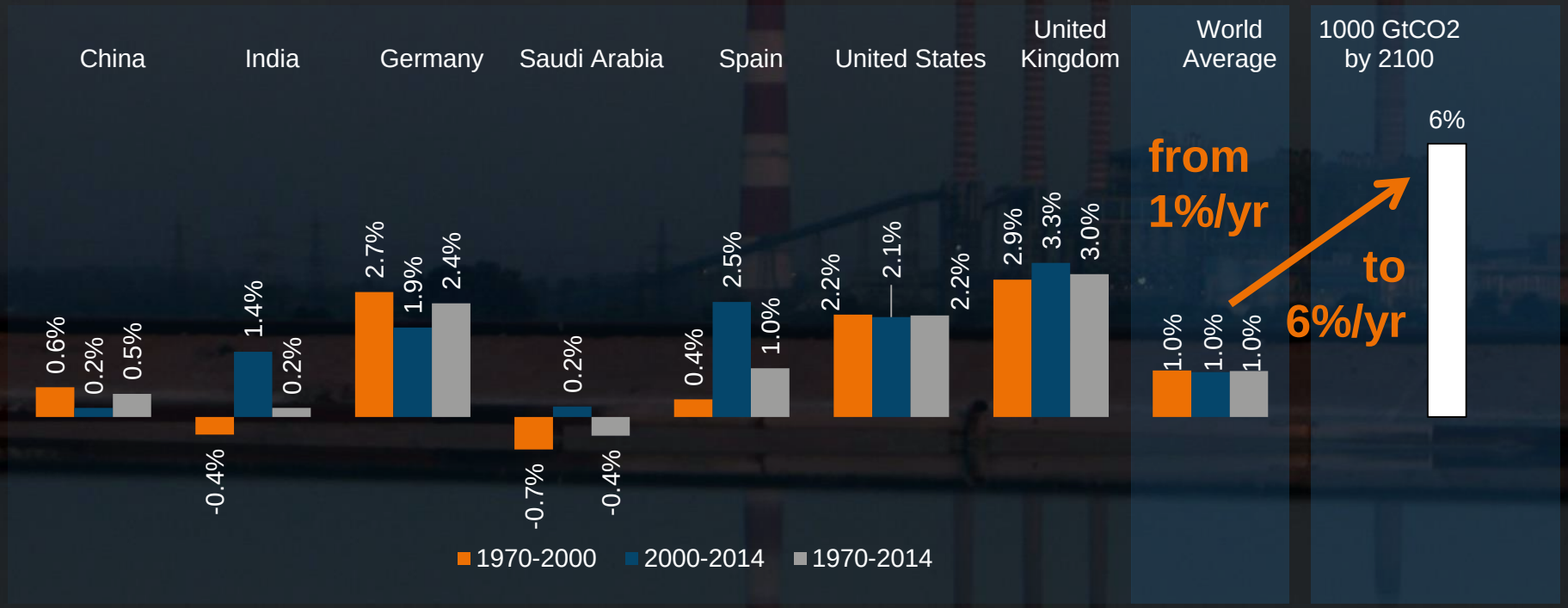
% reduction p.a. 1970-2015 Actuals

2015-2060 de-carbonization required to achieve 1000 $GtCO_2$ by 2100



Source: Total Economy Database, BP (2015) Statistical Review, IPCC (2015) "AR5, Synthesis Report";
Note: Positive % changes denote a reduction in CO_2 emissions [Gt] per GDP [USD]

Note: Assumes global GDP growth of 2.6%

World Energy Issues Monitor
2018

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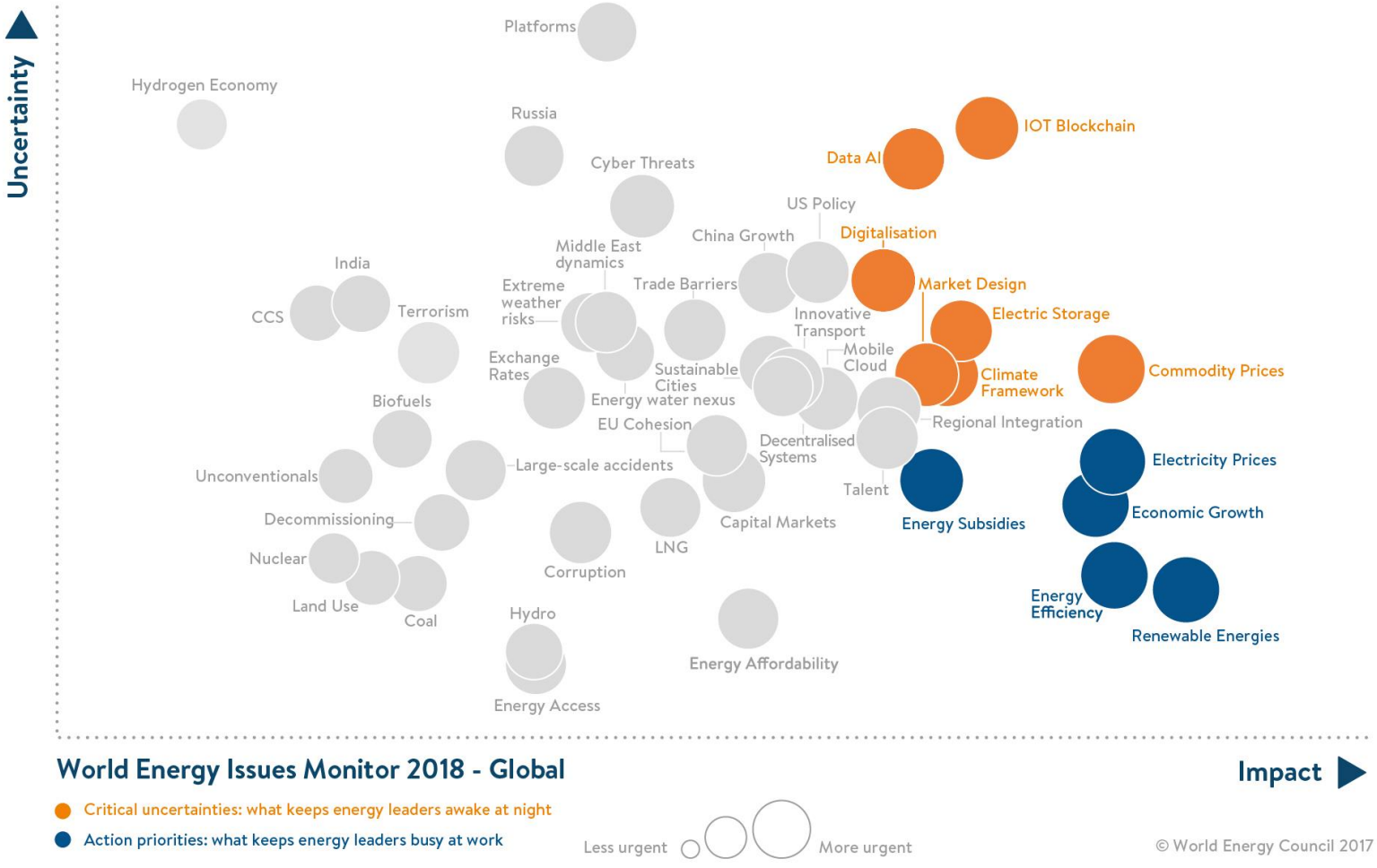

World Energy Issues Monitor
2018

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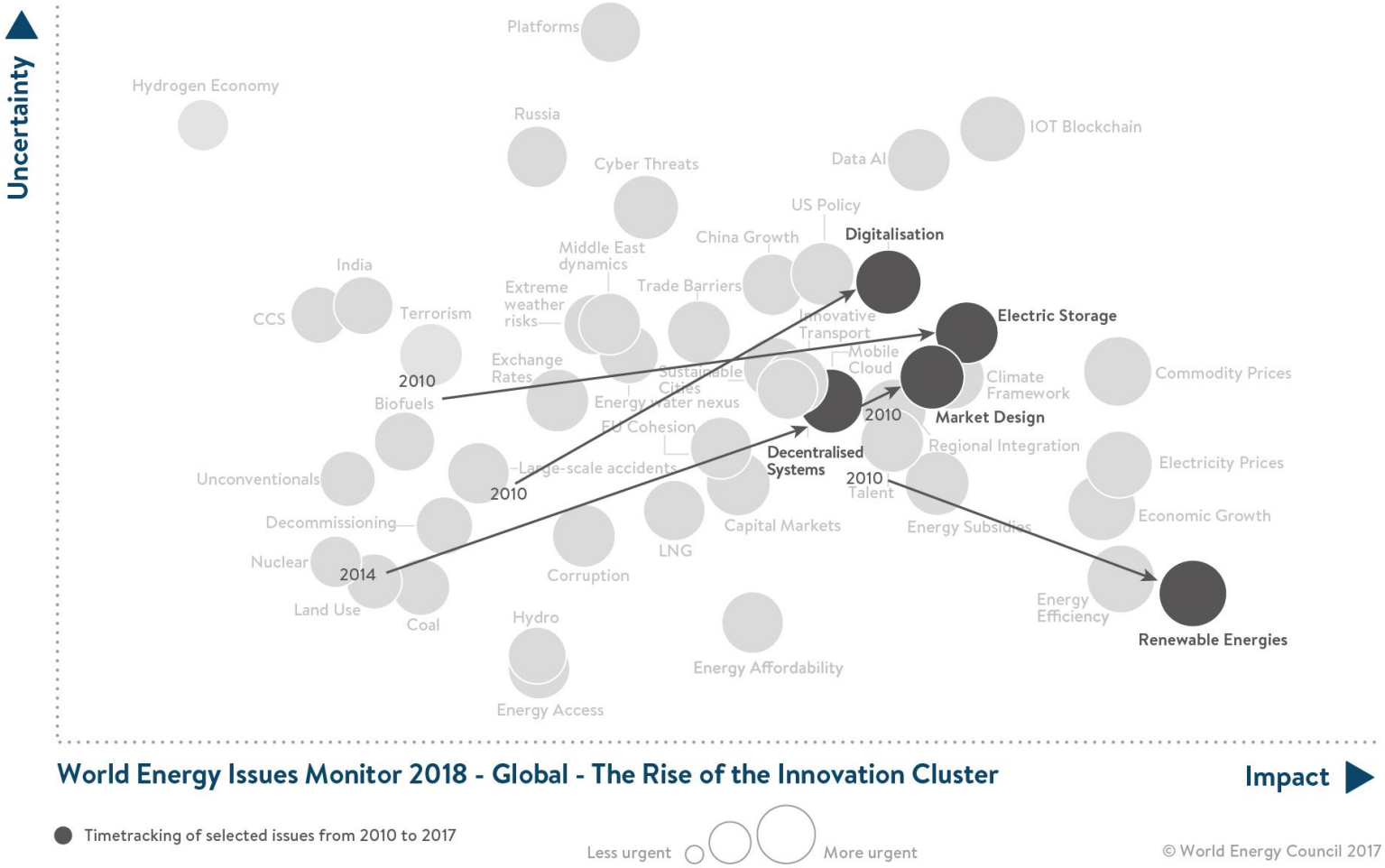

World Energy Issues Monitor
2018

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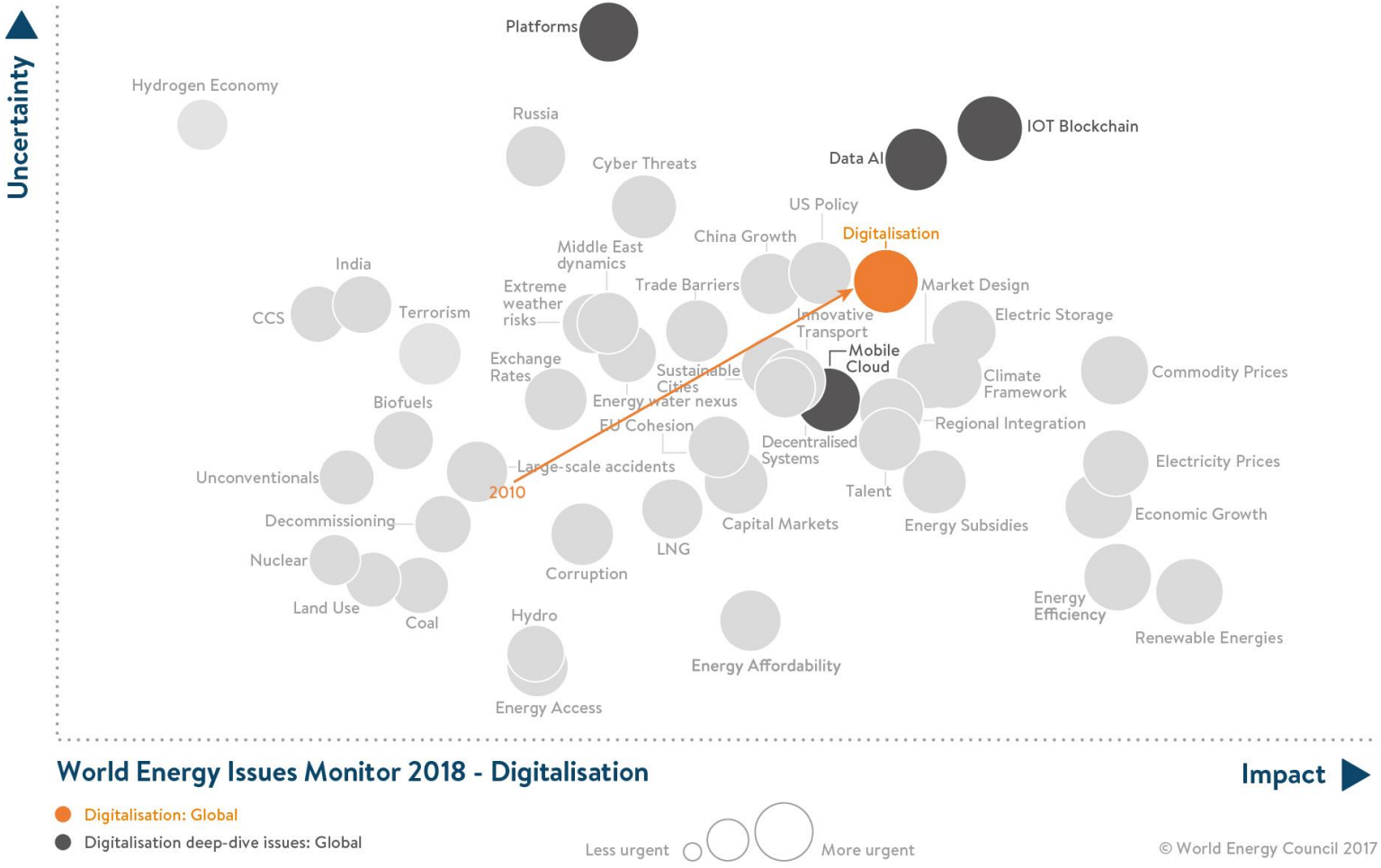

World Energy Issues Monitor
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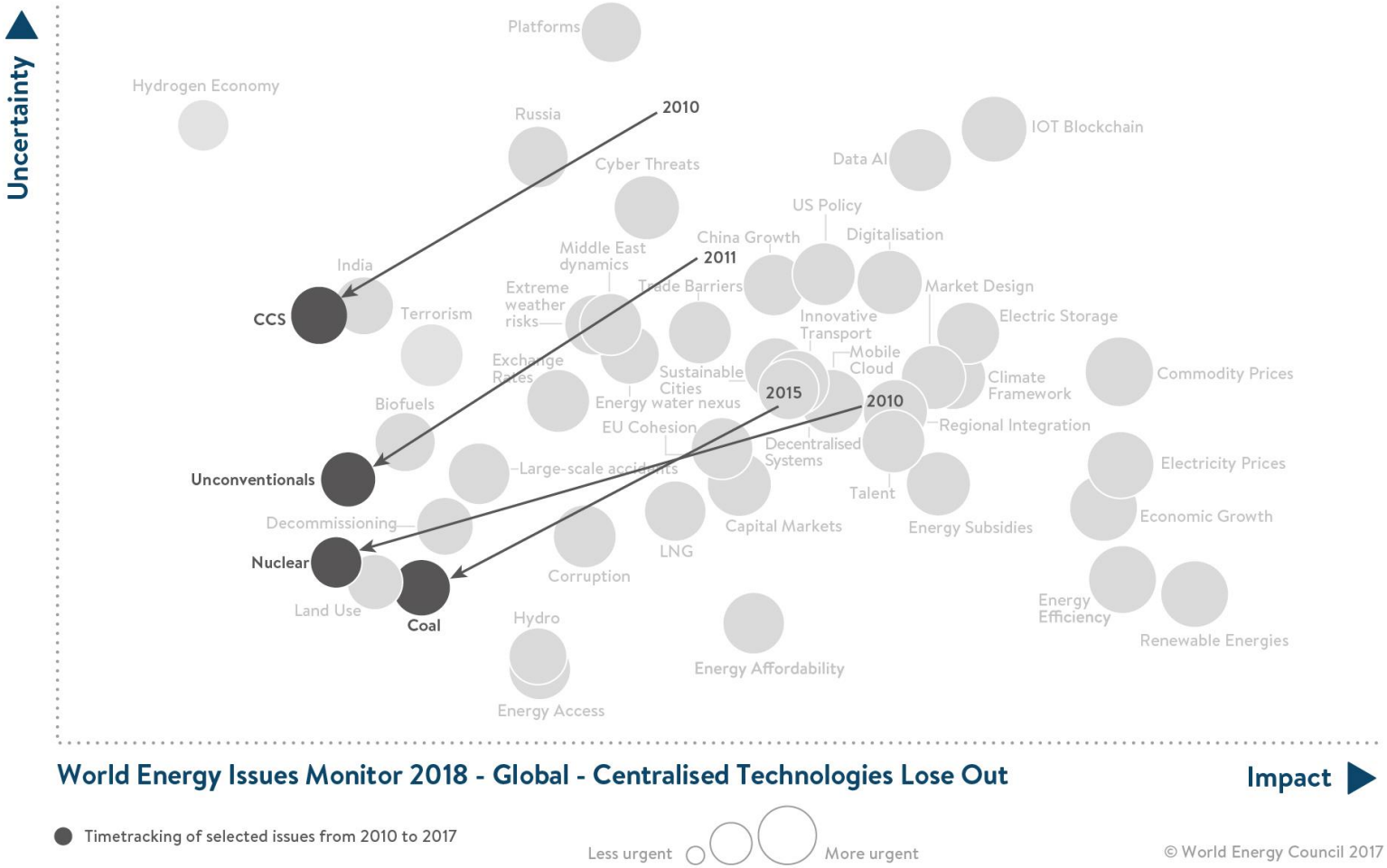

World Energy Issues Monitor

2017, Mexico

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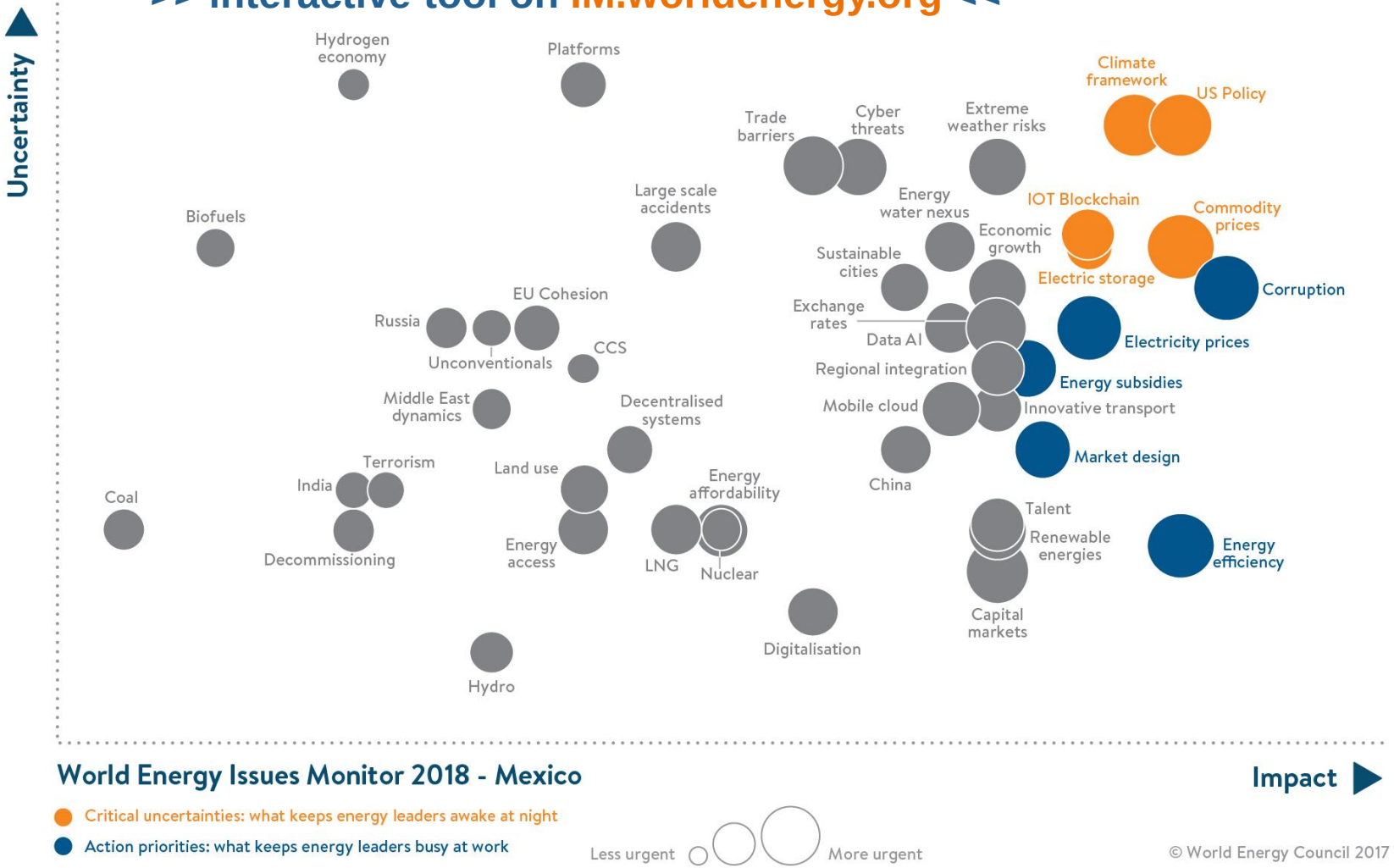
>> interactive tool on IM.worldenergy.org <<




17/11 Mexico’s Energy Auction
$19.18/MWh average price
17/10 300MW in Saudi Arabia
$$17.86/MWh average price
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“uberisation in energy”

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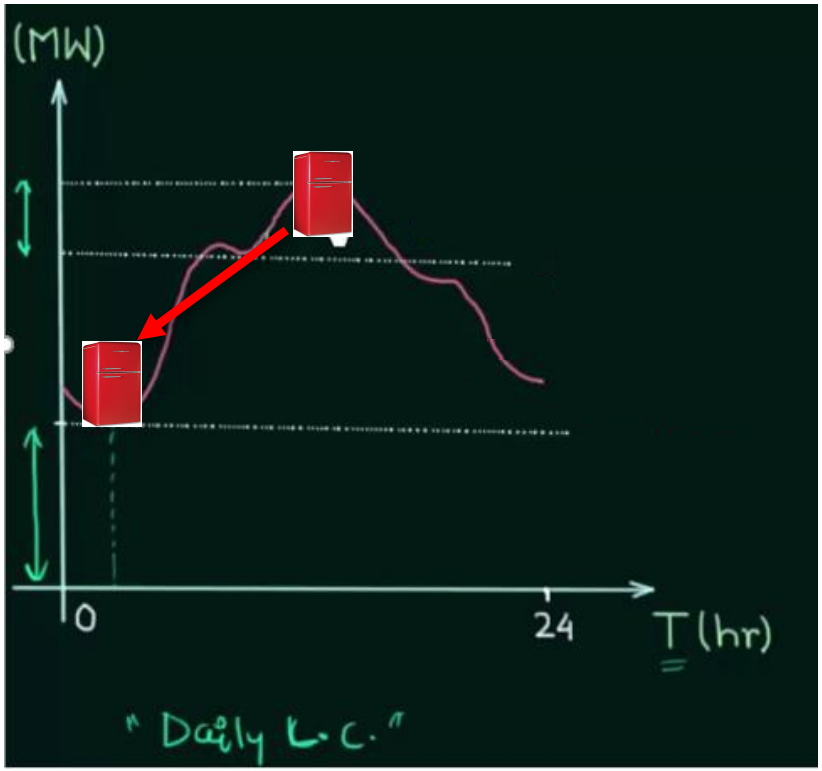

California's DERPs

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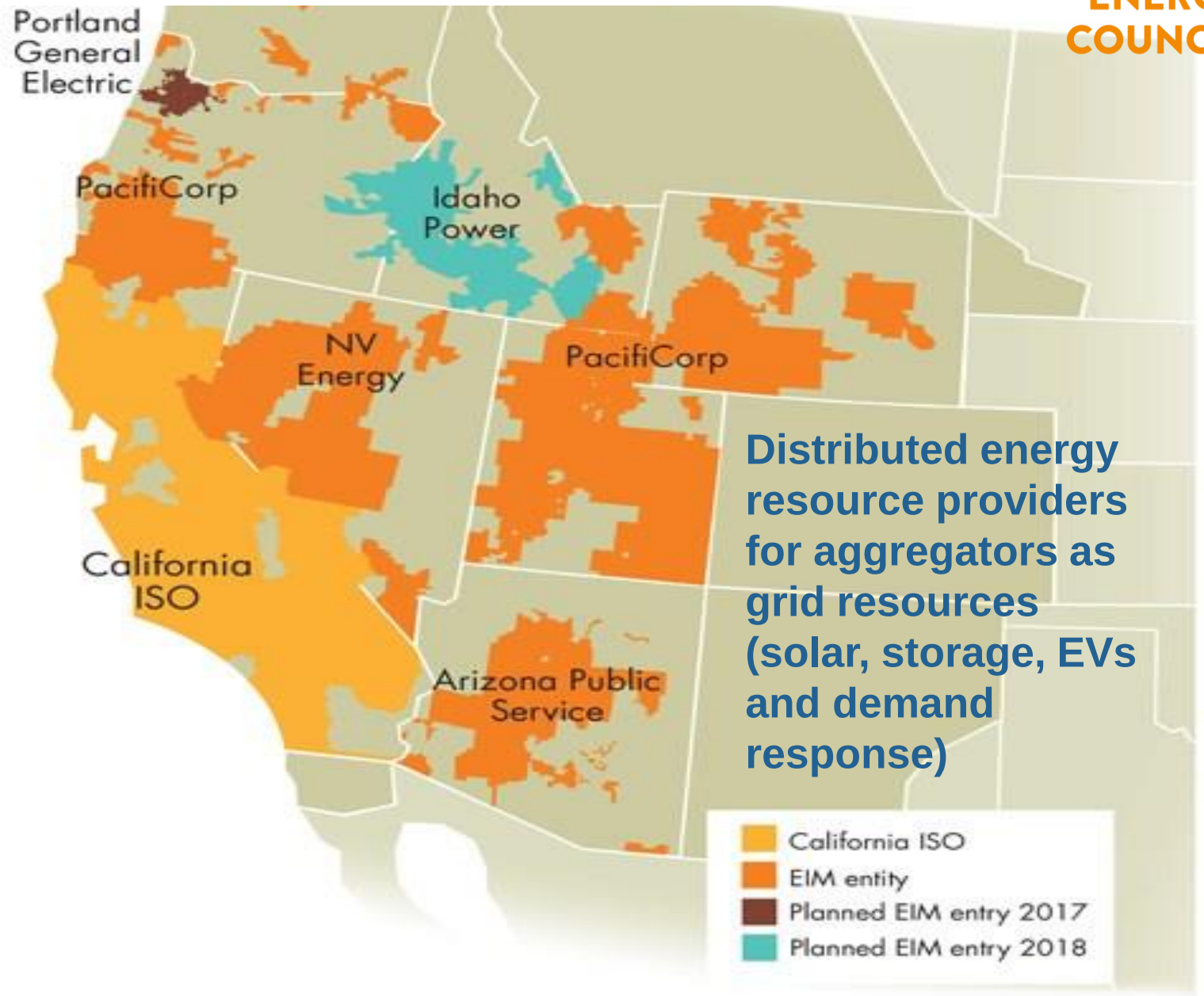

Distributed energy resource providers for aggregators as grid resources (solar, storage, EVs and demand response)

Digitalization & decentralization: Rural household solutions

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Do it yourself: DHL-style

Green molecules, building on existing supply chains: Formic Acid, Ammonia, …

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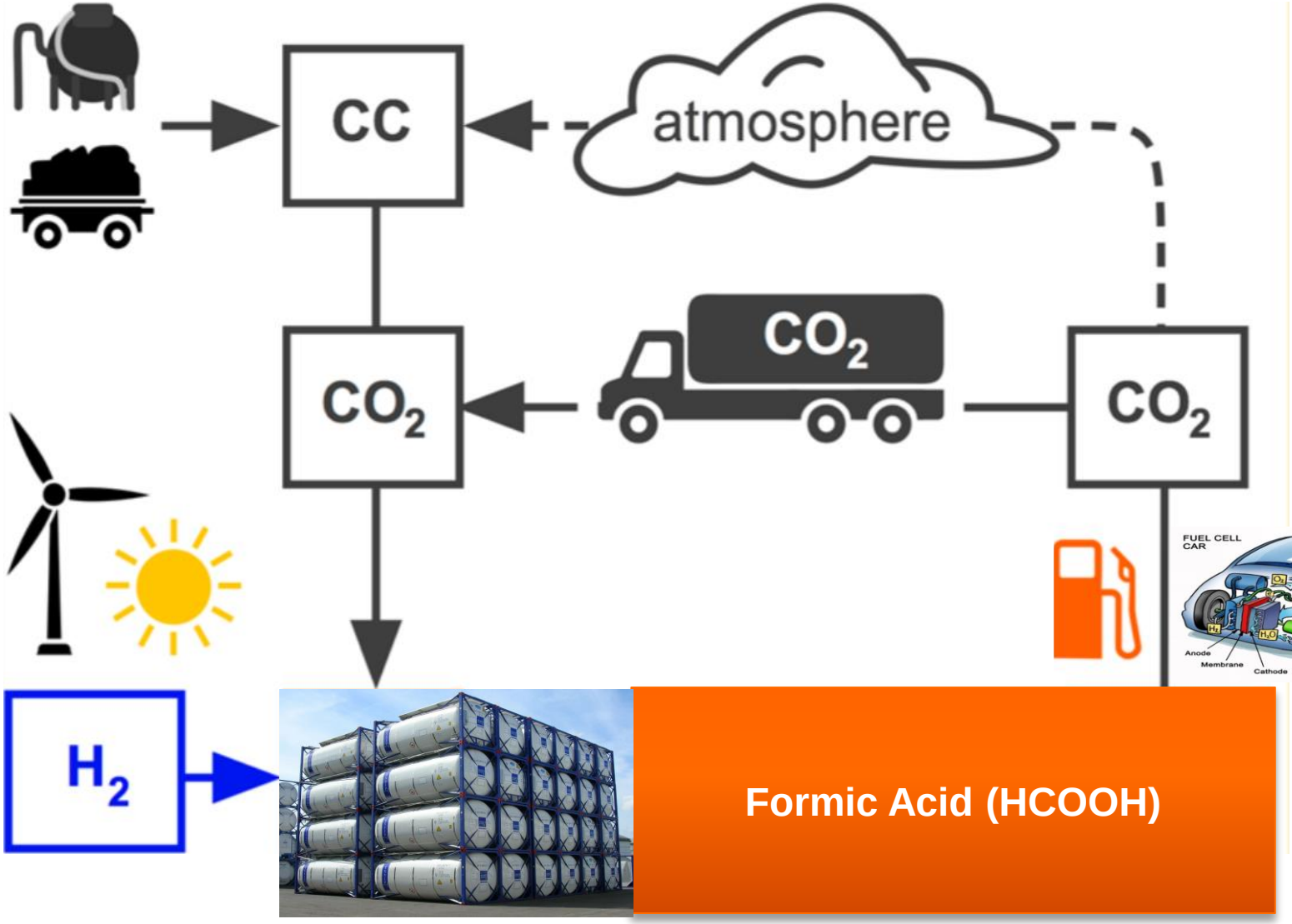

New Risks / Resilience
Extreme Weather Events

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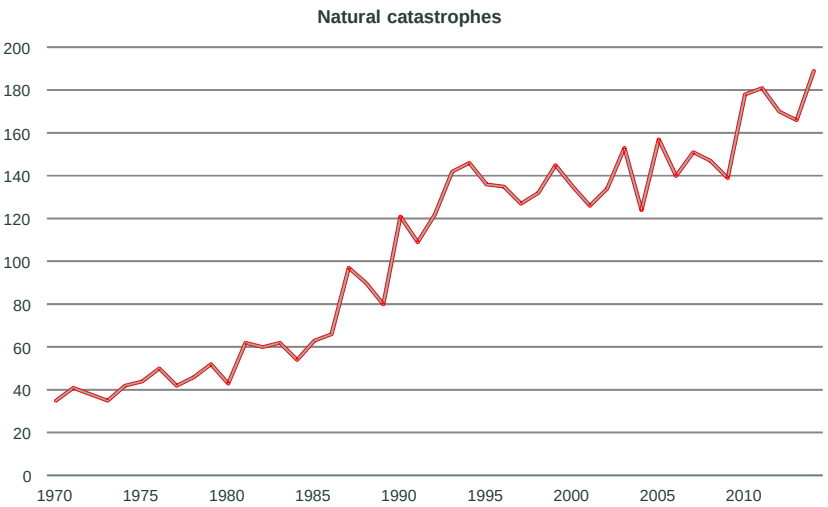
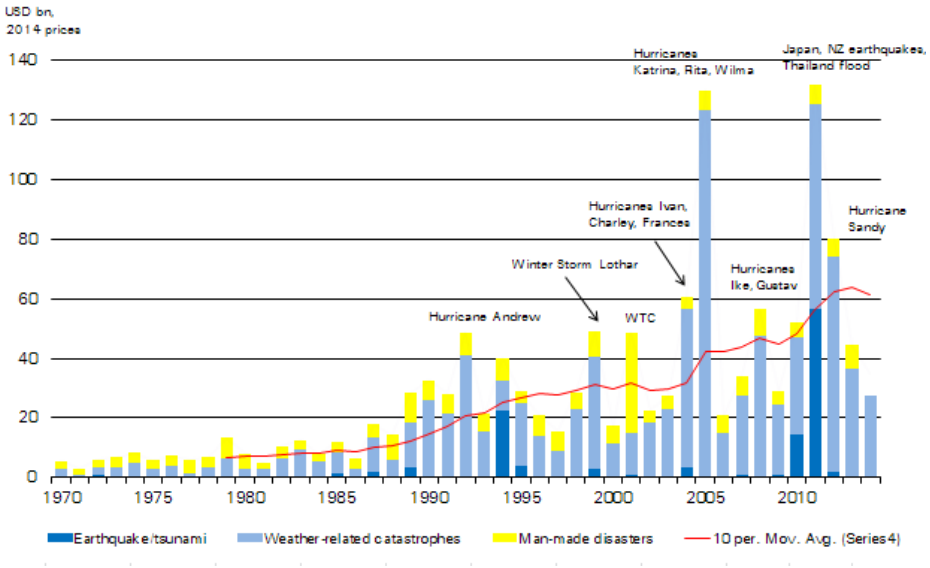
Number of natural catastrophes, 1970-2014: factor 4



Source: Swiss Re Sigma 02/2015

Insured catastrophe losses, 1970-2014



- **Comparing the last 5 years to the last 20 years: The occurrence of extreme events has roughly quadrupled; according to IPCC this is largely related to the 40% increase of carbon dioxide in the atmosphere.**
- **From impact-resistant "hard"/'safe-fail' components to "soft"/'fail-safe' systems.**
- **The solution appears to be 'smarter not stronger'.**

Source: WEC Financing Resilience Report, 2015 (October 1); also Swiss Re, 2015: Sigma report No 2/2015

New Risks / Resilience

New Risks / Resilience

World Energy from 1970 and Pre-determined elements of the Grand Transition

	Factors that shaped world energy 1970 - 2015	Pre-determined elements 2015 - 2060
Population / Workforce	▪ Global population grew 2x (1.7% p.a.)	▪ Global population will grow 1.4x (0.7% p.a.)
New Technologies	▪ ICT revolution ▪ Productivity growth rate of 1.7% p.a.	▪ Pervasive digitalisation; combinatorial impacts and productivity paradox
Planetary Boundaries	▪ 1,900+ Gt CO_2 consumed	▪ 1,000 Gt CO_2 max. consumed to 2100 for the 2°C target
Shifts in Power	▪ Rapid economic rise of developing nations ▪ Growing role for global institutions, e.g. UNFCCC, IMF, WTO and G20	▪ 2030: India is most populous country ▪ 2035-45: China is the world's largest economy
Resiliency	▪ Fail-safe, "oak" systems	▪ Safe-fail, "reed" systems

Scenarios Key Findings

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1. The world per capita energy demand will peak before 2030.
2. Demand for electricity will double to 2060.
3. The phenomenal rise of solar and wind energy will continue at an unprecedented rate.
4. Coal and oil demand peaks have the potential to take the world from “Stranded Assets” to “Stranded Resources.”
5. Transitioning global transport forms one of the hardest obstacles to overcome in an effort to decarbonise future energy systems.
6. Limiting global warming to no more than a 2°C increase will require an exceptional and enduring effort, far beyond already pledged commitments and with very high carbon prices.
7. Global cooperation & trade, coordinated climate policy and technology innovation are needed to balance the Energy Trilemma.

4 Demand peaks for coal and oil

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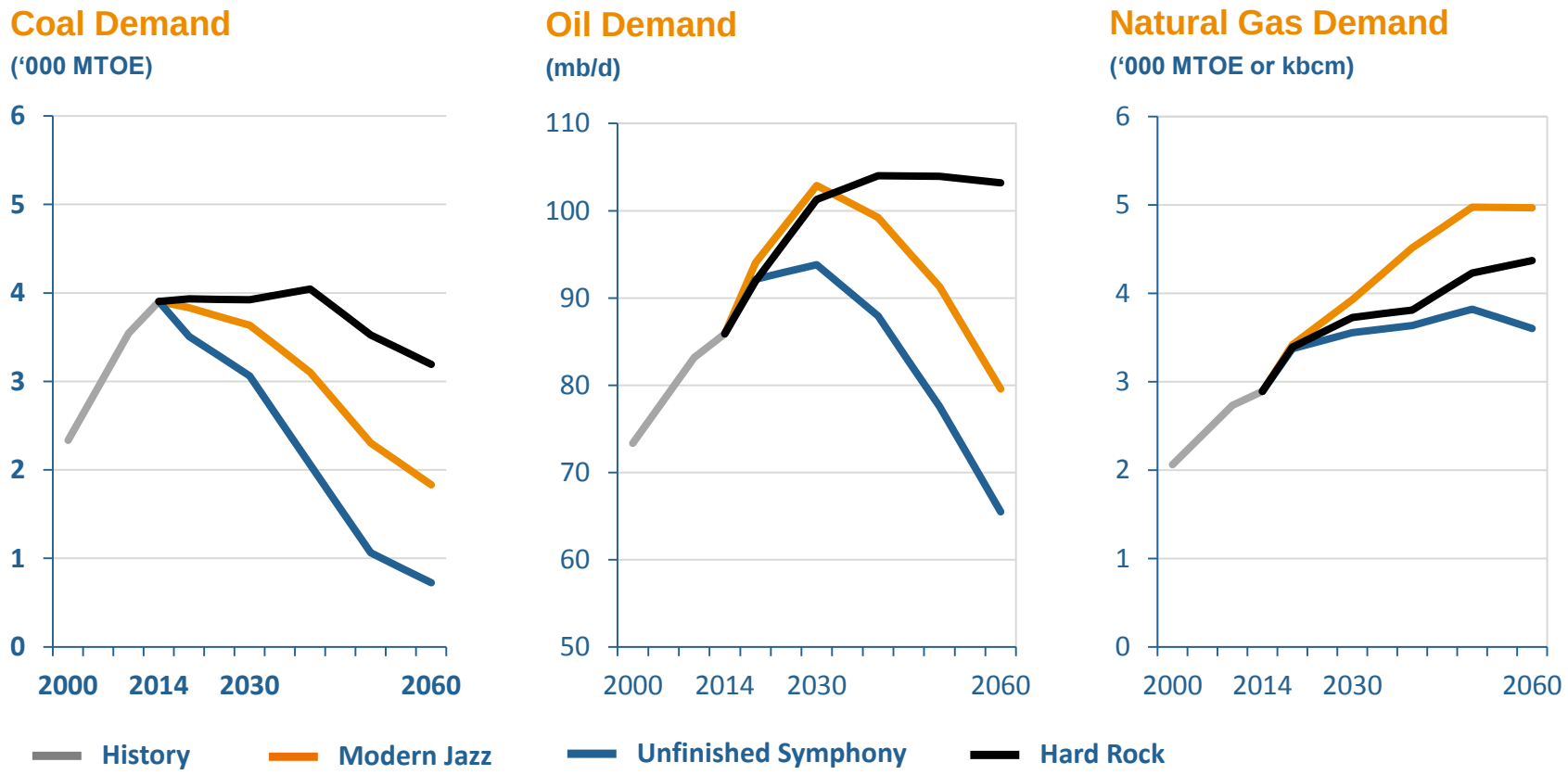
… have the potential to take the world from “Stranded Assets” to “Stranded Resources”.



6 Limiting global warming

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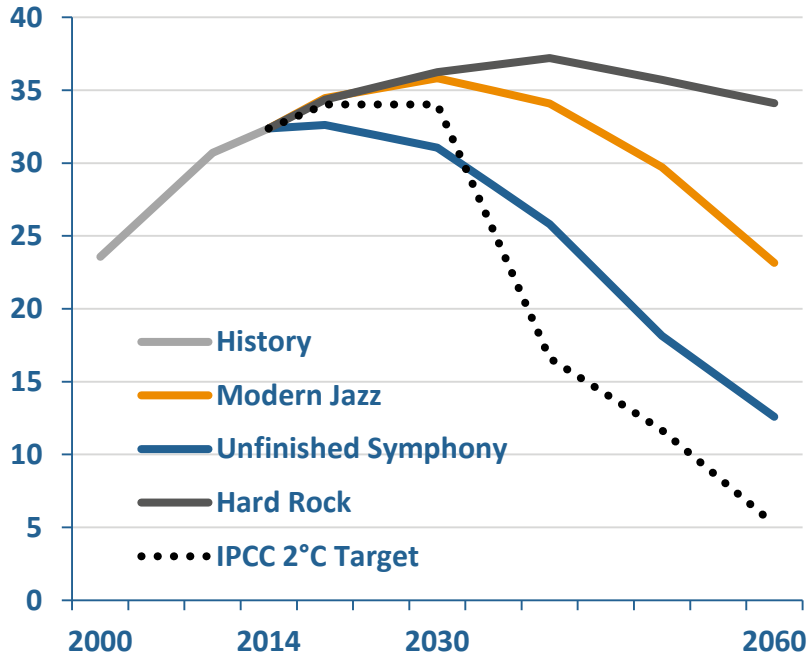
… to no more than a 2°C increase will require an exceptional and enduring effort, far beyond already pledged commitments and with very high carbon prices.

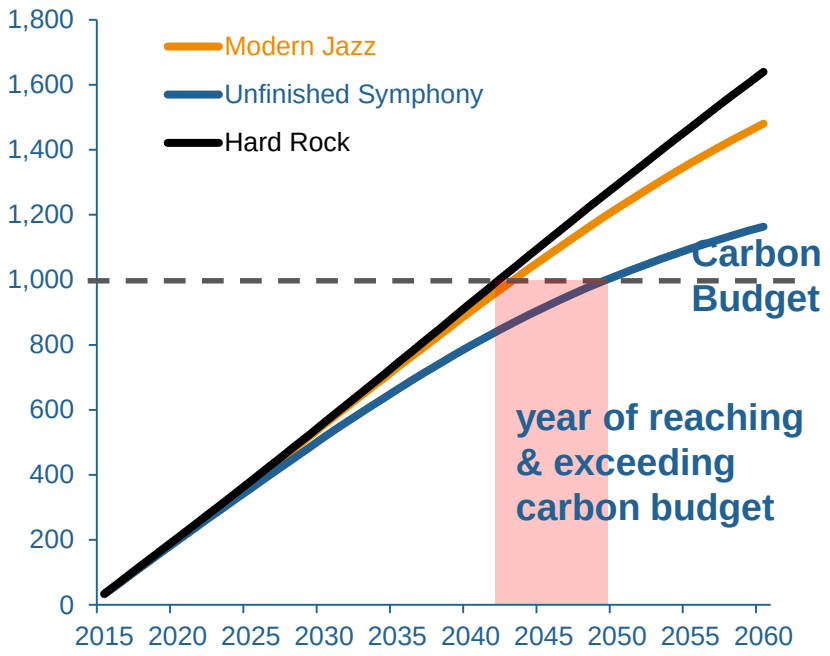
Annual Carbon Emissions

(Gt CO_2)



Cumulative Carbon Emissions 2015-2060

(Gt CO_2)



Balancing the ‘Energy Trilemma’

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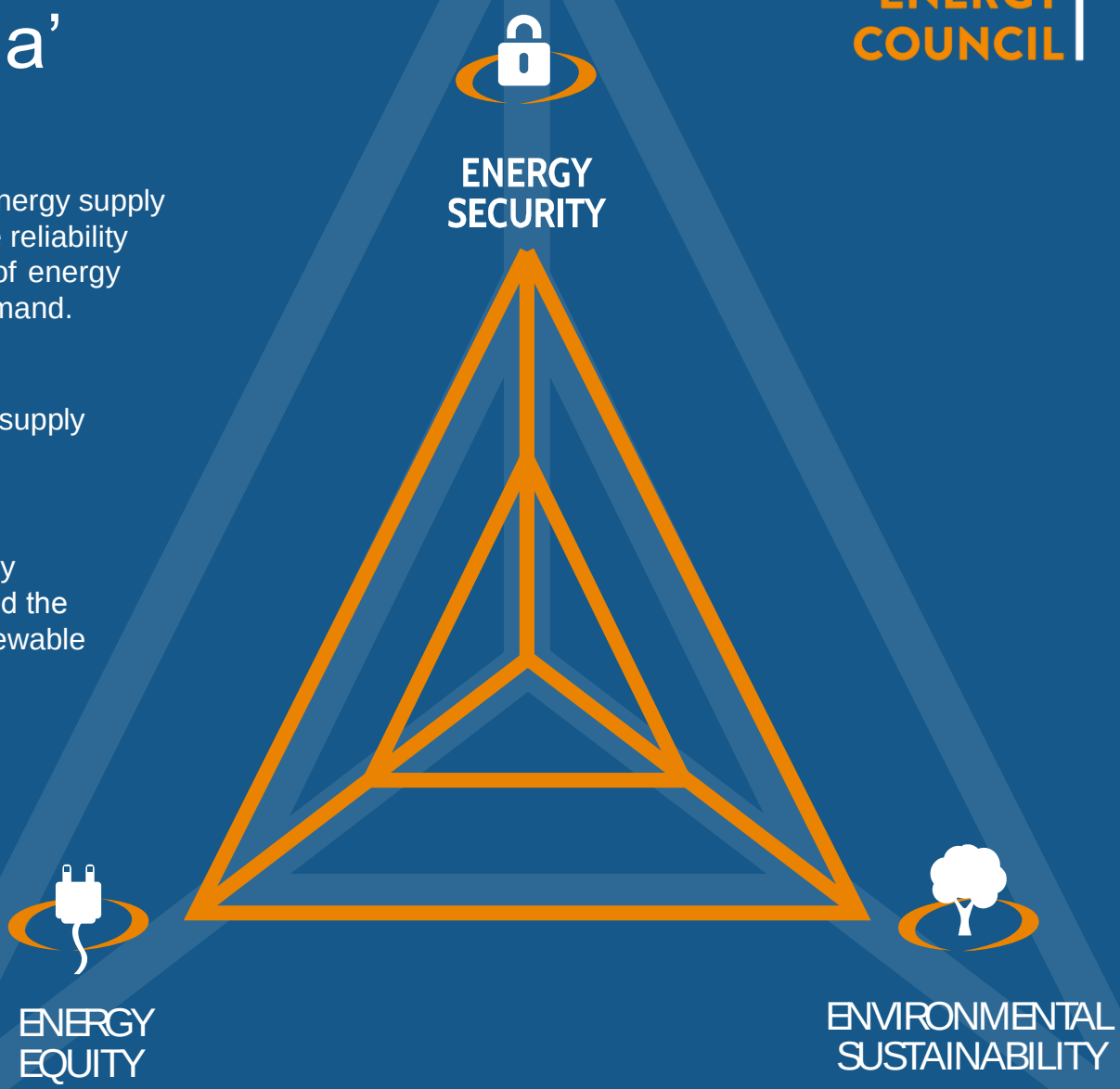
Energy Security
The effective management of primary energy supply from domestic and external sources, the reliability of energy infrastructure, and the ability of energy providers to meet current and future demand.

Energy Equity
Accessibility and affordability of energy supply across the population.

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



7 ENERGY TRILEMMA IN 2060

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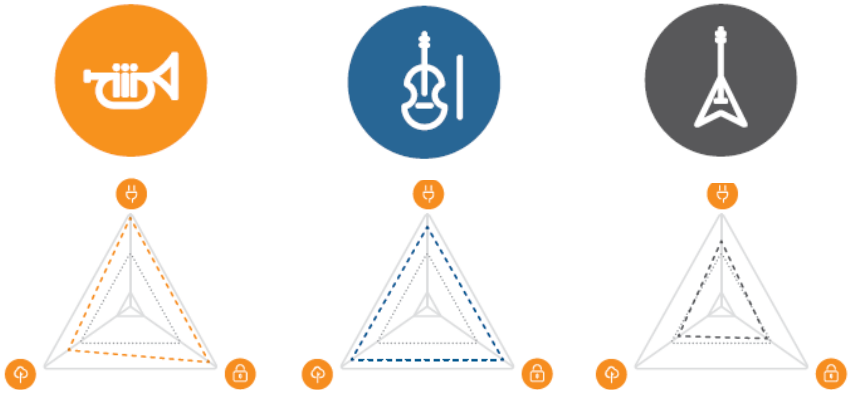
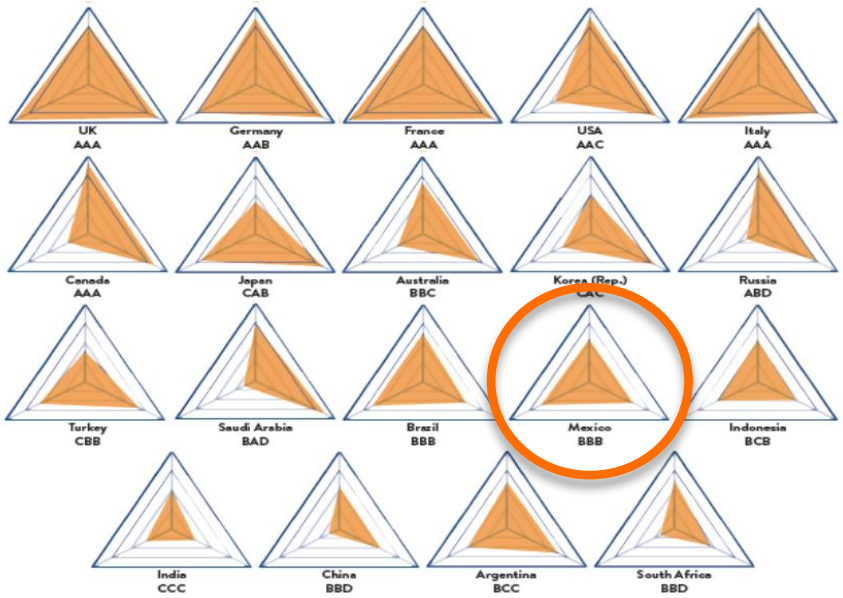
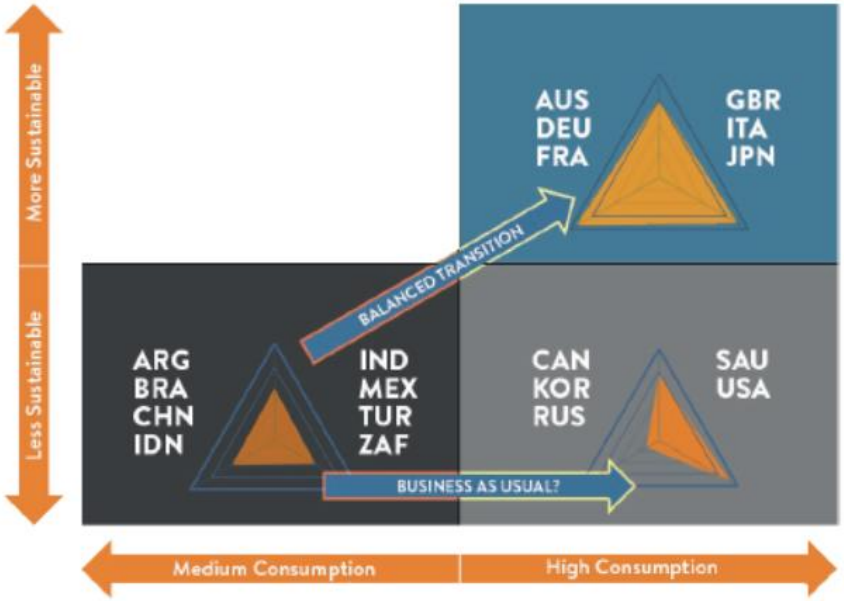


	Modern Jazz	Unfinished Symphony	Hard Rock
Energy Security	• Higher energy production • Greater trading and diversity of international fossil energy suppliers	• Wider diversity of energy resource types • Government-promoted investment in Infrastructure	• More domestic production • Lower capacity for funding infrastructure • Lower trade
Energy Equity	• Energy Access for all by 2060	• 0 – 0.5 bn people still lack access to energy	• 0.5 – 1 bn people still lack access to energy
Environmental Sustainability	• Surpass Carbon budget in early 2040s • Emissions fall 28% below 2014 volumes in 2060	• Surpass carbon budget in before 2060 • Emissions fall 61% below 2014 volumes in 2060	• Surpass carbon budget in early 2040s • Emissions are 5% above 2014 volumes in 2060

World Energy Trilemma in G20





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Achieve "AAA"

- Energy Security: diverse energy mix & strong global relationships for long term supply security are more important than significant reserves or net exports.
- Energy Equity: over 1000 kWh/yr of electricity per capita for 100% of their population; also managed energy affordability and demand growth.
- Environmental Sustainability: few G20 countries (GBR, FRA, ITA) emit less than 750 $MtCO_2$ /yr, whilst maintaining efficient consumption between 5000 and 10,000 kWh/yr per capita.

- **Robust transition pathways balance Trilemma aspects in line with growing prosperity and**

World Energy Trilemma 2018

Mexico

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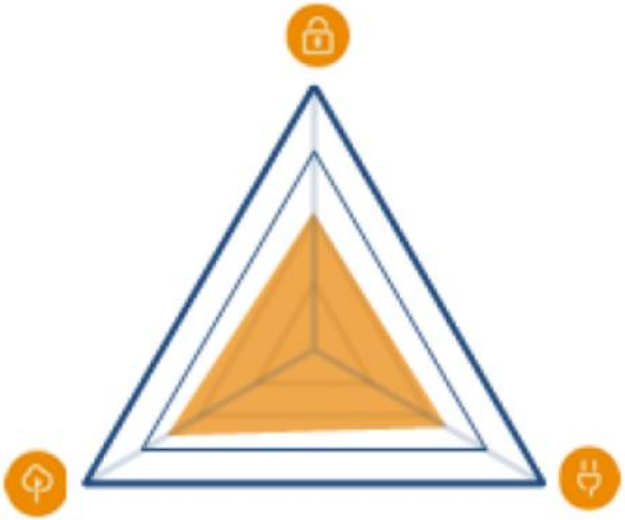
RANK

58

SCORE

BBB



	2016	2017	2018	Trend	Score
Overall rank and balance score	52	57	58	▶	BBB
Energy performance					
Energy security	59	57	65	▶	B
Energy equity	71	73	70	▶	B
Environmental sustainability	55	50	42	▶	B
Contextual performance	55	55	61	▶	

8 BUSINESS MODELS IMPLICATIONS CASE: MEXICO

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Modern Jazz

- ✓ The high degree of technology transfers between countries would increase the efficiency of local O&G operations
- ✓ The access of multinational companies to the country would increase given the high degree of market openness, boosting competition
- ✓ The government would support private companies through an efficient and effective regulatory framework

Unfinished Symphony

- ✓ The government would drive the energy sector to a more environmentally sustainable model, allowing the adoption of technologies focused on increasing the efficiency and mitigation of CO_2 emissions
- ✗ A more stringent local regulation would force the private sector to limit their CO_2 emissions and increase their renewable energy consumption, losing competitiveness to international players

Hard Rock

- ✓ Local stakeholders may take advantage of the innovation and knowledge sharing fostered globally
- ✗ However, local policies would be focused on increasing energy security through the development of domestic resources potentially increasing local energy costs (while the rest of the world has access to the most cost effective resources).

8 BUSINESS MODELS IMPLICATIONS CASE: MEXICO

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IDENTIFIED BUSINESS MODELS

Oil and Gas · Electricity · Both · Technology driven · New business model

Category	Business Model
Energy Equity	Battery carrier
	Extension of electricity network through a community trust
	Gas to wire model in gas field areas with shortage of gas pipelines
	Renewable energy powered domestic devices
	Solar steam sterilizer of surgical equipment for marginalized communities
Energy Security	Cognitive exploratory system powered by open access data
	Platform to connect O&G industry players to accelerate developments
	Specialized energy headhunting
	Trader and logistics integrator powered by fintech
	Uberization of O&G operations (well as a customer)
Energy Plus	Flying cars network
	Mobile recharging stations
	Pre-payment electricity smart meters
	Wireless electricity solutions for electronic devices

Category	Sub-category	Business Model
Environmental Sustainability	Energy efficiency and mitigation of CO_2 emissions	Energy intelligence provider
		Smart battery integrator
		Smart house from brick to appliance
		Ridesharing system enabler
		Service provider for industrial carbon abatement/energy efficiency
		Software platform for carbon abatement
		Zero waste business
	Clean energy penetration	Power generation based on Enhanced Geothermal System (EGS)
		Bio-fuel production from selected waste
		Nuclear fusion power stations
		Electricity generation stations powered by human mechanical energy
		Electricity generation system for the agriculture sector
		Enabler for green energy projects requested by cooperatives
		Platform that provides potential power generation forecasts from renewables
		Platform to connect renewable energy players to accelerate development
		Platform to give freedom of energy choice to electricity customers
		Renewable energy procurement through reverse auctions

8 BUSINESS MODELS IMPLICATIONS CASE: MEXICO

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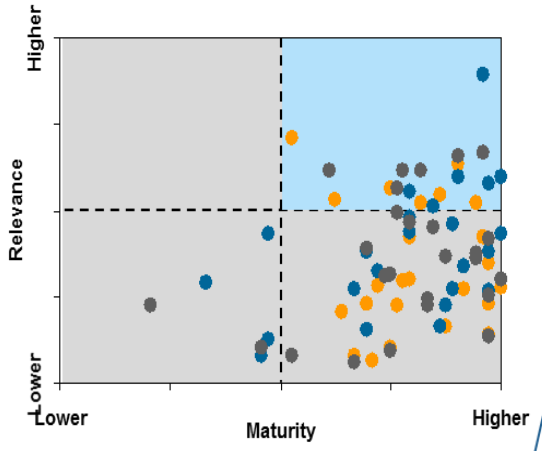
LOCAL BUSINESS MODEL SCORES

Modern Jazz · Unfinished Symphony · Hard Rock

Significant for further analysis[1]



EXAMPLES OF SIGNIFICANT BUSINESS MODELS

- Energy equity
- Energy security
- Energy Plus
- Energy efficiency and mitigation of CO_2 emissions
- Clean energy penetration

Significant business models by scenario

Modern Jazz

- Solar steam sterilizer for surgical equipment for marginalized communities
- Gas to wire model in gas field areas with shortage of gas pipelines

Unfinished Symphony

- Smart house from brick to appliance
- Platform to give freedom of energy choice to electricity consumers

Hard Rock

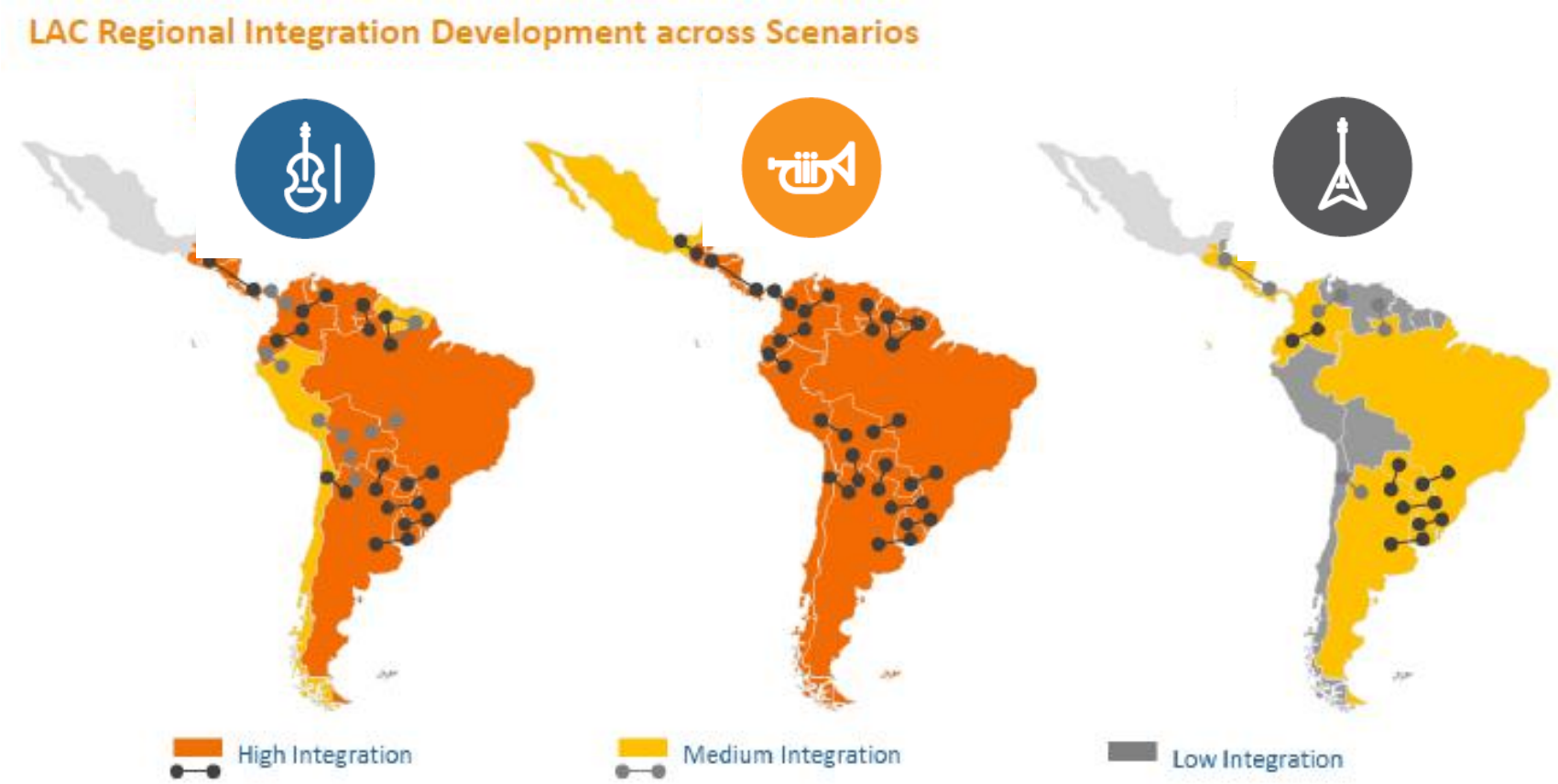
- Platform to connect O&G industry players to accelerate development
- Cognitive exploratory system powered by open access data

Significant business models across all scenarios

- Platform to connect renewable energy players to accelerate development
- Energy intelligence provider
- Platform that provides potential power generation forecasts from renewables

Regional integration across the scenarios

Regional integration in LAC can be shaped by the presence of strong regional governance structures



Call to action: accelerate the energy transition

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INTERNATIONAL POLICY FOCUS

- Trade & transfer of technology
- Carbon pricing and sun-setting of subsidies
- Regional integration in all continents

NATIONAL POLICY FOCUS

- Market reform: support transition developments & ensure digital preparedness
- Focused R&D: system critical innovation
- Capacity building: transition skills
- Critical role of cities: local empowerment

MACRO-RISK MANAGEMENT

- Beware of “stranded resources”
- Avoid heavy costs of a Hard Rock scenario

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Energy realities are shifting.
Faster than ever.

Focus on innovation is critical.
If you don't – someone else will.

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