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## Executive summary



“This report gives a comprehensive outlook towards an electricity system for Europe and North Africa based completely on renewable energy in 2050. Its particular value is pointing out that this will be the result of an evolutionary development mainly of the economical, legal and regulatory framework and does not require fundamental technological breakthroughs. Most of the required technical components are available in principle already today. This is a sound basis for the roadmap.”

Jochen Kreusel

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Chairman of the Power Engineering Society of the German Association for Electrical, Electronic and Information



## 2. Executive summary

The combination of increased demand for electricity and security of supply is a very powerful driver of major power sector change in Europe and worldwide. Currently, for example, about 50% of Europe's energy demand is met with imported fuels and there are projections that this could increase to 70% in the coming decades<sup>1</sup>. Economic development and increasing use of electricity-consuming devices will increase future demand for electricity.

Alongside demand and security of supply issues, climate change also poses a global threat. Substantial and fairly rapid decarbonisation of electricity generation and many other sectors will have to take place if the world is to have any chance of staying within the 2°C goal for limiting the effects of global warming. In Chapter 3, we look at these and other challenges facing the region's current power systems and examine whether a vision of Europe, in combination with countries in North Africa, developing an integrated power grid with 100% of electricity generation coming from renewable sources by 2050 is possible.

The key components of such a vision are:

- A regional power system based on a SuperSmart Grid;
- The rapid scaling up of all forms of renewable power, with the ultimate goal of decarbonising electricity generation in Europe and North Africa;
- A unified European power market that is united with the North African one, allowing for the free trading of electricity between all countries;
- The production of electricity at the most suitable sites by the most suitable renewable technologies; and
- Affordable electricity for each European Union and North African country and the eradication of energy poverty.

In Chapter 4, we set out a roadmap that outlines what European Union and North African (EU-NA) climate change and energy policy developments need to occur in the period to 2050 if this vision is to be achieved. Supported by a coherent policy transition, such a roadmap of activities could support the delivery of a sustainable, reliable and integrated power system for EU-NA. It proposes a holistic view, taking into account existing infrastructure and electricity generation capacities, and illustrates the necessary market, financial, infrastructure and policy milestones that would need to be put in place. It also considers other drivers and forces that could either promote or hinder the vision and suggests ways in which these could be managed for success.

Of course, in addition to renewables, there are other routes to addressing these concerns – most significantly, the expansion of nuclear power and the development of carbon capture and storage (CCS) from the burning of fossil fuels. Our exclusion of these routes from this report is not intended as any comment on their merit. Our goal is to examine what it would take to shift even further to a 100% renewable electricity supply.

The 2050 vision requires simultaneous and coordinated progress on many fronts – finance, technology, research and development (R&D), the development of adequate supply chains, change in generation mix and grid capability. Our 2050 roadmap identifies the key enabling areas to be government policy, investment, market structure, and infrastructure, and outlines the developments needed in each to achieve the 2050 vision. The developments in each are considerable and complex but we believe they are achievable.

- **Policy:** At a European policy level there is a need to build on the existing EU directives. The setting of firm and binding targets for Member States for 2030 to 2050 to inform the strategic planning process will require further guidance and new directives. This would include, for example, guidance to support the implementation of Article

9 of the Renewables Directive dealing with imports of electricity, and the development of a new directive on grid regulation which would mandate long term EU-level planning of grid infrastructure. These actions would, in turn, allow national renewable energy targets and incentive structures to reflect more ambitious targets in the short term. To achieve the 2050 goal of 100% renewable electricity, policies would also need to incorporate mechanisms to disincentivise construction of new fossil fuel power plants. All of this is possible using the existing EU processes and structures. For North African countries, the more immediate need is the development of institutional capacity to support a move to greater use of renewables. Steps are underway already in a number of countries and, with further support from the EU, could be in place in the short term, allowing for closer policy negotiations with Europe for electricity trade and, in the longer term, greater alignment between EU and the North African energy policy.

- **Investment:** The costs associated with such a transition will not be insignificant. Experience to date with other large infrastructure programmes suggests that the financing and investment capacity is available, provided we can create the policy environment for projects and programmes. At this point in time large sums of money have already been pledged by Multilateral Development Banks (MDBs), the private sector and the EU to support the expansion of renewables across the region, in particular in North Africa. The challenge sometimes has been the availability of credible projects to unlock this funding. The policy changes outlined above and ongoing technology developments will help to reduce risk premiums and provide certainty for investors. Better project information, better engagement with the renewables industry and better use of financial structuring experience will all help to turn these early projects into more mainstream investments for the financial community. As installed capacity grows, the track record of these early investments can then support the business case for larger and more ambitious projects.
- **Market structure:** Building on a trend towards a greater cooperation between individual EU power markets today, there will be a need for these to develop, first, into a smaller number of regional markets and then into a single EU regional market by 2020. The introduction of new long distance transmission infrastructure linking North Africa to Europe and real time pricing and support schemes, including mechanisms to reward dispatchability, will help stimulate this market unification process. Increasing connections and trade over time will then support the development of a unified EU-NA power market.
- **Infrastructure and planning:** The recent formation of two new organisations, the Agency for the Cooperation of Energy Regulators (ACER) responsible for developing common standards and approaches for cross-border trade and the European Network of Transmission System Operators for Electricity (ENTSO-E) promoting the reliable operation and optimal management of the European transmission system, will encourage centralised long term planning of the activities needed to transform the existing infrastructure. The ability to deliver a significant increase in existing transmission and renewable generation capacity across the entire region will, however, be closely tied to developments in the policy and investment areas above. Over time, the existing infrastructure will begin to evolve to reflect the desired 2050 end state, with the completion of commercial scale demonstration plants, the ongoing development of renewable technologies, the adoption of these and associated smart technology into upcoming projects and the inclusion of increased amounts of storage and flexible reserves.

The summary of the key steps that need to take place on the roadmap from 2010 and 2050 is outlined in graphic form following this executive summary. Inevitably, given the magnitude of a vision of 100% renewable electricity for Europe, the ultimate feasibility of such a shift can only be fully judged as each stage in the shift is completed. The proposed step by step approach provides leaders with the opportunity to learn while doing and to adjust policies over time. It will also support the optimisation of cross-sectoral output while achieving the vision.

We conclude, in Chapter 5, by reviewing the critical question of cost and other key considerations that arise. The costs of switching to a 100% renewable electricity future need to be more fully explored. The most recent economic models show that the short-term costs of transforming the power system may not be as large as previously thought. Encouragingly, the costs of individual renewable technologies are continuing to decrease. Indeed, once this transformation has taken place, a power system based on low-cost renewable technologies is likely be able to provide countries with opportunities for substantial economic growth and consumers with considerable - and growing - cost savings compared to a business as usual approach.

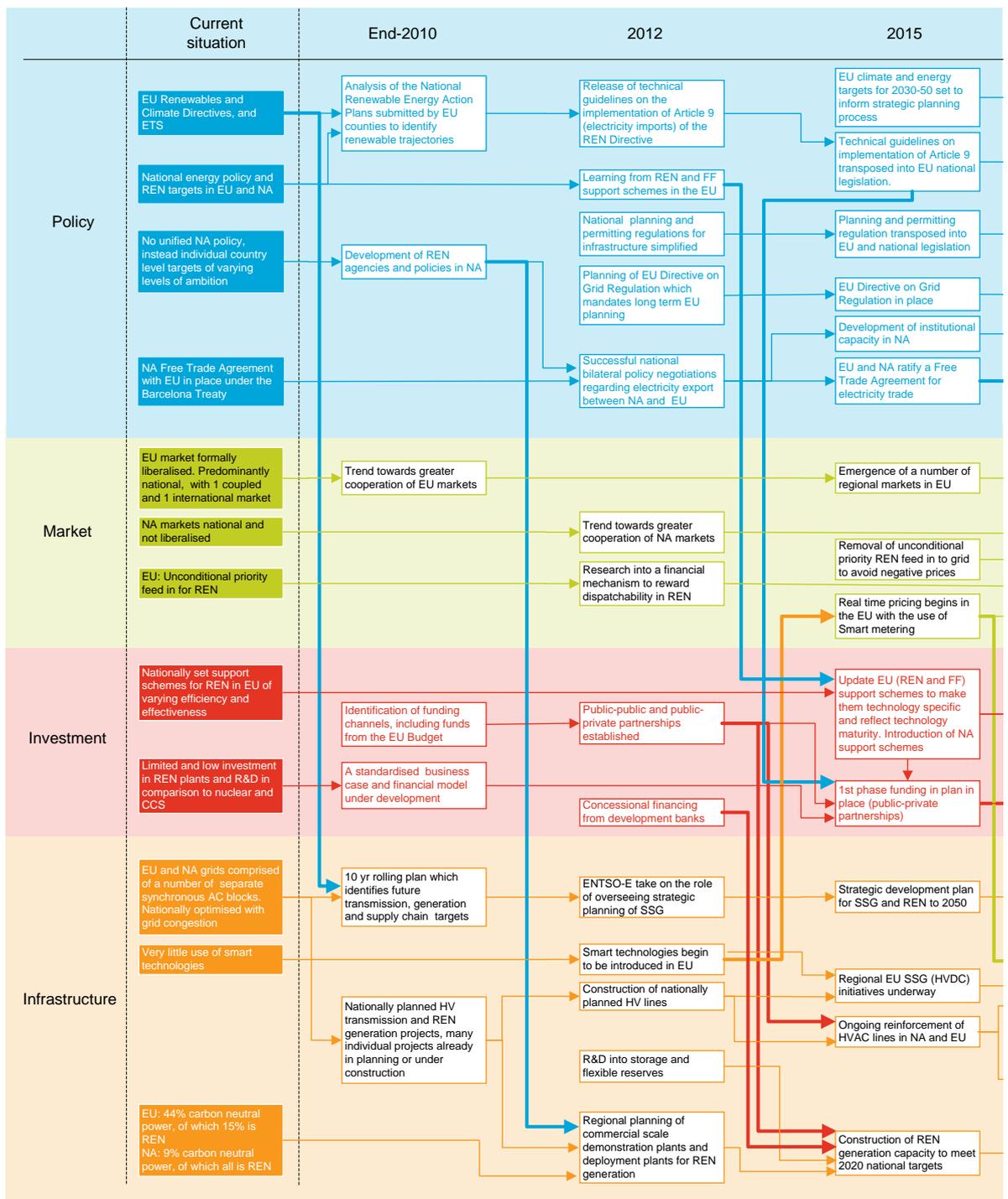
We also review the fresh challenges that, if it was achieved, a move to 100% renewable electricity would present. In particular, we look at the critical issue of energy security. Might a 2050 power system in which Europe relies on imports from North Africa threaten European energy security, rather than improve it? We conclude that, even with its heavy reliance on power from North Africa, the 2050 roadmap would actually lead to a net decrease in the reliance of the power sector on imported energy, as well as to a greater diversification of the countries from which those imports stem.

Timing is also important because, with the passage of time, the opportunity to meet the 2°C goal for limiting the effects of global warming becomes more constrained. Small scale domestic renewable energy solutions will play a growing part, but there is a pressing need to identify and deploy larger scale solutions that can have a more dramatic impact on CO<sub>2</sub> emissions. The full potential of these solutions will, in many cases, necessitate international cooperation on a pan-regional scale to enable both their financial development and their physical implementation. If developed collectively, with sharing of investment costs and benefits, there are likely to be more viable opportunities that can be pursued.

We hope this report will contribute to the development of new solutions to our energy and climate change challenges. The roadmap it outlines is intended to stimulate debate. It is also meant to show that we can be ambitious in our vision. We already have most of the necessary building blocks in place today – they perhaps just need to be configured differently. Finally, we hope that the report can support an ongoing and constructive 'open source' discussion between government, industry and other stakeholders across Europe and North Africa to deliver the change that is needed in the power sector in the coming years.

### A Roadmap to 2050: Linking a 100% Renewable Power Sector with a SuperSmart Grid in Europe and North Africa

Our 2050 vision is one of a 100% renewable electricity in the EU and NA. To achieve this from the complex power system of today, there is no singular definitive or correct route, but rather a number of differing but complementary paths. This schematic illustrates one such roadmap. It is based on our assessment of the milestones required to achieve the vision, and should be considered as one potential way, not the only way, to do so.



We have identified four key enabling areas into which all essential activities fall: Policy, Market, Investment and Infrastructure. The interdependencies between these themes are critical to achieving the vision and are shown in bold. Milestones are stated for either the Europe, North Africa, or where no specific region is given the milestone applies to both.

