Platform For Energy Forecasting (PEF) Strategic Project Roadmap Update June 2020

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Background

In April 2018 , ESO initiated strategic transformation project to develop and implement state of art forecasting capability to deliver value to consumers by providing accurate possible, user friendly comprehensive forecasts to our stakeholders to make informed decisions ahead of real time

Our strategic forecasting project , aims to replace our existing energy forecasting system (EFS) with advance cloud based platform for energy forecasting (PEF) while designing & improving forecasting models , methodologies and apply advanced statistical learning & machine learning modelling techniques & automation.

This pack is an update to PEF roadmap published in June 2019. In the updated roadmap, we have included high-level modelling approach, methodologies and forecasting accuracy improvements made so far

We would welcome the opportunity to discuss our project , platform, modelling approach and demonstrate this technology in action

Project Summary

Initial core phase of project PEF aims is to focus on (1) National Demand Forecast (2) Grid Supply point (GSP) forecast (3) Wind power generation forecast (4) Solar power generation forecast

National Demand forecast (refer as INDO on BMRS) and national solar power generation forecast are fully developed and are already in use

Grid supply point (GSP) level forecasts have been developed using new machine learning approach. The GSP forecasts has been further enhanced into three sub-components: GSP Net Demand, GSP Wind power and GSP solar power, further contributing to improved accuracy by explicitly incorporating forecasts for distribution connected generation. This newly developed GSP forecasts are currently in a trial and validation phase, ensuring it can deliver maximal benefit

In 2020/21. our aim is to further enhance national demand forecasting capability, including a new machine learning approach and develop a wind power generation forecasting modelling approach and methodology

Subsequent Enhanced phase is to focus on additional fuel type forecasts and continuously drive forecasting efficiency through innovation while keeping up with market and system changes

We aim to develop bespoke forecasts for individual units where frequency, resolution and forecast horizon can be flexed depending on stakeholder needs, consumer benefit realization, availability of improved data & model performance

Our Purpose & Vision

Purpose

Deliver state of art forecasting capability to support electricity system operations and market participants to make efficient system balancing decisions ahead of real time to deliver value to consumers

Vision

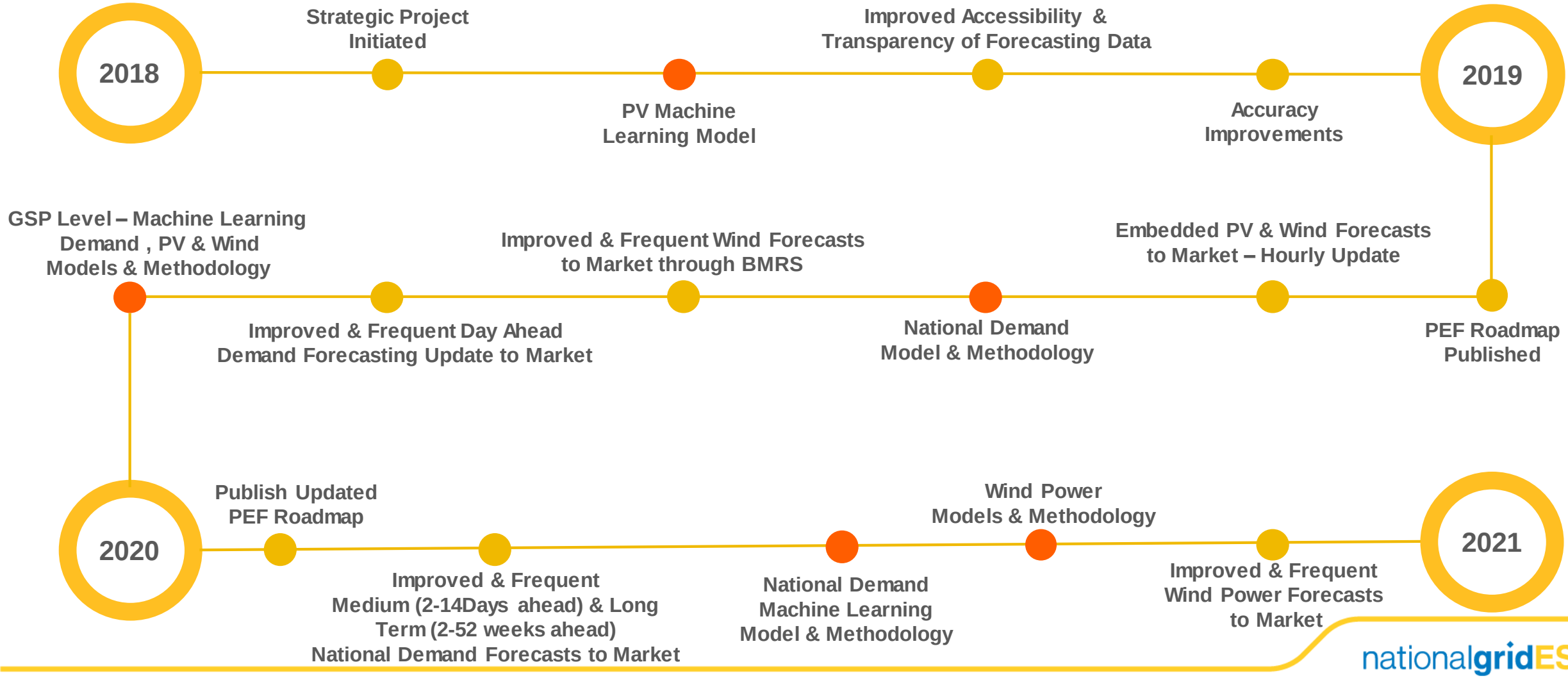
Develop and Implement NEW ESO forecasting capability towards supporting zero carbon electricity system operations by 2025 , while delivering tangible benefits to consumers through Innovation , Technological Adaptation , Automation & AGILE ways of working

New Improved service to market

New modelling approach & methodology

Year in this slide refers to the financial year

PEF Journey So far and what's next



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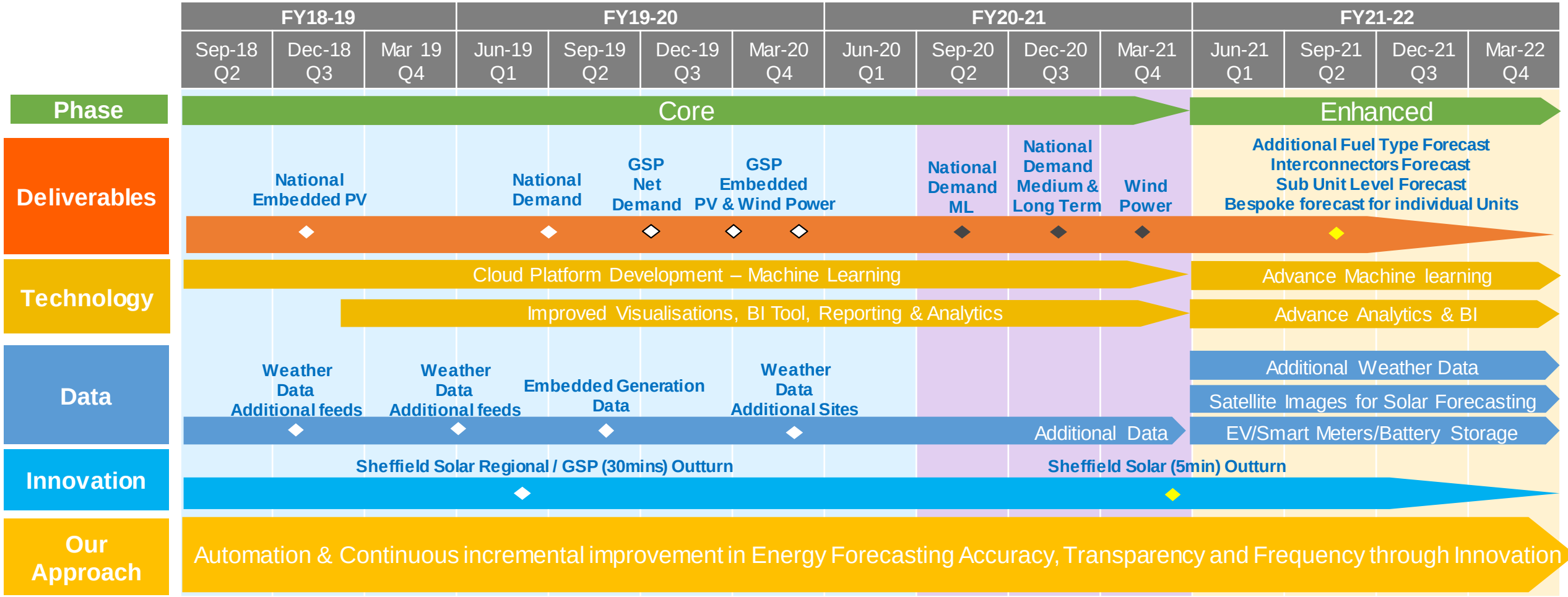
PEF Roadmap- Update

- Delivered & In Use
- Developed & Under Validation
- Under development or to be developed
- Subject to consumer benefit realisation , availability of improved data and model performance



PEF Roadmap published in June 2019

We have delivered value to consumers

More frequent and accurate forecasts enable market participants to balance their position ahead of time, reducing the requirement for balancing services and residual balancing actions

IMPROVED ACCURACY

Improves quality of service and helps lower bills than otherwise be the case

- Project PEF has delivered a step change forecasting accuracy improvements by
  - Developing & Implementing of new modelling techniques and methodologies
  - Implementing improved & frequent data feeds
- **~12%** improvement in forecasting core KPI between April 2018-Feb 2020 **(Pre COVID-19)**
- **~20%** improvement in short term national demand forecast accuracy

IMPROVED FREQUENCY

Provides valuable frequent information to our stakeholders

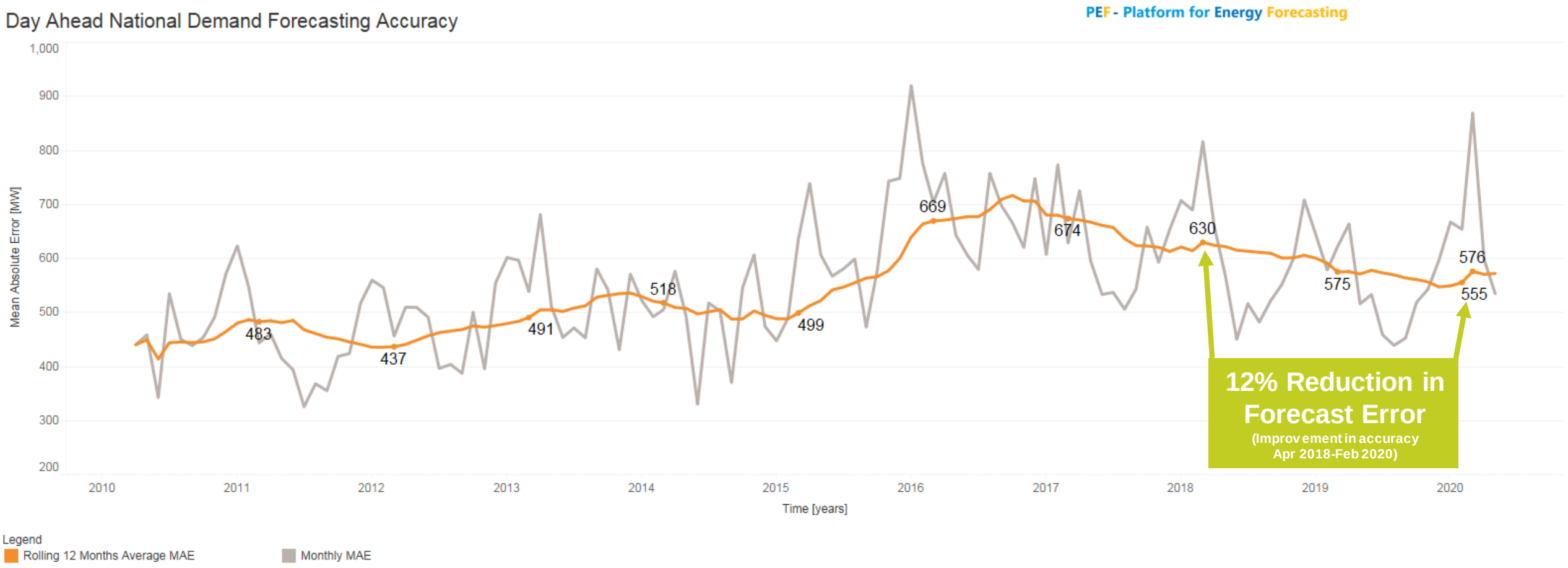
- Project PEF has improved frequency of forecasts published to market
  - Solar Power Forecasts from 4 updates daily to 24 updates daily
  - Embedded Wind Forecasts from every 6 hours to every 3 hours (From 4 updates to 8 updates daily)
  - BMU Wind forecast forecasts from every 6 hours to every 3 hours (from 4 updates to 8 updates daily)
  - National Demand Forecasts from 4 times daily to 24times daily

IMPROVED TRANSPARENCY

Easy to access and transparent forecasting data allow stakeholders to make better informed decision

- In addition to energy forecasting dedicated website - All Our forecasting forecasts and data is also available at ESO Data Portal in machine readable format

Energy Forecasting Core KPI



Facilitating other ESO improvements

Power Available

We aim to incorporate Power available data in PEF and subsequently validate and may use in our wind power forecasting approach

This contributes to our continued efforts to improve wind power models and forecasting accuracy and response optimisation

Inertia Monitoring

We aim to provide GSP level net demand , embedded PV & wind power forecasts & outturn estimates for the development & validation of Inertia monitoring

This contributes to our efforts to optimise ESO's holding of reserve by increasing confidence in the system requirements with the increasing number of embedded generators

Margin & Reserve

We aim to provide National Demand, embedded PV & wind power forecasts to assess the system margins & reserves levels

This contributes to our efforts to facilitate the market to anticipate system requirements, lowering balancing costs

PEF & Our modelling approach

Platform for Energy Forecasting (PEF)

Our strategic forecasting platform for energy forecasting (PEF) is underpinned by scalable & flexible technology hosted on an advanced cloud platform capable of simultaneously processing large datasets, model validations and perform computations to make end to end forecasting process ~80% more efficient and provide as accurate as possible ,timely & frequent information to our stakeholders

Platform for energy forecasting (PEF)

- **Can run tens of thousands of concurrent forecasting models using some of the latest machine learning, deep learning and reinforcement learning integrated with statistical approaches**
- **Is self-adapting as the demographics of the energy ecosystem continue to morph to a zero-carbon model**
- **Enables us to implement - Our core forecasting capabilities : (1) Data Management (2) Reporting & Advanced analytics (3) Modelling & Automation (4) Operational support and monitoring**

PEF New Forecasting Capability Build

Four Core enabling capabilities that will sit at the heart of ESO's new Energy Forecasting - with the ability to develop and implement improvements to deliver consumer value

Operational Support & Monitoring

24/7 support, maintenance and trouble resolution for data capabilities, ensuring system stability, robustness and compliance with grid code and license obligations

Modelling and Automation

The wide enablement of automation and advance modelling technologies (machine learning) to streamline operations and deliver sustainable and ongoing improvements

Reporting & Advanced Analytics

Data exploration & KPIs reporting, embedding insights into operations and for the market participants to deliver value

Data Management

Implement effective management, control and governance to create and maintain a trusted data set on which forecasting models, operations, market and reporting can rely on

Acquire feedback, Learn and iterate

Ability to launch ad-hoc projects (Innovation) with specialised skillsets/capabilities to deliver consumer value by developing new solutions to improve or extend forecasting capabilities

National Demand Forecast

We have re-designed the mathematical modelling we use for national demand forecasting for each cardinal point from now to 365days ahead. This new modelling approach has resulted about 20% improvement across the accuracy of all cardinal points

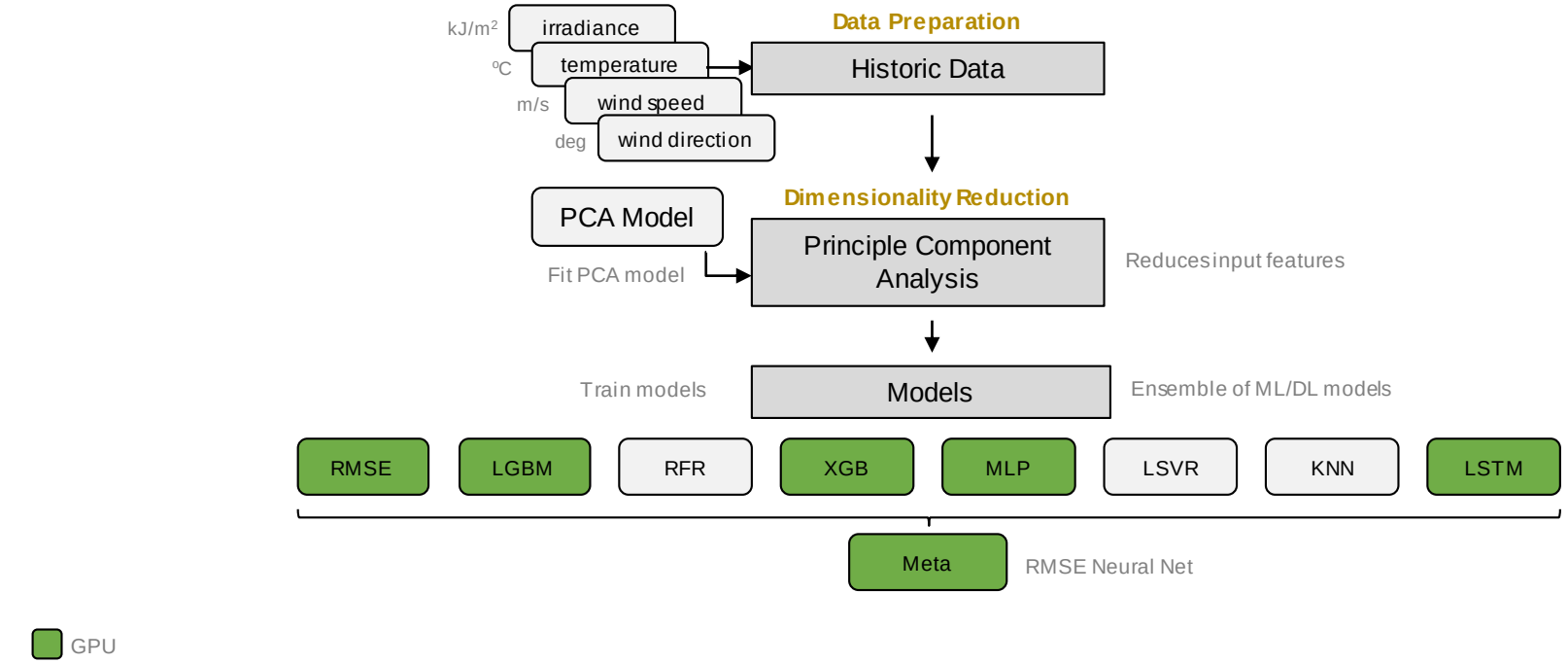
- We have employed a more inclusive approach to embedded generation
- Basing forecasts on a proxy for GB consumer demand including embedded generation components and National Demand
- This allows to capture behavioural patterns more efficiently
- Same Cardinal Point methodology is used, and interpolated into half-hourly demands
- Forecasts for unmetered embedded wind and solar power generation are subsequently included to arrive at a National Demand forecast
- Re-ordering of sequence allows for a clearer separation between the impacts of behaviour and embedded generation on National Demand

GSP Forecast

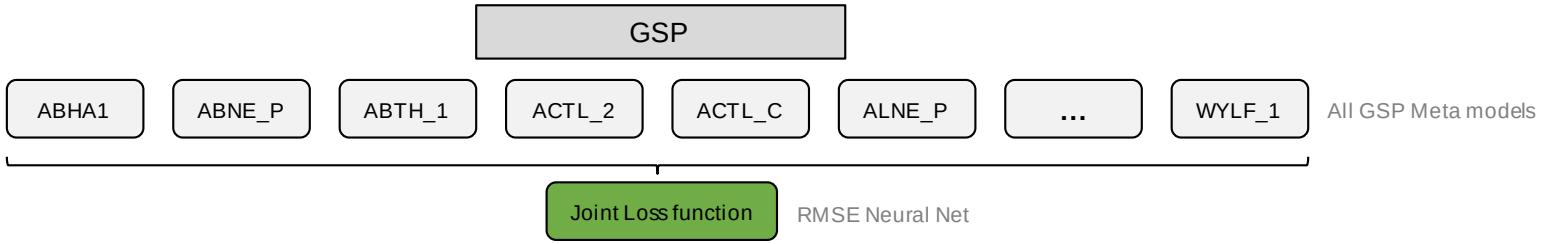
We have developed a completely new machine learning GSP forecasting modelling approach and methodology to predict Net Demand , Unmetered embedded Solar & wind generation forecasts at GSP levels. Early analysis indicates a positive step change improvement in GSP forecast accuracy - These new forecasts are undergoing internal validation

- **GSP Model Training Scale**
  - Approximately 10 deep learning & machine learning models per GSP;
  - We make use of latest data by regularly re-training approx. 7000+ models on an advanced cloud platform
- **GSP Model Prediction Scale**
  - Updated every hour with new data available;
  - Predictions for each settlement period from now to 14days ahead;
  - Nowcasting on weather data to correct for errors in weather forecast throughout the day
  - Potential to increase forecast regularity and granularity dependant on data frequency & model performance
- **In addition to historic metering & weather data , we have used**
  - Electralink data for over 1900 embedded wind MPAN's (~6.5GW Capacity)
  - GSP level solar outturns produced by Sheffield Solar

Machine Learning Model Training Single GSP



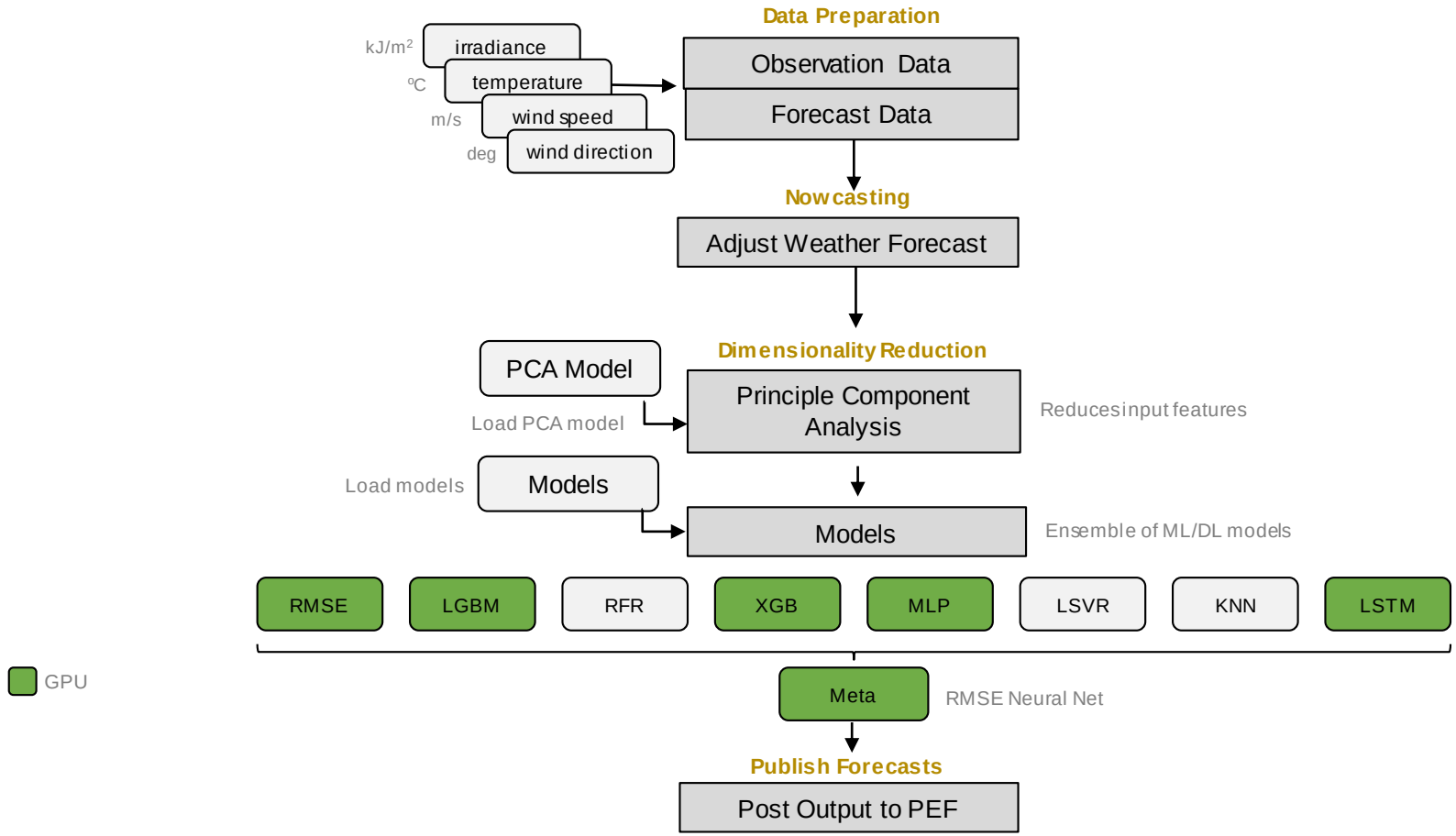
Machine Learning Model Training Interacting Layer



$$\sum_{i=1}^{n} MSE_i$$

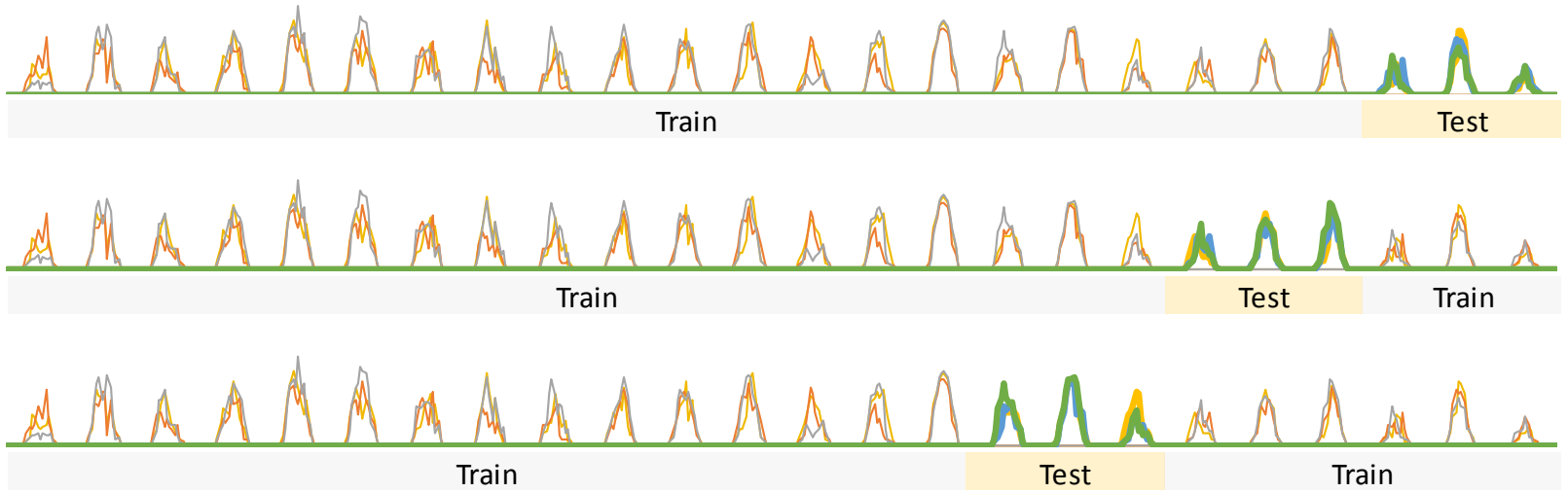
- Joint Loss function optimising and reducing the Sum of GSP meta model MSE by adjusting each GSP individual model weights.
- Early stopping on the Joint Loss training to avoid overfitting
- Joint loss function enables the ability to take into account grid functionality and interactions

Machine Learning Model Prediction Single GSP



Evaluate Model Performance

- Split/fold data into k folds using k-Fold Cross Validation
- Train models on train set (k-1), evaluate performance on test set (k), repeat k times on different folds
- k-fold cross validation allows models to be tested on unseen historical data
- Prevents Neural Nets and other complex ML models from overfitting, ensuring the model will perform well with future unseen data



Repeat for all folds…

Additional Information

What we publish

- Our forecasts & data as required by grid-code & licence obligations are published through BMRS ;
- Our Historic Demand data, Day ahead, 2 Day ahead and 7 Day ahead national demand forecasts , Day Ahead Wind power forecasts, Embedded generation forecasts are available at our dedicated Website for energy forecasting;
- We also provide an email service to deliver our incentivised forecasts and historic demand data – Click to Subscribe ;
- Our Historic demand data and energy forecasts are also available in machine readable format at ESO data portal

Sumit Gumber

Product Manager – Platform For Energy Forecasting (PEF)

Email : sumit.gumber@nationalgrideso.com

Henk Pietersen

Business Lead – Platform For Energy Forecasting (PEF)

Email : henk.pietersen@nationalgrideso.com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