The development of renewable energy, including both offshore and onshore wind, is central to our energy policy. Energy derived from our indigenous renewable sources improves the security of our supply and provides a hedge against volatile imported energy prices. This benefits all society through a reduced dependence on fossil fuels and achievement of a cleaner, more sustainable environment where employment and national competitiveness can be strengthened, and our low carbon energy makes us an attractive place to do business.

With the goal of a more secure, cleaner and affordable energy future in mind, SEAI has developed a suite of roadmaps that consider possible scenarios moving from the present to the longer term horizon of 2050. This involves considering resource availability, technology and supply chain development paths, transmission and system integration requirements and our existing and future regulatory environment. A roadmap considers these issues, maps a potential path to a future deployment scenario, and estimates some of the benefits of achieving that scenario.

This roadmap considers an accelerated deployment path for onshore and offshore wind to 2050, and was developed alongside roadmaps for Smart Grids and Electric Vehicles, with consistent assumptions applied, including a significant increase in Irish electricity demand to 2050 driven by population growth, increased electrification of the residential and services sectors, the delivery of a smarter grid, and policies to encourage electric vehicle adoption. The wind roadmap builds on the work of the International Energy Agency and identifies possible barriers and constraints to increased deployment, and estimates CO₂ reduction, value of generation, and job creation benefits.

Ireland’s wind resource potential is vast. Onshore, it represents some of the most cost effective renewable resource in Europe, and offshore it benefits from Ireland’s extensive area of offshore territory in the Atlantic and the Irish Sea. With reference to the most recent assessments of wind energy potential onshore and offshore, this roadmap shows low, medium and high scenarios for deployment, generating many times more than Ireland’s own electricity demand, and as much as 2.5% of total projected European electricity demand by 2050.

The scenarios recognize that wind turbine technology, as well as technology for integrating wind energy into electricity systems designed for conventional power, will continue to advance in the coming decades. Thus sites being developed today have the potential to repower with more efficient technology or larger capacity turbines. Repowering drives onshore wind capacity growth from 2030 onwards in this roadmap. Ireland has the potential to become a major exporter of renewable electricity to the European market, and, in doing so, can reap the benefits of job creation as well as revenues recognising clean energy. The deployment scenarios envisaged could produce an estimated 20,000 jobs, initially in installation but also driven by a continuing employment market in operations and maintenance.

The impediments to greater deployment of wind energy are not trivial. They range from the rate of infrastructure development and access to finance, to difficulties in getting or retaining planning permission and social acceptance. A number of required near term policy and infrastructure related actions are identified in the roadmap. Many actions have already begun, and are responding to well articulated calls for a more coherent and coordinated approach to addressing existing barriers to deployment. The development of such an approach will enable us to meet our near term targets, and put us on the path to achieving, and reaping the benefits of, the long term deployment scenarios envisaged in this roadmap.

I want to thank the many stakeholders who have contributed their time and their views to the development of this roadmap, and to invite comments from other interested parties to roadmaps@seai.ie.

Prof. J Owen Lewis
Chief Executive, SEAI
Wind Energy Key Points

Technology innovation remains a crucial driver for the potential level of deployment of wind energy

Onshore and offshore wind could create 20,000 direct installation and O&M jobs by 2040

The potential economic value of electricity generated by wind could reach almost €15 billion by 2050

Key Findings

- Given favorable developments in policy and infrastructure, Ireland can achieve deployment of between 11GW - 16GW of onshore wind and 30GW of offshore wind by 2050.
- Wind energy has the potential to generate enough electricity to exceed domestic demand by 2030.
- A comparison of electricity demand and wind generation potential shows the capacity for Ireland’s wind market to become export-driven in the 2020–2030 timeframe.
- As the onshore and offshore wind markets mature, re-powering and operation and maintenance will become key to the retention of a sustainable industry; preparation for this eventuality will increase our benefit from this opportunity.
- The repowering of onshore and offshore wind turbines will contribute over 15GW to 2050.
- The potential economic value of electricity generated by wind could reach almost €15 billion by 2050.
- Onshore and offshore wind could create 20,000 direct installation and O&M jobs by 2040. Offshore wind represents a significantly greater employment opportunity than onshore wind post-2025.
- The wind industry is expected to hit a peak annual investment of between €6 billion and €12 billion by 2040. Wind has a cumulative investment potential of €100 - €200 billion in 2050.
- By 2050 Irish wind could contribute 2.5% to EU Electricity Demand and just over 5% of EU wind energy generation could come from Ireland.
- Onshore and offshore wind represent a significant carbon abatement opportunity - Wind could abate between 400 and 450 Mt of CO₂ by 2050.

Wind energy is currently the largest contributing resource of renewable energy in Ireland. The primary objective of this roadmap is to identify the actions that are required to accelerate the deployment of wind energy, both on and offshore, in Ireland, so that it becomes the largest source of energy; to aid policy makers, and industry and power system actors in their efforts to successfully implement large amounts of wind energy in Ireland. It lists the actions and milestones that could be incorporated in a deployment framework. The resulting 2050 deployment pathway is based on assumptions of the potential for, and timing of, technology breakthroughs in the onshore and offshore sector as well as assumptions about the development of legislative, economic, technical and infrastructural conditions. It considers aspects such as grid reliability, the role of smart grid for improved system balancing and the structural and operational requirements for successful system integration of wind energy.
Wind energy - onshore and offshore wind energy generation scenarios

**POLICY FRAMEWORK, SUPPORTS AND TECHNOLOGY SUPPORT MECHANISMS**
- SEA study for 80% renewables
- NREAP scenario of 16% TFC from Renewables by 2020 and 40% RES-E
- OREDP scenario of 4,500 MW of offshore wind by 2030
- Foreshore consent process for offshore energy projects
- AER VI PPA funding completion timeline
- REFIT for Onshore wind €66.351 - €68.681/MWh
- Announced REFIT 3 Offshore wind Payments €140/MWh
- Energy Roadmap to 2050, European Commission
- EU-Set Plan €6bn funding for Technology Development

**PUBLIC ENGAGEMENT & ENVIRONMENT**
- Public Consultations on an ongoing basis for projects and policy documents, possible need for national policy on public engagement
- SEA completed for the OREDP
- Periodic OREDP Review
- SEA for Grid 25 in progress
- Need for clear and co-ordinated national planning policy approach and implementation

**DEVICE TECHNOLOGY**
- Development of intelligent networks
- 7.5 MW Turbines
- 10 MW Turbines
- 20 MW Turbines
- 130m Hub Height
- 150-200m Hub Height
- Large Offshore commercial windfarm developments
- Development of Deep Offshore fixed foundation turbines in depths up to 60m
- Streamlined optimum materials & parts onshore & offshore turbines
- Development of variability managing devices multipoint HVDC devices
- EU SET Plan reduction of manufacturing costs, transport & erection costs & O & M costs of offshore turbines by 20%

**INDUSTRY**
- Gate 3 rollout of Grid Connection Offers
- Grid 25 Strategy to offer an additional 60% of current power capacity
- ISLES Project
- EWEC 500 MW by 2012
- Further Irish - UK 500 MW InterConnection
- North South 400kV Connector
- North Seas offshore grid initiative
- RPS Study Ongoing to enable system operation with 75% non-synchronous generation
- 50% SNSP
- ESB Corporate strategy to facilitate 6000 MW of wind power by 2020
- Development of the North Seas Grid

**MARKET DEVELOPMENT**
- Development and Harmonisation of EU Target Market
- Definition of EU Funding Mechanisms

**ENERGY ROADMAP TO 2050**
- Maximum 500 MW of Onshore Wind installed per year
- 5000MW of Offshore Wind installed by 2020
- 4500 MW Potential of Offshore wind by 2030
- Repowering begins 20 years after 1st wind installations

**SEA REPORT EXPLORER**
- Offshore Wind - Floating Foundation
- Offshore Wind - Fixed Foundation
- Onshore Wind
- Total Wind Generation (Medium Scenario)
- Onshore Wind (Medium Scenario)

**CHART**
- Electricity Generation GWh/yr
- 2010 - 2050
- Offshore Wind - Floating Foundation
- Offshore Wind - Fixed Foundation
- Onshore Wind
- Total Wind Generation (Medium Scenario)
- Onshore Wind (Medium Scenario)

- Repowering begins 20 years after 1st wind installations

**GROWTH**
- Fixed Foundation Offshore heads towards maturity
- Floating Offshore heads towards maturity
- Onshore Wind High Scenario further 5 GW capacity by 2040

**ENERGY DEMAND**
- North South 400kV Connector
- Further Irish - UK 500 MW InterConnection
- Further 2000 MW Ireland - UK and Ireland - EU InterConnection

**INFRASTRUCTURE**
- Development of the North Seas Grid
- System upgrades to onshore connections to accommodate repowering
- Grid 25 Strategy to offer an additional 60% of current power capacity
- ISLES Project
- EWEC 500 MW by 2012
- Further Irish - UK 500 MW InterConnection
- North South 400kV Connector
- North Seas offshore grid initiative
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Wind energy - onshore and offshore wind energy generation scenarios

POLICY FRAMEWORK, SUPPORTS AND TECHNOLOGY MECHANISMS

PUBLIC ENGAGEMENT & ENVIRONMENT

SEAI study for 80% renewables

NREAP scenario of 16% TFC from Renewables by 2020 and 40% RES-E

OREDP scenario of 4,500 MW of offshore wind by 2030

OREDP high scenario of 39,500 MW of offshore wind by 2050

Public Consultations on an ongoing basis for projects and policy documents, possible need for national policy on public engagement

SEA completed for the OREDP

Periodic OREDP Review

Development of variability managing devices
multipoint HVDC devices

AER VI PPA funding completion timeline

REFIT for Onshore wind €66.351 - €68.681/MWh

EU-Set Plan €6bn funding for Technology Development

Energy Roadmap to 2050, European Commission

Lean/Technology Development

Gate 3 rollout of Grid Connection Offers

System upgrades to onshore connections to accommodate repowering

Grid 25 Strategy to offer an additional 60% of current power capacity

EWIC 500 MW by 2012

DS3 Study Ongoing to enable system operation with 75% non-synchronous generation

50% SNSP

ESB Corporate strategy to facilitate 6000 MW of wind power by 2020

Further Irish - UK 500 MW InterConnector

Development of the North Seas Grid

Further 2000 MW Ireland - UK and Ireland - EU InterConnection

Streamlined optimum materials & parts onshore & offshore turbines (minimising manufacture, construction and operating & maintenance costs)

200-250m Hub Height

20 MW Turbines

10 MW Turbines

150-200m Hub Height

Development of Offshore Floating Turbines in depths >100m

Large Offshore commercial windfarm developments

Further need for infrastructure as capacity outweighs demand

Repowering of windfarms begins 20 years after initial installation

4500 MW Potential of Offshore wind by 2030

500MW of Offshore Wind installed by 2020

Maximum 500 MW of Onshore Wind installed per year

Announced REFIT 3 Offshore wind Payments €140/MWh

Financial supports for on and offshore wind begin to decline as industry matures

SEA Report explored total development potential for offshore wind

Ireland can achieve deployment of 11GW - 16GW of onshore wind and 30GW of offshore wind by 2050

Development of Deep Offshore /fixed foundation turbines in depths up to 60m

Large Offshore commercial windfarm developments
Wind Energy to 2050

Our assessment shows that the wind energy resource represents a significant value to Ireland by 2050. This value is presented in terms of its ability to contribute to our indigenous energy needs, the benefits of enhanced employment creation and investment potential, and the ability to significantly abate carbon emissions to 2050. Furthermore, a comparison of electricity demand and wind electricity generation shows a great capacity for Ireland to export excess wind energy in the 2020 – 2030 timeframe.

Cumulative Capacity with Repowering of Onshore and Offshore Wind Installations to 2050

Annual Electricity Demand vs. Wind Generation

**Key Point:** Ireland has the potential to generate enough electricity to exceed domestic demand by 2030.
Annual Onshore and Offshore Wind Employment Figures to 2050

5 Year Average Onshore and Offshore Wind Employment Figures to 2050

Wind Energy Resource Value Expressed in Cost Per Barrel of Oil Equivalent in 2050

**Key Point:** Onshore and offshore wind generation could create 20,000 direct installation and operation and maintenance jobs by 2040

**Key Point:** Onshore and offshore wind generation could create 20,000 direct installation and operation and maintenance jobs by 2040.

**Key Point:** The potential economic value of electricity generated by wind could reach €15 billion by 2050 on the basis of fuel substitution. While financial support may be required in the early years of this deployment scenario, as technologies mature and market structures evolve from those designed for conventional generation, providing incentives for benefits not currently priced, supports for wind should no longer be necessary.
Key Point: The Irish wind industry is expected to hit a peak annual investment of between €6 - €12 billion by 2040. Wind has a cumulative investment potential of €100 - €200 billion in 2050.

Key Point: This calculation assumes a carbon content for gas fired generation of 205.6 grams CO₂ per kWh for the generation displaced by wind. While base load gas-fired generation may increase in efficiency and become less carbon intensive over time, the operation of gas-fired generation may change to mitigate against this (i.e. increased use as peaking plant). For this reason the factor of 205.6 grams of CO₂ per kWh was applied consistently through to 2050.
Irish Contribution to EU Electricity Demand in 2050

- EU Demand met by Irish Wind Generation 2.5%

Irish Contribution to EU Wind Generation in 2050

- Total Irish Wind Generation 5%

Map of Windfarms in Ireland

- Connected
- Contracted
- Gate 3 Live Offer
- Grid Applicant

Rest of EU Demand
Total Irish Wind Generation
Rest of EU Wind Generation
Total Irish Wind Generation