Future and Historical Renewable Energy Resources and Weather-related Demand



in Ireland



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The Renewable Energy Sector continues to grow

- Renewables would need to supply **70-85% of electricity by 2050** (to limit to 1.5 degC by the end of century).
- Wind and solar energy appear to be feasible options (growth, cost, low risk).
- The Irish electricity sector ~29% renewable energy sources, the majority of which is wind energy.
- Wind energy has had huge growth in Ireland and is projected to continue to grow.
- Solar energy generation is still quite limited in the Republic, but is having rapid growth in Northern Ireland
- Electricity demand is projected to increase in the Republic by 20-57% by 2027.



How do Climate Projections translate to Renewable Resources and Demand for Ireland?

- A much better understanding of how climate change will impact the renewable energy resources and demand is required.
- We will study wind energy, solar energy and electricity demand together.
- While other factors will influence the future energy system, this study aims to understand the isolated effects of weather/climate on future energy systems without introducing other dimensions of uncertainty.



Data and Models

- MERA reanalysis: 1981-2016
- 5 regional downscaled climate models: 1981-2005, 2041-2060, 2081-2100
- 2 scenarios: RCP 4.5, RCP 8.5
- Wind capacity model, Solar capacity model based on Renewables Ninja
- Weather driven Electricity Demand model built on historic demand data and population weighted weather variables





Electricity Demand Model

Isolate residual demand: Remove climatic, seasonal and economic variability



 $D_R = D - \overline{y} - y'$

Fit a Regression Model based on Temperature, Radiation, and Wind

$$D_R = a T_e + b T_e^2 + c I_{global}^h + d W_{surface} + \epsilon,$$

Electricity Demand Model

- 24 Models for each hour of the day.
- Models trained on 5 years of historical electricity demand data.
- Weather variables are **population weighted.**
- Each model is **trained for each season** individually
- Output: all Ireland hourly demand



Solar Capacity Model

 Solar Capacity depends on Irradiation (direct and diffuse), Temperature and Panel efficiency:

$$\frac{P}{C} = I'\eta(I',T').$$

 Where panel efficiency depends on the technology, the direction and tilt of the panel and the solar angles:

 $\eta(I',T') = 1 + k_1 \ln I' + k_2 (\ln I')^2 + T'(k_3 + k_4 \ln I' + k_5 (\ln I')^2) + k_6 T'^2$



Wind Capacity Model





- Smoothed power curves represent wind farm power.
- Input: wind speed at hub height.
- Or density adjusted wind speed.
- We assume **different turbines** for onshore and offshore locations.

Project Status:

Currently available:

- A high resolution hourly wind capacity dataset for the Irish region 1981-2016.
- A high resolution hourly solar capacity dataset for the Irish region 1981-2016.
- A time series of hourly weather driven electricity demand for the Irish region **1981-2016**.

Coming soon:

- A 5 model ensemble of high resolution climate projections of wind and solar capacity in the mid term (2041-2060), and long term (2081-2100) under RCP 4.5 and RCP 8.5.
- A 5 model ensemble of future projections of weather driven electricity demand for Ireland.





Project Status:

- We currently have a historical (1981-2016) high-resolution model of wind and solar energy capacity and weather driven demand for Ireland based on MERA.
- Upcoming work will provide model-based mid and long-term projections of renewable energy resources and demand in Ireland under different RCP scenarios, and a measure of the associated uncertainty.
- These historical and future model-derived data will be useful in planning future energy systems and to provide typical supply and demand profiles under future weather regimes.



