

Analysing Energy Demand and Weather in Ireland: Correlations and Spatial Patterns

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17th May 2018

MÉRA Workshop

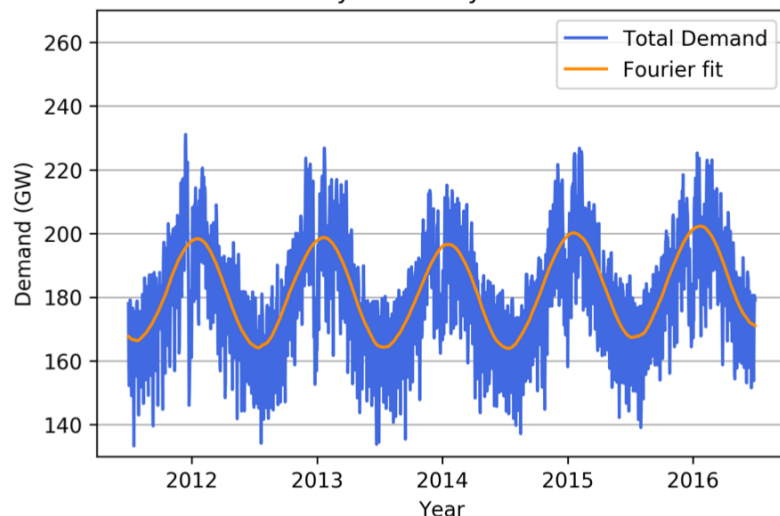


Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

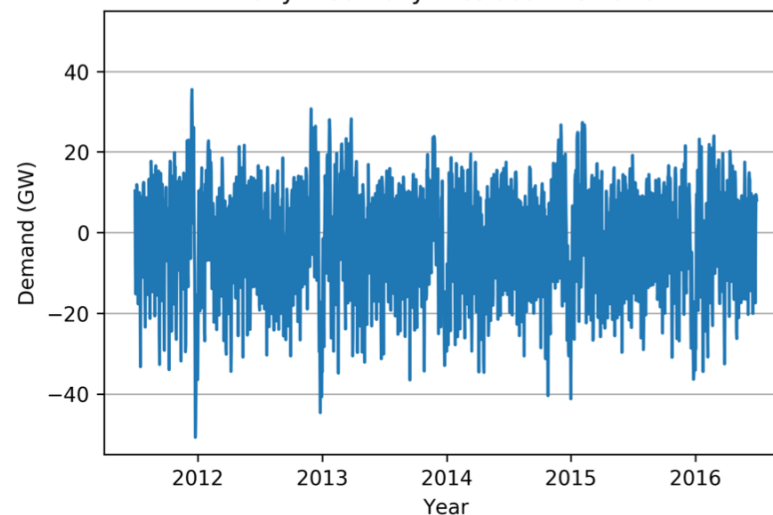


All Ireland Electricity Demand Profiles

Daily Electricity Demand



Daily Electricity: Residual Demand



$$\text{Total Demand} - \text{Fourier fit} = \text{Residual Demand}$$

Annual trend:

- Climatic differences, GDP, electricity prices, technology evolution and societal changes.

Seasonal trend:

- Fluctuations in temperature and daylight.

Driven by:

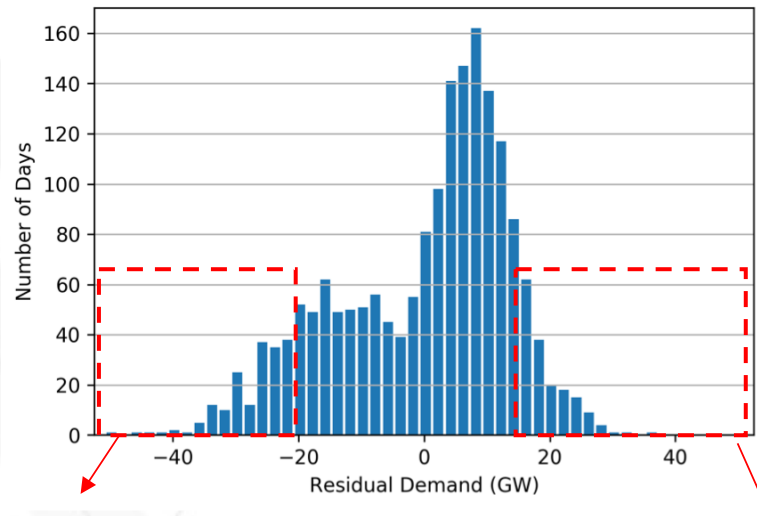
- Day of week.
- Public holidays.
- Weather: Temperature, illumination (clouds) and wind.

High and Low Residual Demand Days

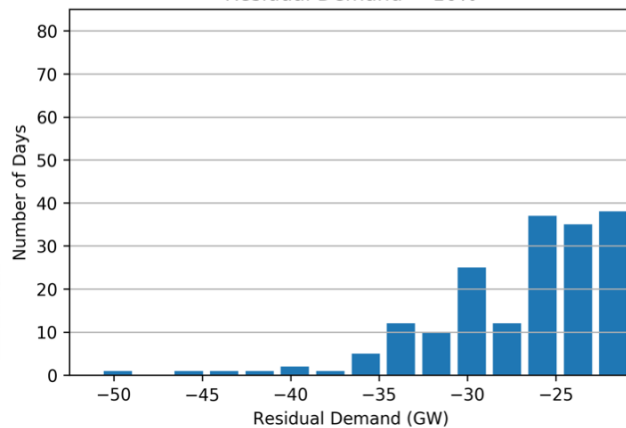


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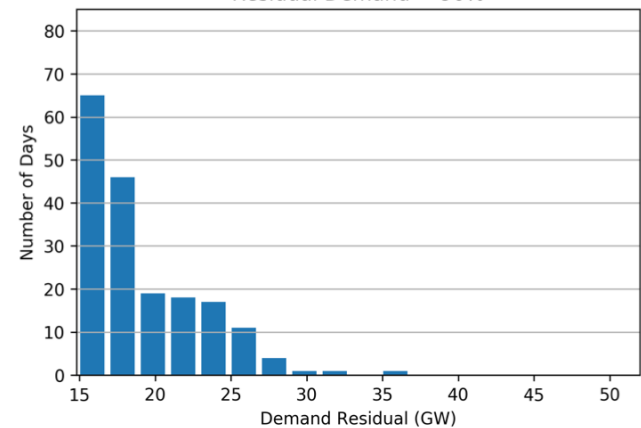
Energy Systems Integration
Partnership Programme



Residual Demand < 10%

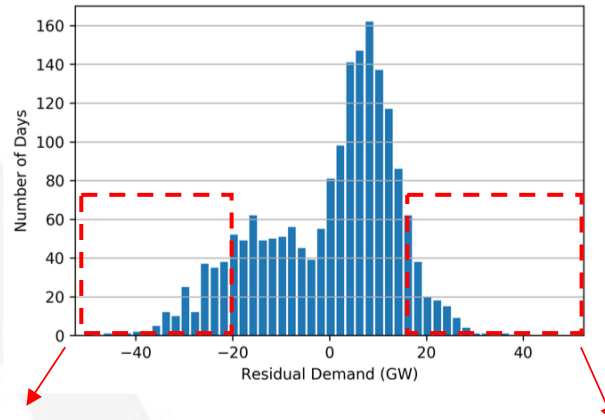


Residual Demand > 90%

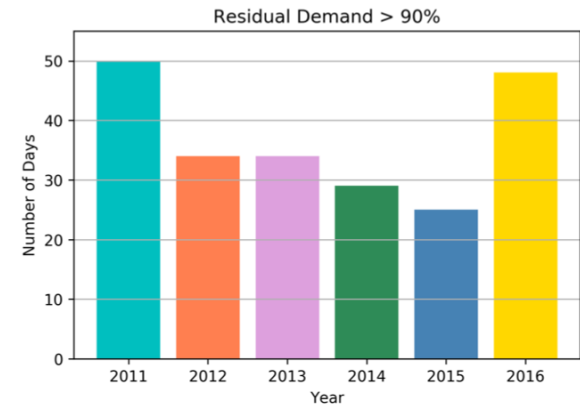
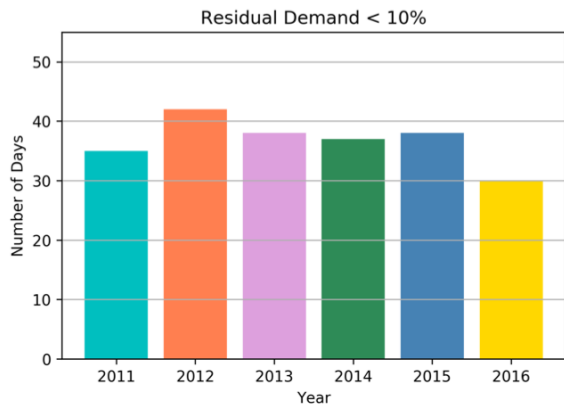
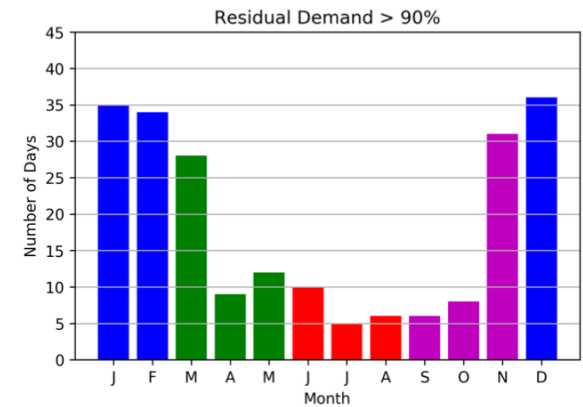
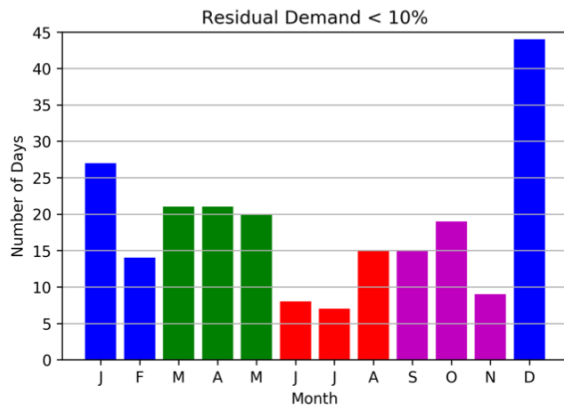


Month-Year Profiles of High and Low Residual Demand Days

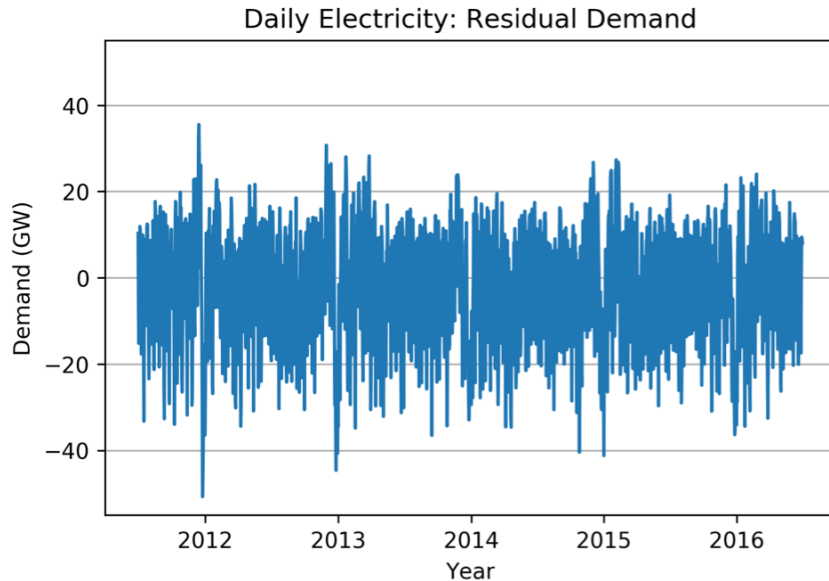
Low demand in December
due to holidays.



High demand in Winter
and 2011 and 2016.



Finding the Weather Driven Component of Demand



Residual Demand Driven by:

- Day of week.
- Public holidays.
- Weather: Temperature, illumination (clouds) and wind.

Fit a Linear Regression Model based on

Cradden and Mc Dermott, Environmental Research Letters (2018)

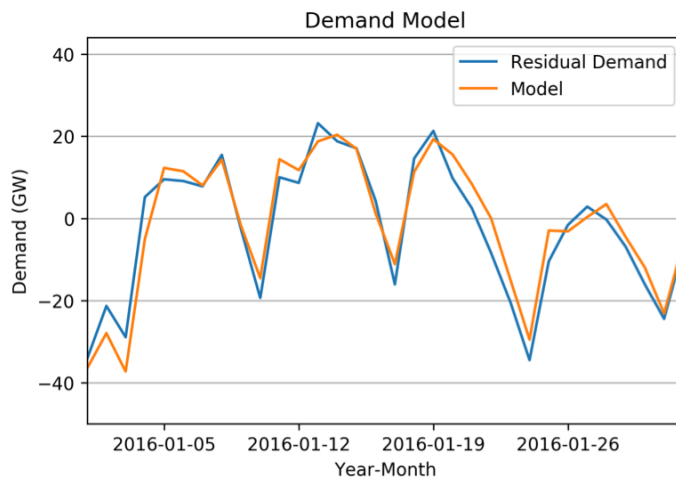
$$\mathbf{D_R} = a\mathbf{T_e} + b\mathbf{T_e}^2 + c\mathbf{Cloud} + d\mathbf{Wind} + e\mathbf{Day} + f\mathbf{Hol} + g\mathbf{Xmas} + \epsilon$$

where effective temperature is defined

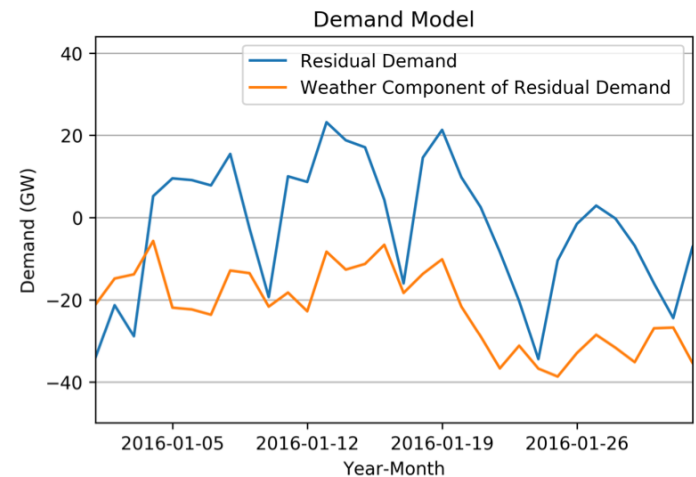
$$\mathbf{T_e}(t_n) = \frac{1}{2}\mathbf{T}(t_n) + \frac{1}{2}\mathbf{T_e}(t_{n-1})$$

Finding the Weather Driven Component of Demand in Winter

- Train the model on **WINTER** data.
- Weather variables from **Dublin Airport observations**.
- Remove **Day**, **Hol** and **Xmas** terms to get weather component.



$$D_R = aT_e + bT_e^2 + c\text{Cloud} + d\text{Wind} + e\text{Day} + f\text{Hol} + g\text{Xmas}$$

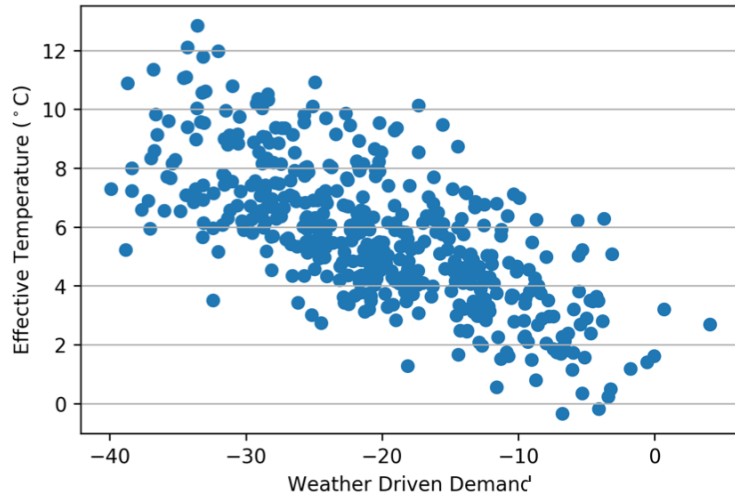


$$D_{\text{weather}} = D_R - e\text{Day} - f\text{Hol} - g\text{Xmas}$$

Weather driven demand correlations with Dublin Winter Observations

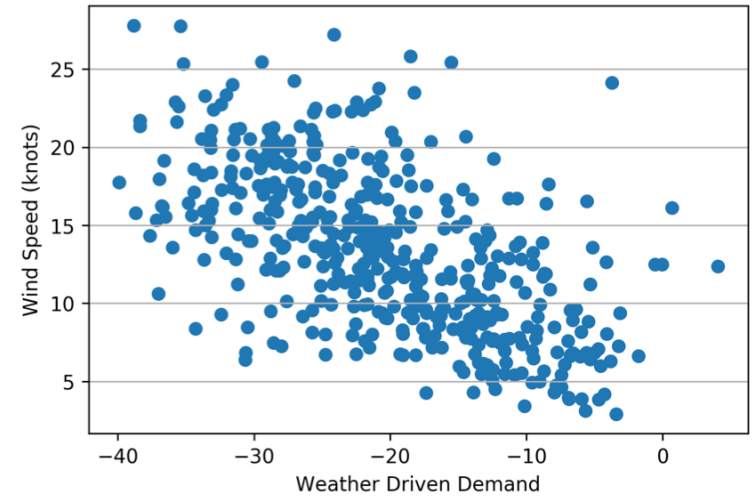
Effective Temperature

$r = -0.698$



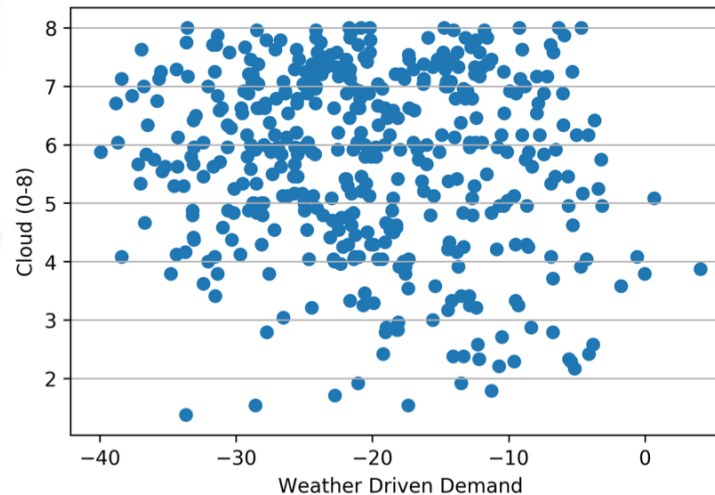
Wind Speed

$r = -0.588$



Cloud Amount

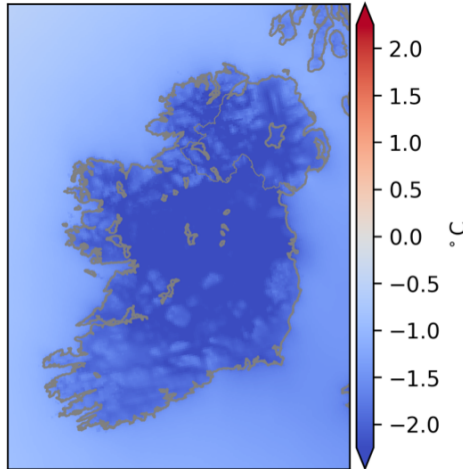
$r = -0.125$



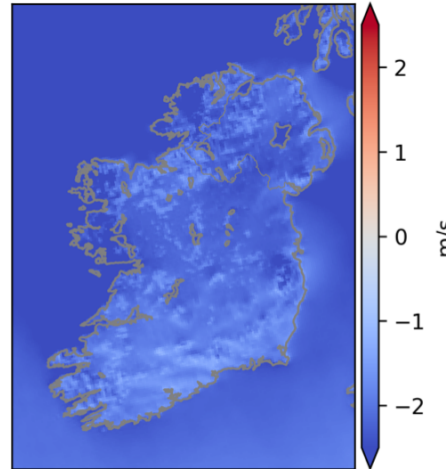
MÉRA: Spatial patterns of Weather on Extreme Demand Winter Days

**High
Weather
Driven
Demand
Days.**

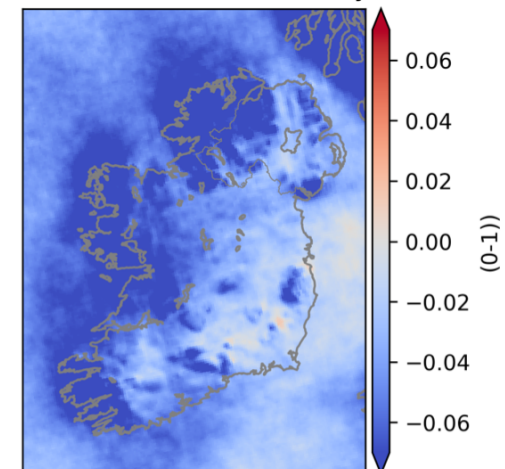
2m Temperature Anomaly



10m Wind Speed Anomaly

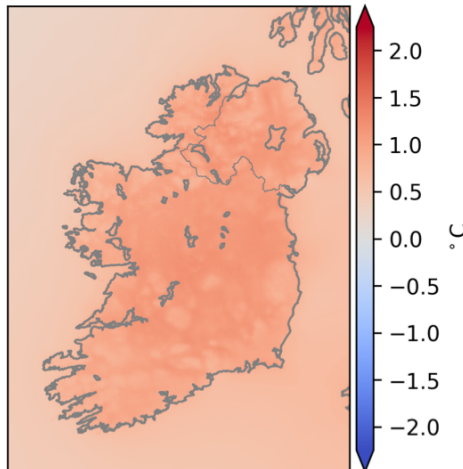


Total Cloud Cover Anomaly

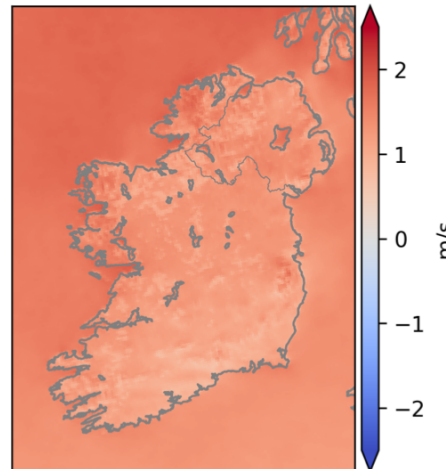


**Low
Weather
Driven
Demand
Days.**

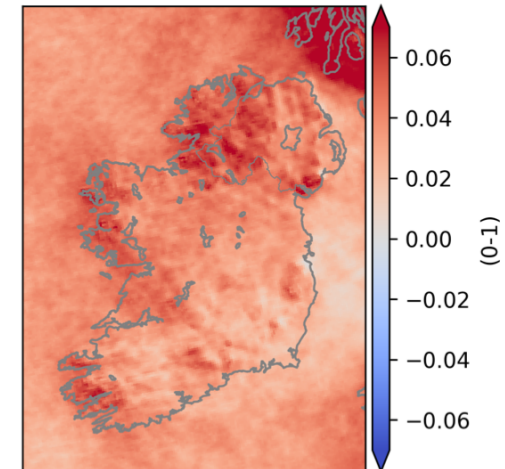
2m Temperature Anomaly



10m Wind Speed Anomaly



Total Cloud Cover Anomaly



Conclusions and Future Work with MÉRA

- Implemented and validated a **model** to extract the **weather driven component** of electricity demand.
- Showed **correlations** between weather driven **demand** and **Temperature, Wind Speed and Cloud** (observations).
- Identified **spatial patterns** of weather on **high and low demand** days using MÉRA.

Future work:

- Use MÉRA to **improve models** by weighting weather over large population centres.
- Analyse spatial patterns associated with high/low **hourly demand**.
- Consider spatial patterns associated with **large model errors**.
- Investigate the **demand response to extreme weather** events (regionally).

Contact Details

www.esipp.ie



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