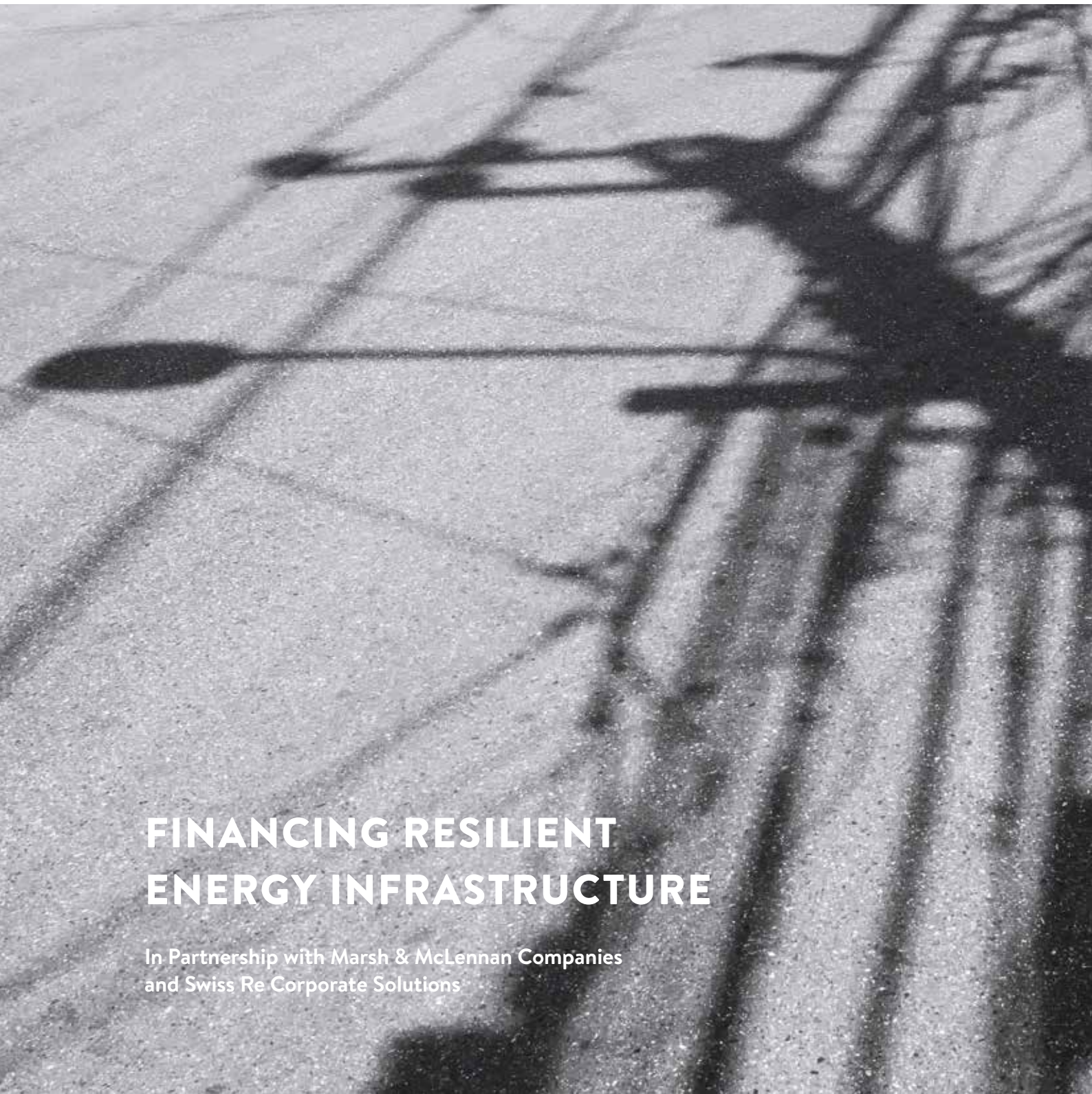
WORLD ENERGY COUNCIL

# World Energy Perspectives

## The road to resilience | 2016



## FINANCING RESILIENT ENERGY INFRASTRUCTURE

In Partnership with Marsh & McLennan Companies and Swiss Re Corporate Solutions

## ABOUT THE WORLD ENERGY COUNCIL

The World Energy Council is the principal impartial network of energy leaders and practitioners promoting an affordable, stable and environmentally sensitive energy system for the greatest benefit of all.

Formed in 1923, the Council is the UN-accredited global energy body, representing the entire energy spectrum, with over 3,000 member organisations in over 90 countries, drawn from governments, private and state corporations, academia, NGOs and energy stakeholders. We inform global, regional and national energy strategies by hosting high-level events including the World Energy Congress and publishing authoritative studies, and work through our extensive member network to facilitate the world's energy policy dialogue.

Further details at www.worldenergy.org and @WECouncil

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**World Energy Council**
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**Registered Office**
62–64 Cornhill
London
EC3V 3NH
United Kingdom

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## ABOUT THE ROAD TO RESILIENCE – FINANCING RESILIENT ENERGY INFRASTRUCTURE

The World Energy Council has partnered with energy and finance leaders to identify the key challenges and recommendations to finance resilient energy infrastructure. The project is supported by insights from Swiss Re Corporate Solutions, Marsh & McLennan Companies, Inc., and the European Bank of Reconstruction and Development. Combined with the Council's annual energy trilemma analysis on political and regulatory risks, the Road to Resilience series provides decision makers with an encompassing understanding of the risks involved in financing resilient energy infrastructures.

The Road to Resilience series features three reports:

- Managing and financing extreme weather risks
- Managing the risks of the energy-water-food nexus
- Managing cyber risks

The full reports can be found at **www.worldenergy.org/publications**

# FOREWORD

Extreme weather events have increased by a factor of four over the past 30 years. Cyber threats keep energy leaders in Europe and North America awake at night. 98% of power supply depends on the availability of water in an increasingly water stressed world. With accelerating energy systems integration, resilience is no longer just about returning single assets to full operation after a disruptive event. When interdependent parts of a system are blacked out, the system as a whole is at risk of being deadlocked. As Hurricane Sandy or Typhoon Haiyan and many other extreme weather events have illustrated, re-starting the energy system can be delayed by days, possibly weeks, if critical system parts cannot be restarted autonomously. The same may happen after a cyber breakdown with 'black-brained' system components. Black-starting capability, decentralised decision autonomy and local empowerment have become key words for system operators.

Increasing competition for water and water stress, as experienced in parts of Latin America, the Middle East, and other world regions expose the sector, which in terms of its water intensity is exceeded only by agriculture, to a multitude of operational vulnerabilities across the entire value chain. The increasing interconnection and digitisation of the energy sector, ranging from smart grids or digital oil fields to the internet of things, along with the sector's critical role in the functioning of a modern economy, makes the energy sector a highly attractive target for cyber-attacks geared to disrupt operations. As experienced in the Ukraine at the end of 2015, an attack on a SCADA system used to operate the power grid can impact the power supply of a country. A lot is at stake and new risks have become the focal point of boardroom and cabinet discussions.

The different risks to resilience have very distinct meaning and priorities in different regions. Yet the imperative to cope with these risks is a powerful catalyst for innovation with transformative global impact: innovation in technology, system design and management, cross-country and cross-value-chain cooperation, the required policies and, last but not least, financing concepts. Securing the future investments to expand and transform the sector is the critical challenge ahead. For the financial sector, our resilience work highlights both risks and opportunities. Neglecting a deeper understanding of the shifting resilience landscape will expose short-sighted investors, while a variety of financing mechanisms are available – and under development – to better cope with emerging risks.

This report provides seven recommendations, which will aim at improving the financing of resilient energy infrastructures. Further insights can be found in the individual reports: The road to resilience – managing and financing extreme weather risk, The road to resilience – managing the risks of the energy-water-food nexus, and The road to resilience – managing cyber risks.

The Road to Resilience series is just the beginning of a long journey of adaptation and innovation. It is a process of aligning interests, informing debate and encouraging new thinking. We would like to thank our partners and the team of global experts for their work in producing this important work and we hope you find these insights informative and valuable as you look to build a resilient and sustainable energy system.

**Jeroen van der Veer**
Executive Chair, Road to Resilience

**Christoph Frei**
Secretary General, World Energy Council

## THE ROAD TO RESILIENCE – FINANCING RESILIENT ENERGY INFRASTRUCTURE

Emerging physical, financial and virtual risks pose ever greater threats to the energy sector, and they do so at a time of transition, in both policy and technology. These threats impact both the physical structures and the capital returns that are needed to evolve energy systems to a more sustainable future. Demand for secure, affordable and environmentally sustainable energy is increasing due to population growth, ongoing urbanisation and a growing global middle class. This demand places strain on energy infrastructure resources just as conditions for the supply and provision of energy services are in transition. A new generation of technologies, and the transformation of markets and business models driven by climate change policy commitments are putting unprecedented strain on the sector. In the face of these challenges, policymakers, energy and finance leaders need to assess current approaches to energy investments and the financing of resilient energy infrastructure.

Mitigation and adaptation to cope with new and rising emerging risks has become crucial for all energy leaders, bringing the need for resilience to the fore. To meet energy demand while ensuring resilience, energy infrastructure must be designed, financed and built with the capability to cope with these new risks.

The World Energy Council's Road to Resilience series focuses on three of the most critical emerging risks – those that were identified as key uncertainties for energy leaders in the Council's annual World Energy Issues Monitor. The Road to Resilience reports examine the evolution of these risks and identify measures to respond through improved financing conditions for investments in energy infrastructure, including financial risk management. While not all of these risks are at the top of the agenda globally they all are among the top uncertainties in several regions and groups of countries. Countries are focused on developing effective responses to these risks and are looking to benchmark approaches and learnings that will support evolving global thinking about energy systems.

## IMPACTS OF EMERGING RISKS ON ENERGY INFRASTRUCTURE

- **EXTREME WEATHER:** The rise in global average temperatures is stimulating more frequent and severe catastrophic weather events, such as very strong storms, droughts or heat waves over unusually long periods, hurricanes or typhoons, and floods. The number of extreme weather events recorded each year has more than quadrupled over the past 40 years. The contribution of severe convective storms alone to overall insured losses has increased by more than 40% in the past 20 years. For example, in 2013 typhoon Haiyan – one of the strongest tropical storms ever recorded – caused more than US$200 million of damage to infrastructure in the Philippines.

  Changes in intensity and frequency of extreme weather events, as well as unseasonal deviations from average weather, affect current and future energy infrastructure and the energy sector's profitability. Impacts on energy systems could include blackouts, shut down of nuclear and thermal power plants due to long-lasting heat waves, or droughts and changing rainfall patterns affecting hydropower generation.

  Extreme weather events are among energy leaders' top uncertainty issues in large parts of the Asia Pacific region, Latin America and Africa.

- **ENERGY–WATER–FOOD NEXUS:** The interdependencies, and sometimes competing demands, between water usage and the production of energy and food triggers economic and social challenges for numerous stakeholders. Energy is, after agriculture, the second-most water-intensive sector, with 98% of electricity supply critically dependent on the availability of water. For example in 2015, hydropower facilities in Brazil sustained economic losses of more than US$4.3 billion due to drought-related energy-rationing and water-rationing measures.

  Food production requires large volumes of water and energy: energy is used for pumping, moving and treating water; and water is used in the production and supply of energy. The energy–water–food nexus can impact the stability of energy supply and demand for years or decades. It is also likely that the impacts of climate change will increase water stress in many countries, cities and rural communities. This brings with it the prospect of greater competition between different uses, as well as individual users of water. Such changes imply further restrictions to energy sector development and design.

The Energy–Water–Food nexus is among energy leaders' top uncertainty issues in China, Middle East, and parts of the Americas.

- **CYBER RISKS:** The digitisation of the energy sector in industrialised countries with highly developed infrastructure has resulted in the rapid development of new methods to enhance operators' ability to readily store and share data. New technology means better grid management for operators.

  But while there are benefits to a more interconnected energy value chain, there are also increased vulnerabilities, with cyber-attacks on industrial control systems (ICS) a prominent concern. For example, in December 2015, hackers caused a three-hour outage for around 80,000 electricity customers in Ukraine. Such attacks could lead to loss of control of key equipment, resulting in machinery breakdown, fire, explosion or fatality. The impact of such attacks on the operations of the energy asset, and on the local community and the wider economy could be significant.

  Cyber threats are among energy leaders' top uncertainty issues in parts of Europe and North America.

Given the evolving risk environment, current resilience approaches and standards for existing and future energy infrastructures may no longer be sufficient.

In order to finance measures that will increase energy security and resilience, it is necessary to have clarity in both company policies and countries' legal frameworks. In some segments of the energy sector, such as utilities, regulators define performance requirements for operators, and these help to set resilience requirements and standards. In other parts of the sector, companies use industry benchmarks or internal performance measures to gauge their resilience and ability to provide continuity of service. However, these standards are often based on historical information and prepare infrastructures to be able to handle events that happen once every 100 years. They do not sufficiently take into account either the changing complexity of the energy sector or emerging risks. The factor-four increase in extreme weather events illustrates that what seemed unlikely 40 years ago has become reality today.

The adoption of new system concepts and innovative financing solutions play a crucial role in improving the resilience of energy infrastructure. The latter can provide energy companies with financial coverage for risks, and can help them recover quickly from setbacks and crises. Insurance, for example, can provide stability to revenue streams and thereby help to attract the investment needed to build resilient energy infrastructure. Capital can be unlocked, and ultimately costs in the project financing process can be reduced. New insurance products that provide protection against hazardous events along the entire energy value chain are becoming available. It is vital that these insurance products continue to be developed, to create financial instruments that help close other financing and protection gaps.

Policymakers, energy leaders and the financial sector must reassess approaches across a number of areas if they are to reduce the risk-margins of energy investments. These areas include improving risk assessment and modelling, better planning and design, and increasing communication and collaboration. The World Energy Council recommends the following seven actions that must be taken by public and private energy sector leaders, policymakers and regulators in order to improve the financing of resilient energy infrastructure.

## RECOMMENDATIONS FOR INCREASING THE RESILIENCE OF ENERGY INFRASTRUCTURE

**1** **ADOPT AN EXPANDED CONCEPT OF RESILIENCE:** The traditional concept of strong and safe energy systems (i.e. 'hard' resilience) must be accompanied by strategies to prevent and/or absorb potential failures, and ensure rapid recovery after a hazardous event (i.e. 'soft' resilience). This expanded concept incorporates smarter, not just stronger, solutions into the design and operation of energy systems. Black-starting capabilities, that is to say the ability to start a system independently after blackouts, of critical system functions is a key component of this concept. Similarly, systems must allow for partial system failure while ensuring they maintain basic functions, as a way to control impact.

**2** **ENCOURAGE DIVERSITY IN ALL INTERRELATED SECTORS:** Diversity increases flexibility and resilience. Diversity in agriculture and food supplies, but also among IT sector services may provide additional security in the operation of an energy system as they mitigate 'monoculture risks'. There are several measures that can mitigate the potential widespread impact of emerging risks, and provide – in some instances – improved energy security: increased use of off-grid energy systems and distributed generation; increased supply of low-carbon energy; improved demand management; and increased application of smart information technologies to optimise energy infrastructure operations.

# OPPORTUNITIES TO IMPROVE THE FINANCING OF RESILIENT ENERGY INFRASTRUCTURE

## EMERGING RISKS

New physical, financial and virtual risks are posing ever greater threats to the energy sector and consequently the wider economy.

They alter the 'risk profile' of the energy system and impact both the physical structures and the capital returns that are needed.

### EXTREME WEATHER

Frequent and severe weather events can affect energy infrastructure across the value chain, and often lead to higher demand.

The number of extreme weather events each year is 4 times higher than 40 years ago.

**4 times**

### ENERGY–WATER–FOOD NEXUS

Energy is the second-most water-intensive industry – after agriculture. Interdependencies and competing demands create challenges.

98% of electricity supply critically depends on the availability of water.

**98%**

### CYBER RISKS

The sophistication and number of cyber-attacks is growing. The first real incidents in the energy systems have been experienced.

By 2018 the oil and gas industries could be spending US$1.87 billion each year on cyber security.

**US$1.87 billion**

## RECOMMENDATIONS

**Taking action will reduce exposure, unlock capital, and ultimately reduce cost. It will ensure the resilience of tomorrow's energy systems, for the greatest benefit of all.**

### 1 SMARTER DESIGN OF ENERGY INFRASTRUCTURE

Energy systems must be smarter, not just stronger, to withstand diverse emerging risks and be more resilient.

### 2 BETTER EVALUATION OF ENERGY SYSTEM DESIGNS

Faced with fluid, changing risks, data has to be forward-looking and localised to better support investment decisions.

### 3 BETTER INFORMATION SHARING AROUND RISKS

Better information sharing around emergent risks and best practices, across sectors and throughout the value chain is needed.

### 4 IMPROVED REGULATION AND MARKET GUIDANCE

Policymakers must develop clear, transparent, predictable legal frameworks to ensure resilience and stimulate finance.

### 5 INCREASED PRIVATE FINANCE IN INFRASTRUCTURE

Resilience is vital in attracting a more diverse group of investors, including institutional investors, to the energy sector.

### 6 MAKE MORE USE OF COST–BENEFIT ANALYSIS IN FINANCING DECISIONS

Fully reflecting the real weather risk, or cyber risk, to a project will improve its risk profile and financing.

### 7 ENCOURAGE DIVERSITY IN THE ENERGY SECTORS AND RELATED INDUSTRIES

Diversity increases flexibility and helps to avoid and mitigate the implications of potential threats.

**IN AN INCREASINGLY FINANCIALLY CONSTRAINED WORLD, FOCUSING ON RESILIENT ENERGY INFRASTRUCTURE MAKES BUSINESS AND POLITICAL SENSE. IT IS NO LONGER AN OPTION – IT IS A MUST.**

**3 IMPROVE INFORMATION SHARING AND MITIGATION COORDINATION ACROSS SECTORS, BORDERS AND VALUE CHAINS:** More cohesive information is needed in relation to new risks. Companies should communicate more information to their supply chains and harmonise cross-border activities; for example, sharing information on emerging cyber threats or best practices in risk management. Governments could create frameworks for such information sharing to eliminate legal or regulatory ramifications. Learning from other sectors and collaborating across public, private and academic sector institutions is necessary to gain a better understanding of the nature of the emerging risks and their potential impacts.

**4 PROVIDE REGULATORY GUIDANCE FOR RESILIENCE:** Policymakers can encourage the development of more resilient infrastructure by creating a legal and regulatory framework that clearly defines the required levels of resilience for energy infrastructure. Legal frameworks are critically important for natural monopolies, such as transmission systems and other critical system functions. They guide the risk management and adaptation measures that should be incorporated into operational and investment decisions for new and existing assets. Although risk management measures have become better defined, adaptation measures for responding to evolving risks often lack regulatory guidance. Common goals or metrics for adaptation are too few or too limited, and the same is true for specific resilience responses, both hard and soft. Similarly, it can be hard for all stakeholders to agree on how much resilience is sufficient, and on how increased resilience can be related to the revenue stream and thus support investment. Transparent and predictable frameworks are needed to ensure the right levels of resilience. This will send clear signals to the energy sector and stimulate financing for resilience.

**5 INCREASE RESILIENCE TO ENABLE INSTITUTIONAL FINANCING IN ENERGY INFRASTRUCTURE:** Addressing and improving energy system resilience is vital if the sector is to attract finance from a diverse group of investors, including institutional investors such as pension funds, investment funds and insurers. Governments alone cannot cover the costs of creating and maintaining current and future secure and reliable energy systems in the context of evolving risks. In many countries, governments have limited capacity to fund the infrastructure necessary to expand energy access, replace legacy assets, and shift to a low-carbon energy system. Opening energy infrastructures as an asset class to all investors can open up large sources of funding to finance future energy supplies. Continued development of insurance products is vital to the creation of financial instruments that help close financing and protection gaps. Such instruments would reduce exposure, unlock capital and ultimately reduce costs in the project financing process.

**6 IMPROVE METHODOLOGIES TO EVALUATE ENERGY SYSTEM DESIGN OPTIONS:** Improved methodologies to evaluate the implications of resilience requirements for energy system design options are needed to support decision-making on infrastructure choices. In the face of evolving risks, historical data may not be effective to support project assessment and investment decisions. Investors and project developers need to be able to better understand the full risk landscape of the energy technology choices being considered in order to reduce the risks of potential stranded assets. The availability of localised and forward-looking data is a critical step towards resilience.

**7 INCORPORATE COST-BENEFIT ANALYSIS OF RESILIENCE IN FINANCING DECISIONS:** To stimulate public and private funding into energy infrastructure and resilience measures, it is critical for all stakeholders to have a common understanding about the risks involved; they must all be able to compare, as accurately as possible, the costs and the benefits of investing in resilience. For example, fully reflecting extreme weather or cyber risks in the cost-benefit analysis of project financing can greatly enhance the project risk profile.

## CONCLUSION

Increasing the resilience of energy infrastructure is not optional – it is a must to ensure the energy system adapts to the shifting risk landscape. The World Energy Council's work on resilience highlights a number of common obstacles that need to be overcome to ensure secure and reliable energy supply and it is critical that policymakers, sector leaders and financial actors work together now to address these.

Resilience priorities may be very different from one region to another. In a context of limited resources these differences on the one hand and adaptation synergies across resilience areas on the other will require every region to find its own path to resilience.

Hard and soft resilience measures, aligned with risk transfer options for residual risks, will reduce exposure, unlock capital, and ultimately reduce cost – and ensure the resilience of tomorrow's energy systems, for the greatest benefit of all.

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## WORLD ENERGY COUNCIL STUDIES COMMITTEE

Brian Statham, South Africa (Chair); William D'haeseleer, Belgium; Claudia Cronenbold, Bolivia; Eduardo Correia, Brazil; Jing Ding, China; Bin Wei, China; Qinhua Xu, China; Yaxiong Zhang, China; Li Zhu, China; Jean-Paul Bouttes, France; Rauno Rintamaa, Finland; Jeanne Ng, Hong Kong; B P Rao, India; Nastaran Rahimi, Iran; Alessandro Costa, Italy; Carlo Papa, Italy; Hardiv Situmeang, Indonesia; Atsushi Noda, Japan; Arturo Vaca, Mexico; Jan Antonczyk, Poland; Ioan Dan Gheorghiu, Romania; Ayed Qahtani, Saudi Arabia; Maria Sunér Fleming, Sweden

## MARSH & MCLENNAN COMPANIES CONTRIBUTORS

Francois Austin (Partner, Oliver Wyman); Amy Barnes (Managing Director, Marsh); Raj Bector (Partner, Oliver Wyman); Leslie Chacko (Principal, Oliver Wyman); David Christensen (Senior Sales Leader, Marsh); Alan Feibelman (Partner, Oliver Wyman); Tom Fuhrman (Managing Director, Marsh Risk Consulting); Michael Gaudet (Managing Director, Marsh USA, Inc.); Andrew George (Energy and Power Chairman, Marsh); Bernhard Hartmann (Partner, Oliver Wyman); Claus Herbolzheimer (Partner, Oliver Wyman); Andrew Herring (Managing Director, Marsh); Anneloes Hesen (Senior Project Manager, Marsh); Tom Jacob (Product Development Leader, Mercer); Jose Maldonado (Business Analyst, Marsh); Matthew McCabe (Senior Vice President, Marsh); Robert Parisi (Senior Advisory Specialist, Cyber, Marsh); Jeremy S Platt (Senior Vice President, Guy Carpenter); Thomas Reagan (Practice Leader, Cyber, Marsh); Angelo Rosiello (Principal, Oliver Wyman); Karen Shellenback (Senior Network Consultant, Mercer); Stella Tse (Senior Client Advisor , Marsh); Luc Vignancour (Senior Client Advisor, Marsh)

## SWISS RE ADVISORS AND PRINCIPAL CONTRIBUTORS

Philippe Aerni (Head Fin Pro P&C and Special Lines, Swiss Re Corporate Solutions), Guido Benz (Director, Swiss Re Corporate Solutions), François Brisson (Head Cyber Technology, Swiss Re Corporate Solutions), Markus Buergi (Vice President, Swiss Re Communications), Maya Bundt (Head Cyber & Digital Strategy, Swiss Re), Eric Durand (Director, Swiss Re Group Underwriting), Martin Hegelbach (Director, Swiss Re Corporate Solutions), Urs Leimbacher (Director, Swiss Re), Stephan Schreckenberg (Director, Swiss Re), Willy Stoessel (Head Cyber, Technology & Construction, Swiss Re Corporate Solutions), Rey Leclerc Sveinsson (Vice President, Cyber Strategy & Risk Services, Swiss Re)

## PROJECT TEAM

Jeroen van der Veer (Chair, Road to Resilience, World Energy Council); Christoph Frei (Secretary General, World Energy Council); Juerg Trueb (Managing Director, Head of Environmental Commodities and Markets, Swiss Re Corporate Solutions); Alex Wittenberg (Executive Director, Global Risk Center, Marsh & McLennan Companies); Didier Sire (Senior Advisor to the Secretary General, Head of Sectoral Programmes, World Energy Council)

## AUTHORS/PROJECT MANAGEMENT

Lucy Nottingham (Director, Global Risk Center, Marsh & McLennan Companies), Oliver Schelske (Senior Risk Research Manager, Swiss Re Centre for Global Dialogue, Group Strategy), Bernd Wilke (Vice President, Swiss Re Communications), Aida Boll (Vice President, Swiss Re Communications), Sandra Winkler (Director Policies, World Energy Council), Einari Kisel (Senior Project Manager, World Energy Council), Katrina Kelly (Project Manager, Financing Resilient Energy Infrastructure)

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CHRISTOPH FREI
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62–64 Cornhill
London EC3V 3NH
United Kingdom
T (+44) 20 7734 5996
F (+44) 20 7734 5926
E info@worldenergy.org

**www.worldenergy.org | @WECouncil**