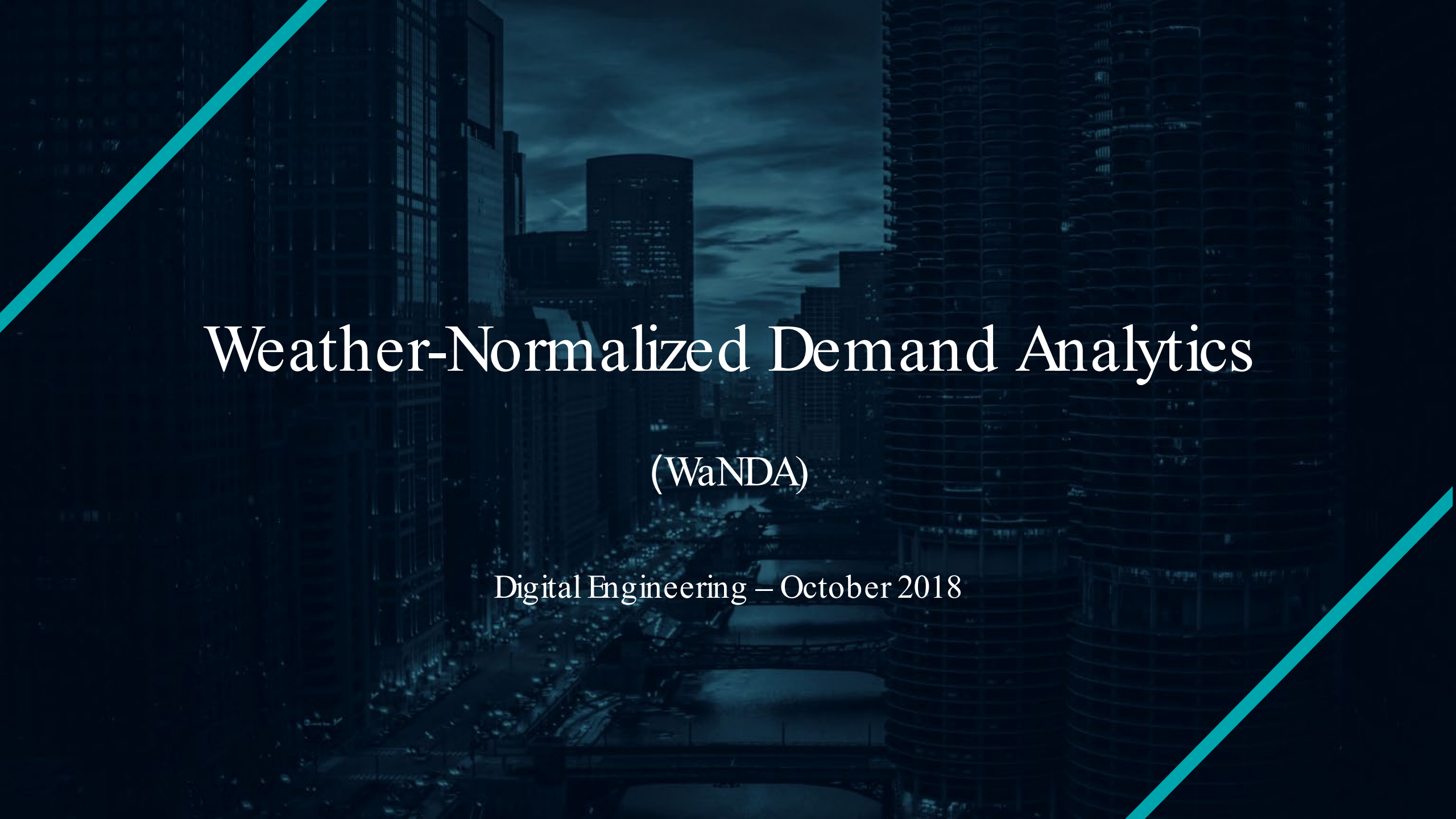

Weather-Normalized Demand Analytics

(WaNDA)

Digital Engineering – October 2018

Introduction

- Why correct demand?
- Existing methods
- Project summary
- Substation-level demandmodeling
- Peak demand trend analysis
- Substation sensitivity to weather
- Key Benefits
- Next steps

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Why correct demand?

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- The way we produce and consume electricity is changing
- Understanding how customer electricity use is changing is critical for network operators
- Electricity demand is significantly impacted by the weather
- Normalizing demand (i.e. removing the effect of unusual weather) exposes the underlying trends in consumer demand behavior
- This allows network operators to make better informed investment decisions, such as targeted reinforcements, or the deferral of network upgrades

Existing methods

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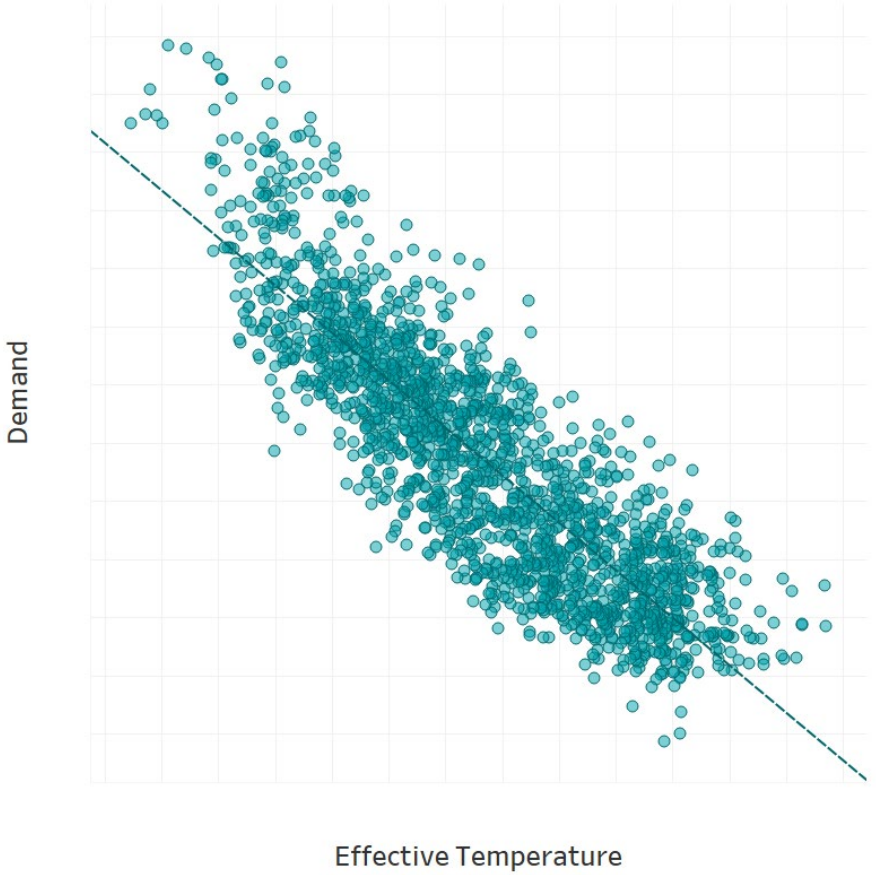
- Methods for correcting demand for the effects of weather are usually very simple
- Often, total network demand will be corrected based on the average temperature at a handful of meteorological masts
  - Relationship used to determine sensitivity to weather
  - Same sensitivity assumed everywhere
- However this approach does not account for the fact that:
  a) The weather conditions vary geographically
  b) Different consumers show different sensitivity to weather



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Project summary

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- We present here a study led by Digital Engineering (DE) which assessed how demand is affec by weather patterns and consumer behavior, at the level of individual substations
- This study focused on a distribution network managed by SP Energy Networks in Scotland, Uk (including around 400 primary substations)
- Different electricity consumers were found to show diverse levels of sensitivity to weather
- The weather was found to vary significantly across the network
- These results are being used to understand the weather-normalized trends in consumer demand at individual substations

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Substation-level demand modeling

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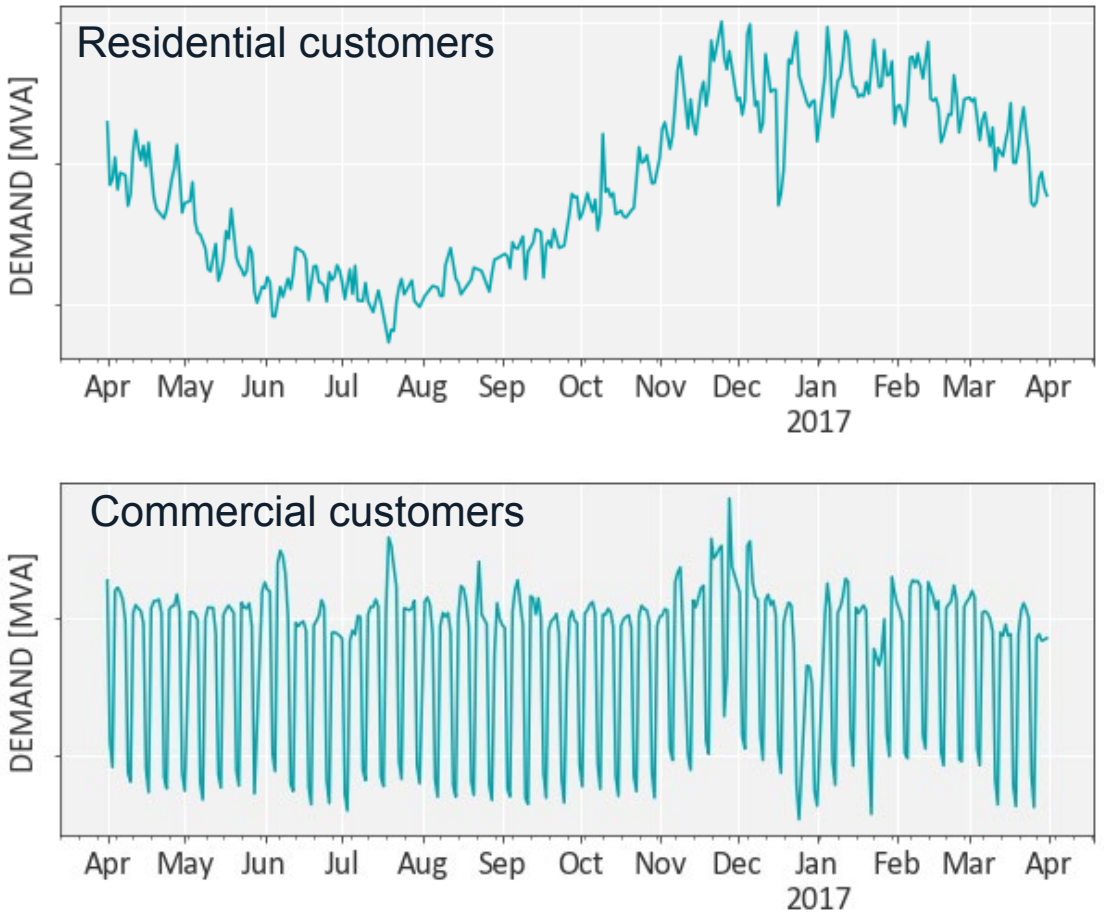
- Different types of customers respond differently to the same weather conditions:
  - Residential areas show strong sensitivity to weather
  - Strong seasonality due to changes in demand for heating and lighting
  - Commercial areas show little seasonal change, but big reductions at weekends
  - Special events (e.g. Winter holiday period) induce one-off changes



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Substation-level demand modeling

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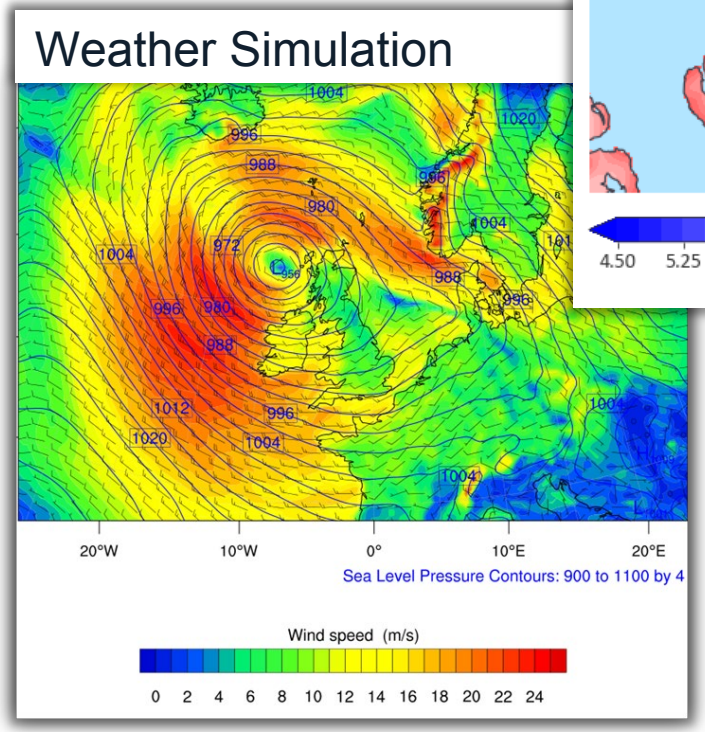
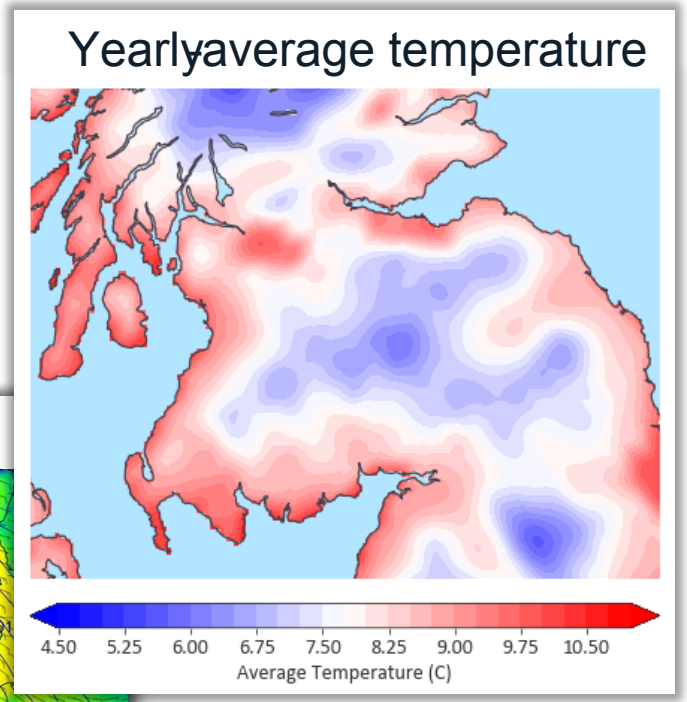
- DE applied their state-of-the-art weather models to re-create 10 years of historical weather data at high spatial and temporal resolution in Scotland
- Weather varies significantly across an electricity network, due to the following:
  - Ground elevation (e.g. hills and mountains)
  - Weather patterns
  - Coastal effects
  - Urban heat-islands (large cities)





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Substation-level demand modeling

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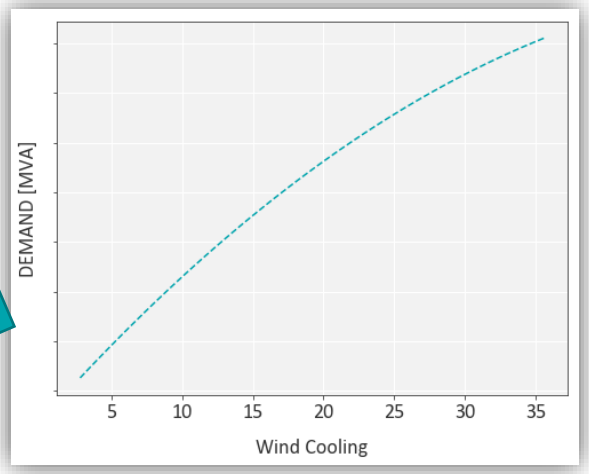
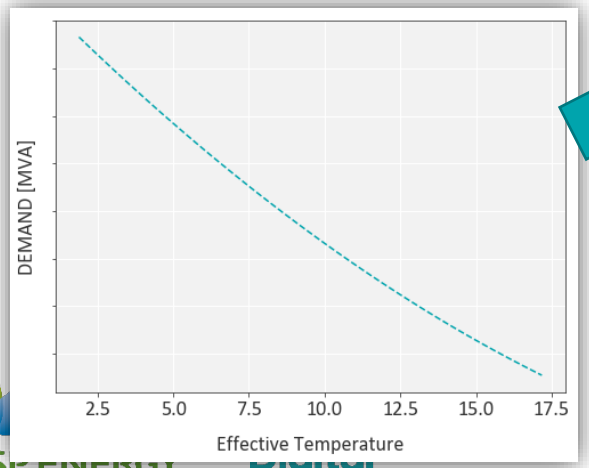
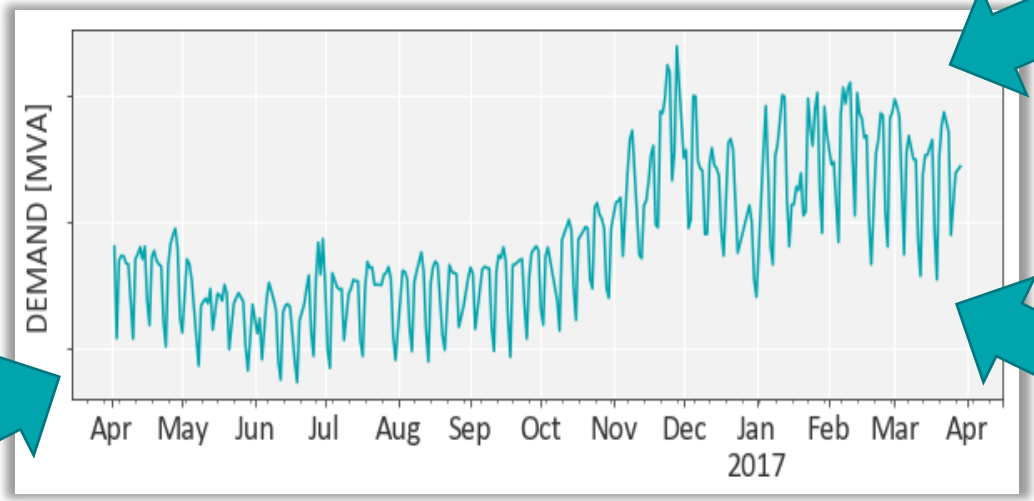
Weather data is combined with a suite of consumer demand response models to produce substation-specific predictions

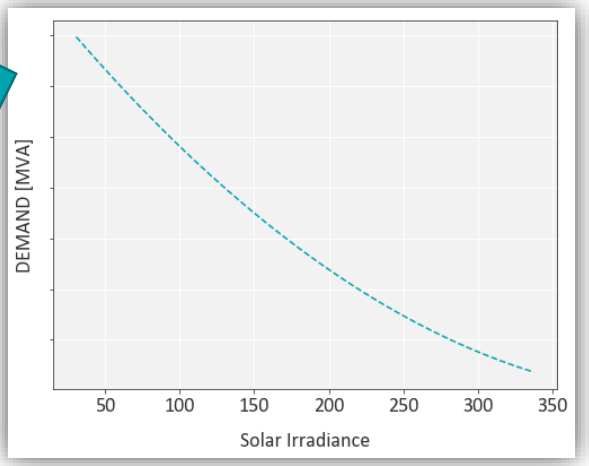
Wind



Temperature







Solar Irradiance

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Substation-level demand modeling

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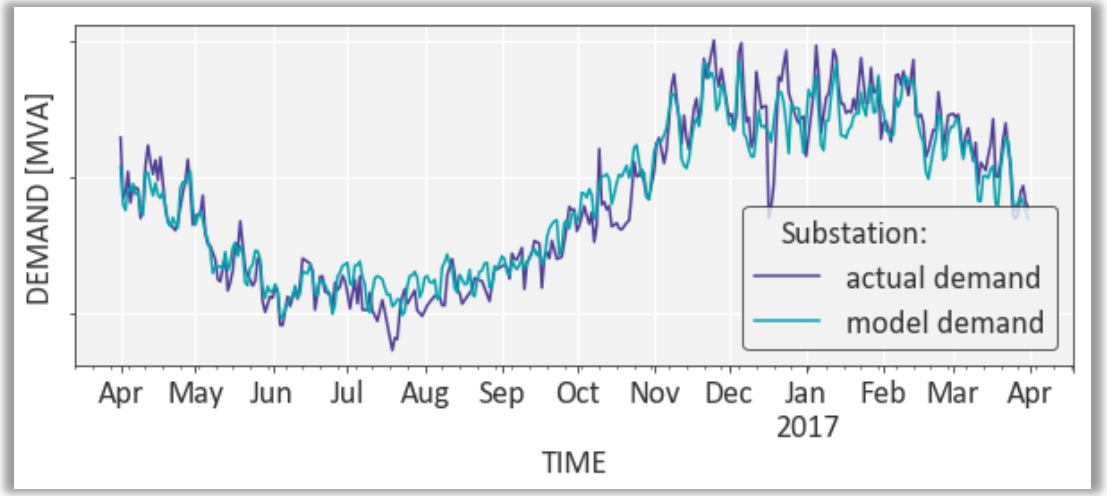
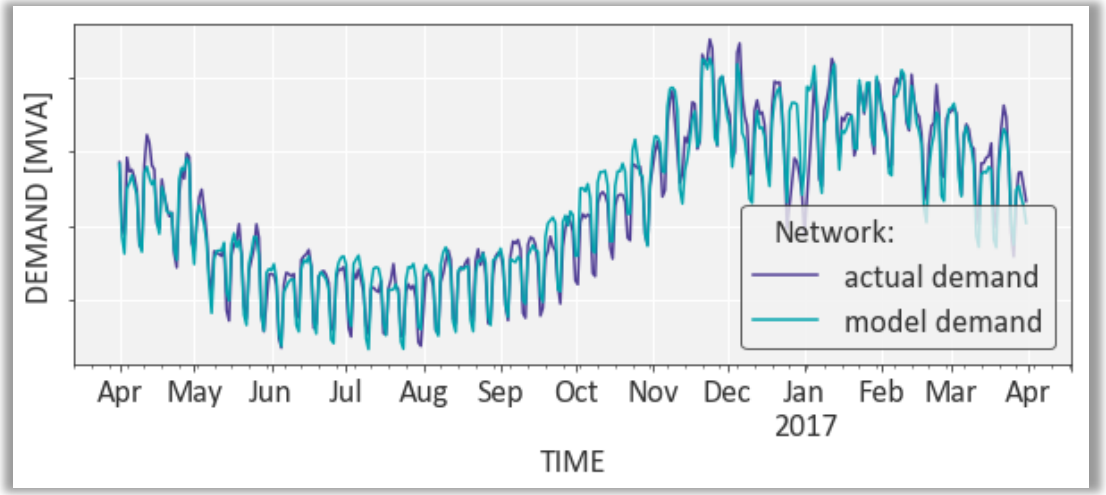
The substation models can be used on their own for granular data about the network…

…or they can be combined to give accurate regional or network level data

These models are data-driven and adaptable to any geographical location worldwide





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Substation-level demand modeling

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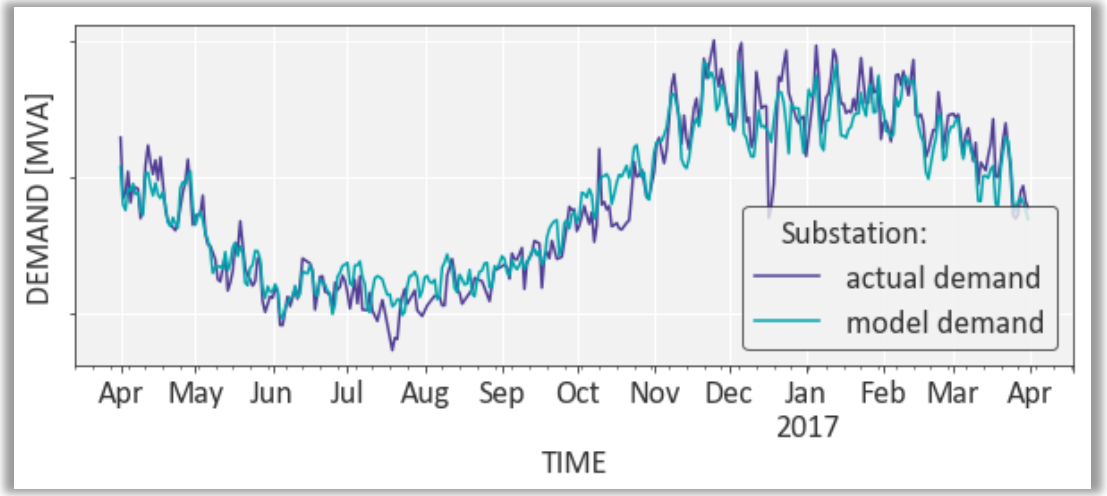
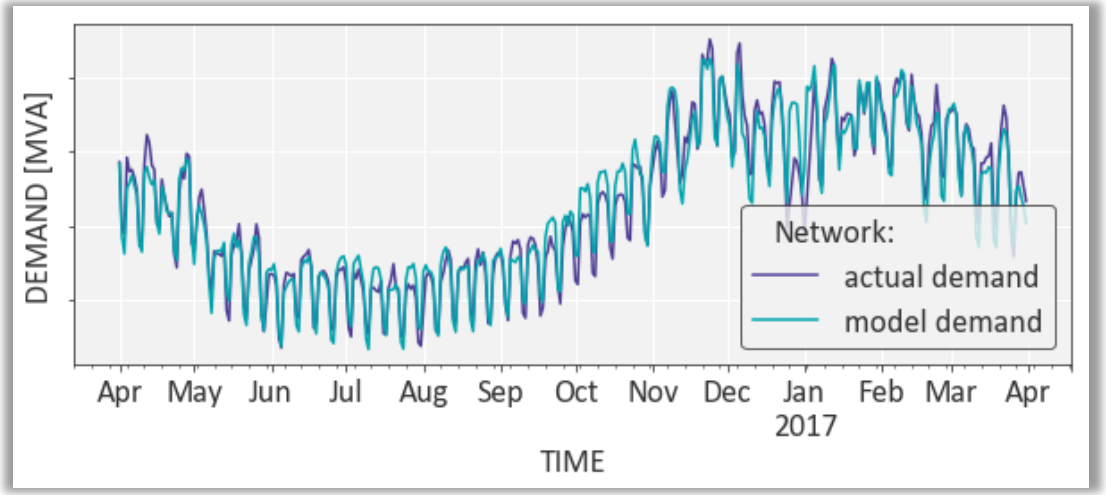
For SP Energy Networks, this project:

- Processed and filtered the demand data from primary substations (see paper for details)
- Calculated ‘weather correction factors’ by comparing the peak demand in any one year to peak demand values predicted using 10 years of weather data
- Analysed historical trends in annual peak demand at each substation
- Predicted the impacts of extreme weather on different substations





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Substation-level demand modeling

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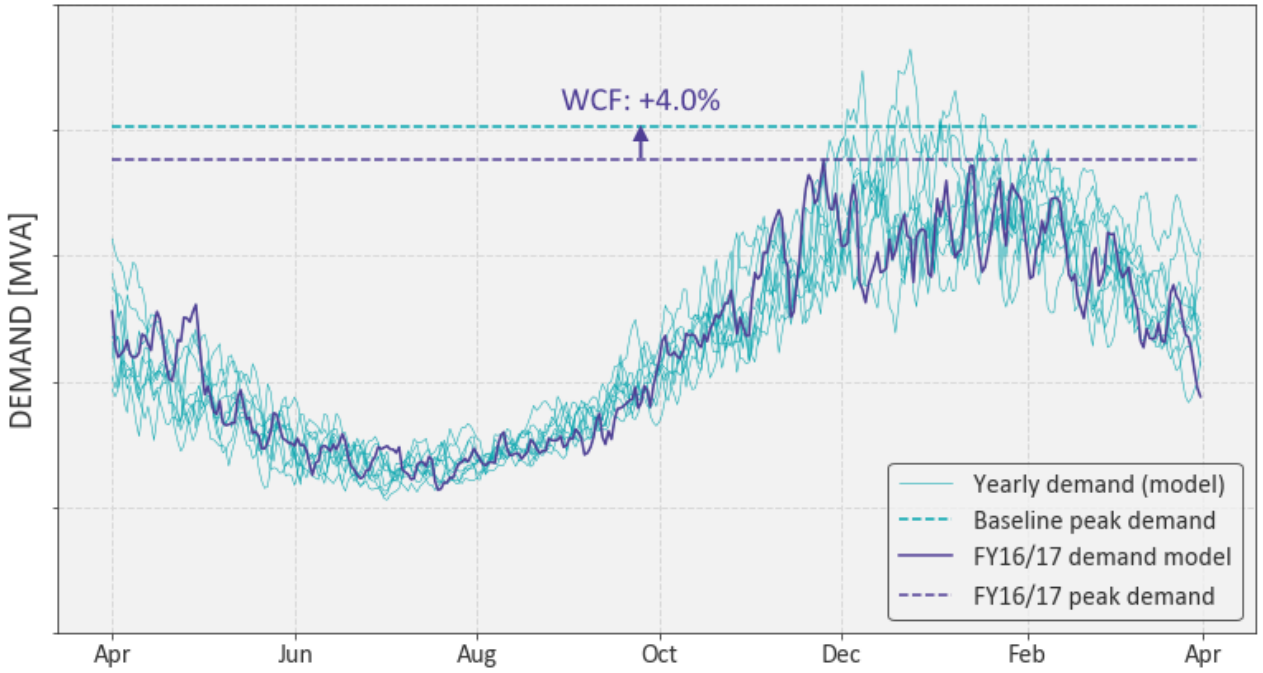
Weather correction factors (WCFs) were calculated by:

- Simulating the demand profile for a given substation and year
- Simulating demand time series using weather data from all 10 years
- Calculating the scale factor required to adjust the peak demand from this year to the long-term average



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Peak Demand Trends

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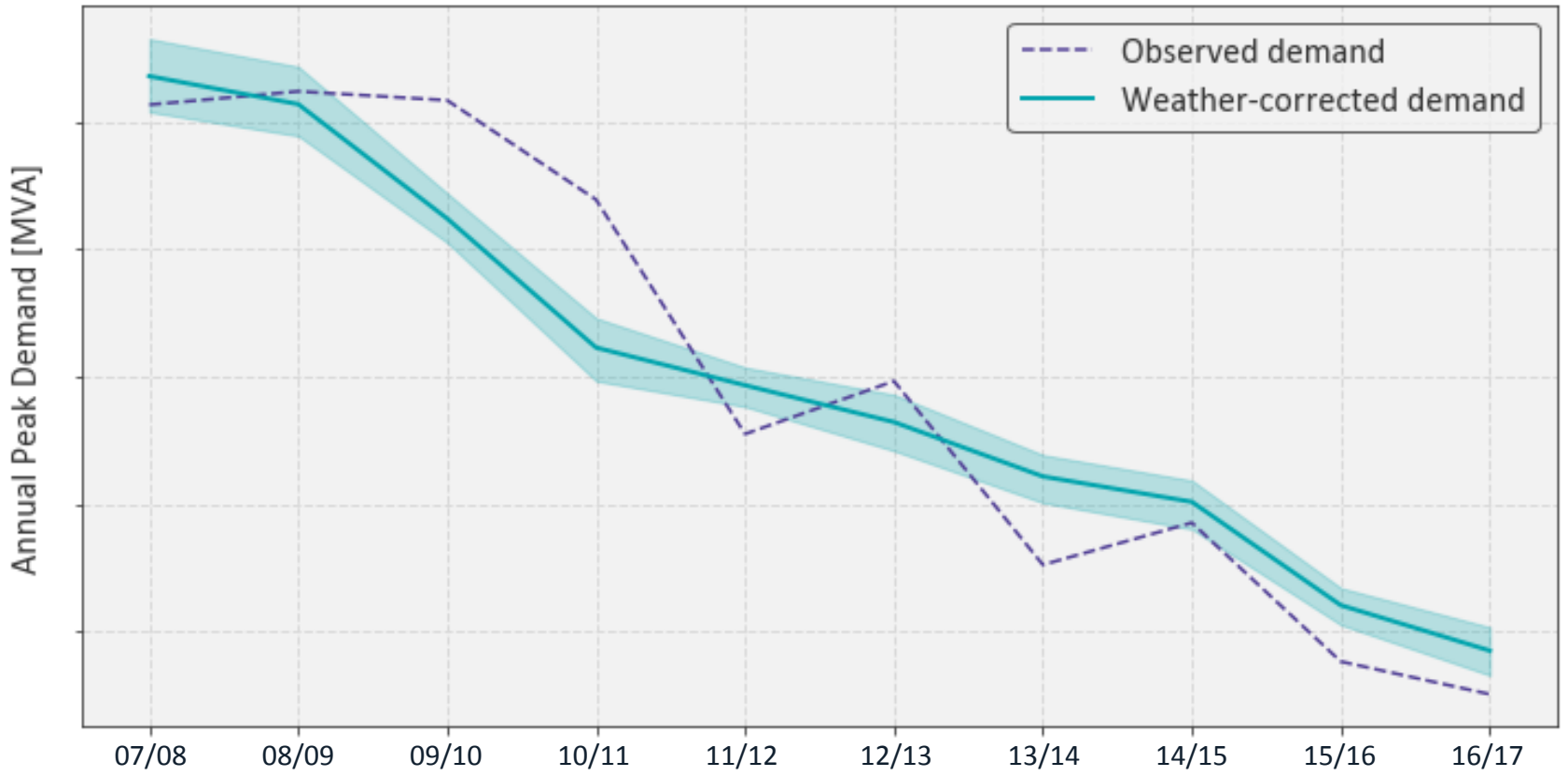

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Peak Demand Trends

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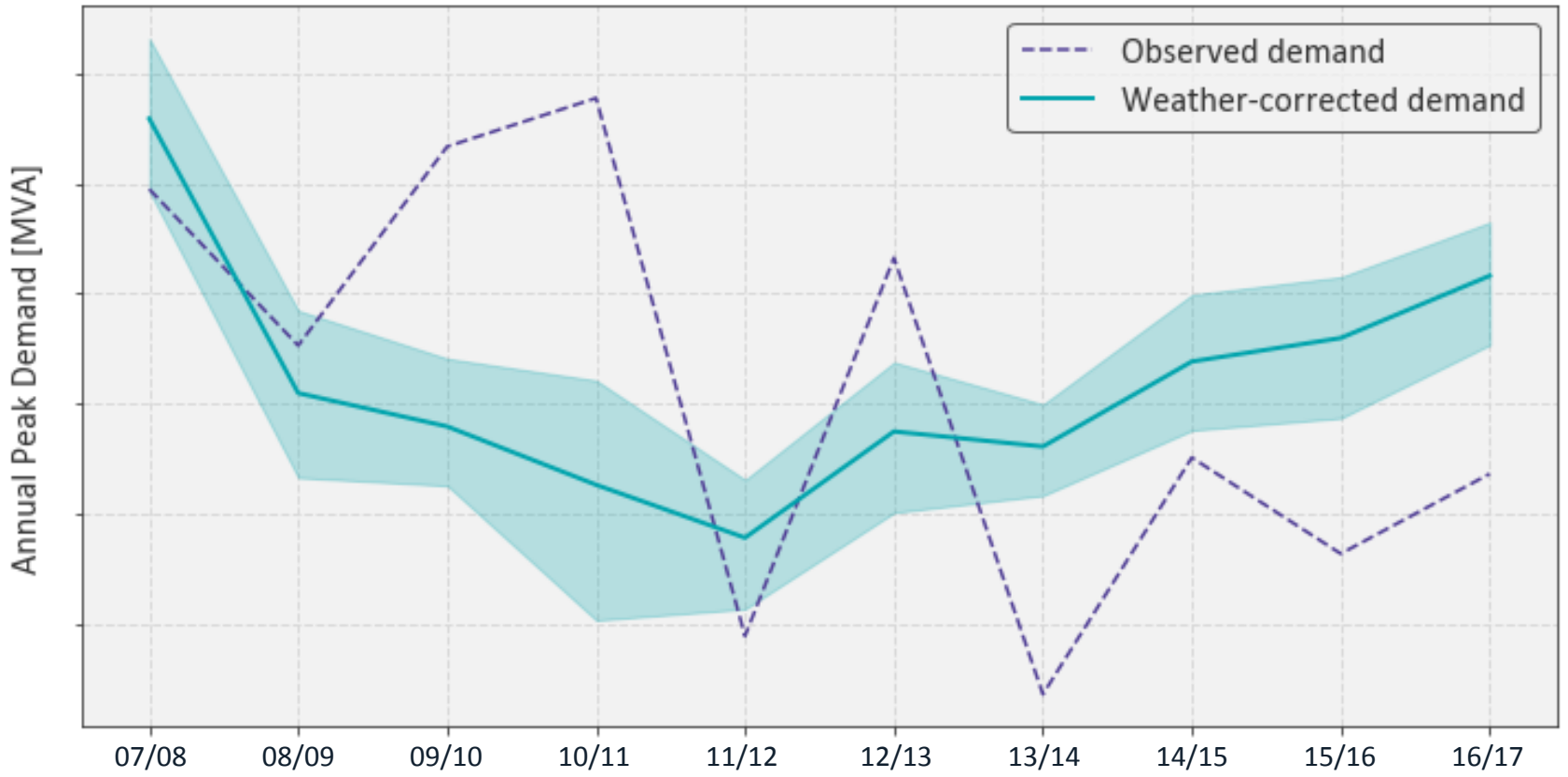

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Substation sensitivity to weather

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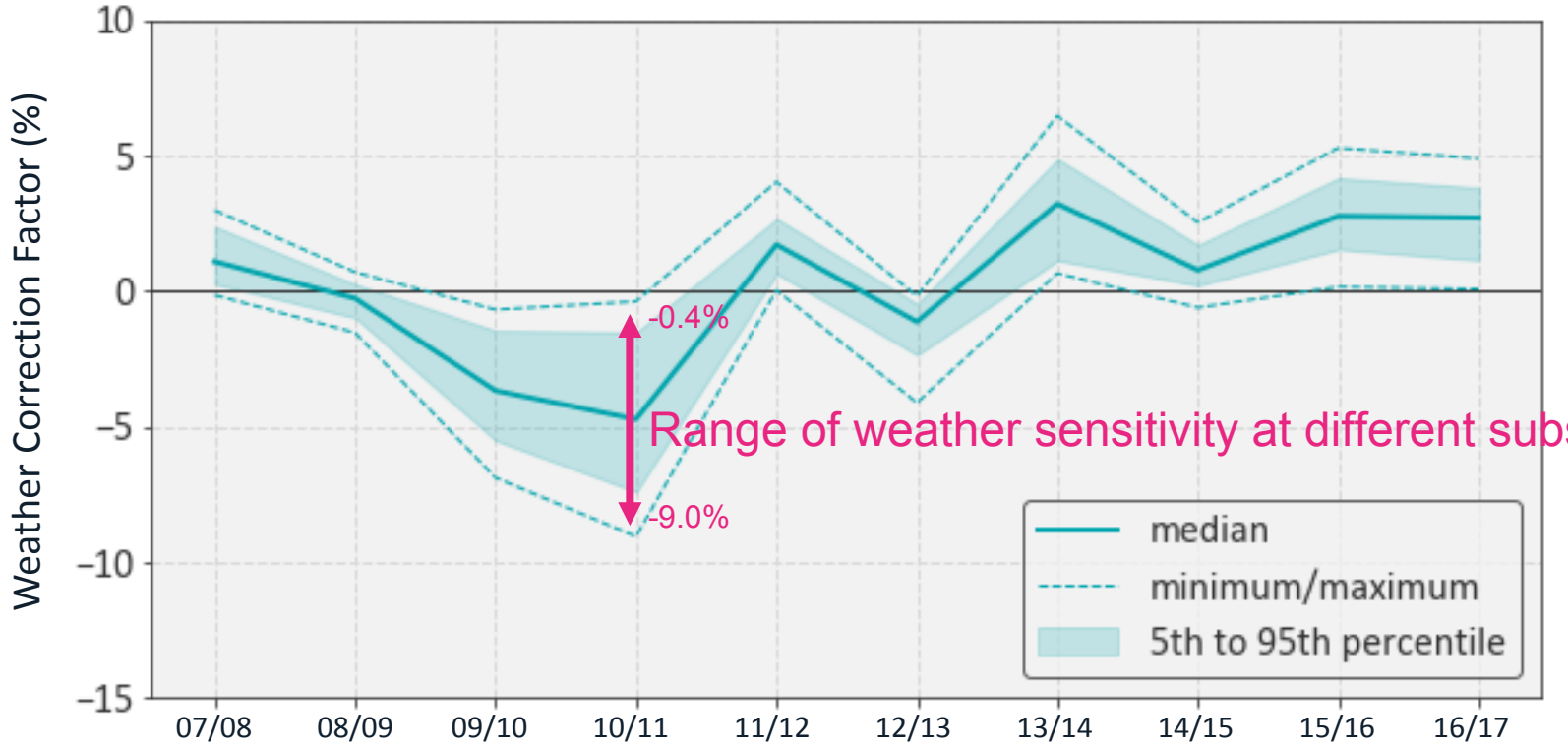

Range of weather sensitivity at different substations

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Key Benefits

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This analysis is helping SP Energy Networks to:

- Improve targeting of investment (reinforcement)
- Assess the potential impact of extreme weather scenarios on different parts of their network
- Improve baseline projections for future demand scenarios
- Enable early warning of substation-level shifts in demand
- Transition to the role of Distribution System Operator

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Next Steps

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Ongoing developments include:

- Enhanced asset ratings through weather correction
- Short and long-term demand forecasting at the substation level
- Inclusion of new technologies (EVs, heat pumps etc.) in future projections
- Integration into core planning tools at SP Energy Networks
- Integration with DE's power generation models for improved "whole-system" transmission modeling

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