Open Source Evaluation Framework for Solar Forecasting

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Outline

1. Project overview
2. Example use cases
3. Framework architecture
4. Data sources
5. Benchmark forecasts
6. Reports and metrics
7. Post-DOE funding plans

Project Overview

Project goal

To develop an open-source framework that enables evaluations of irradiance, solar power, and net-load forecasts that are impartial, repeatable, and auditable.

Our solar forecast evaluation framework will:

- Improve forecasts based on objective, consistent metrics
- Develop user confidence in forecasts → system integration
- Reduce costs associated with forecasts (SETO goals, help providers)
- Easily extend to wind power and load forecasting

Three Key Tasks

Stakeholder Engagement

- Help define use cases
- Guide selection of benchmarks, metrics, data sets
- Provide data
- Aid long-term plan

We need your input!

Support Topic Areas 2 and 3

- Define test data
- Provide evaluation services

Construct the Framework Service

- Open source
- Thoroughly test, document, validate

Sketch of Forecast Trial Use Case

Framework Server

- Website & API
- Data QC
- Reference databases
- Secure databases
- Benchmark power fx
- Analysis engine

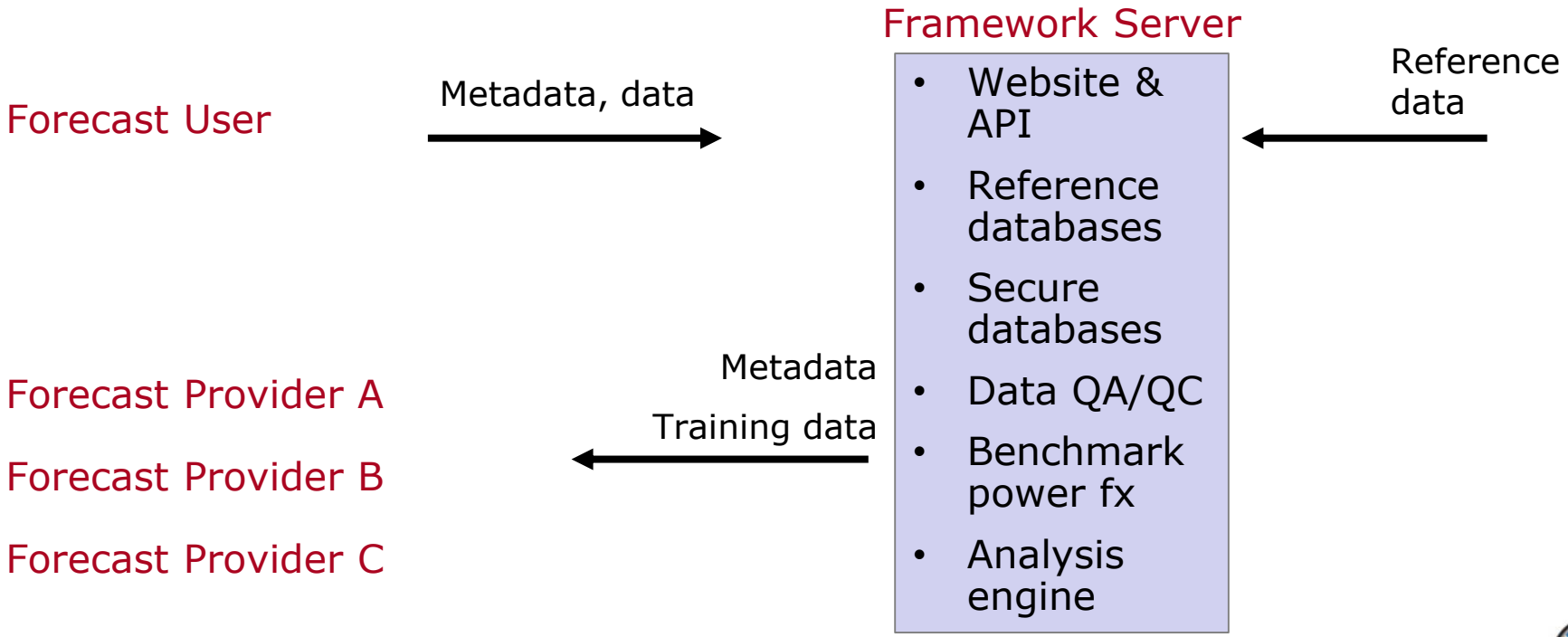
Forecast User

Forecast Provider A

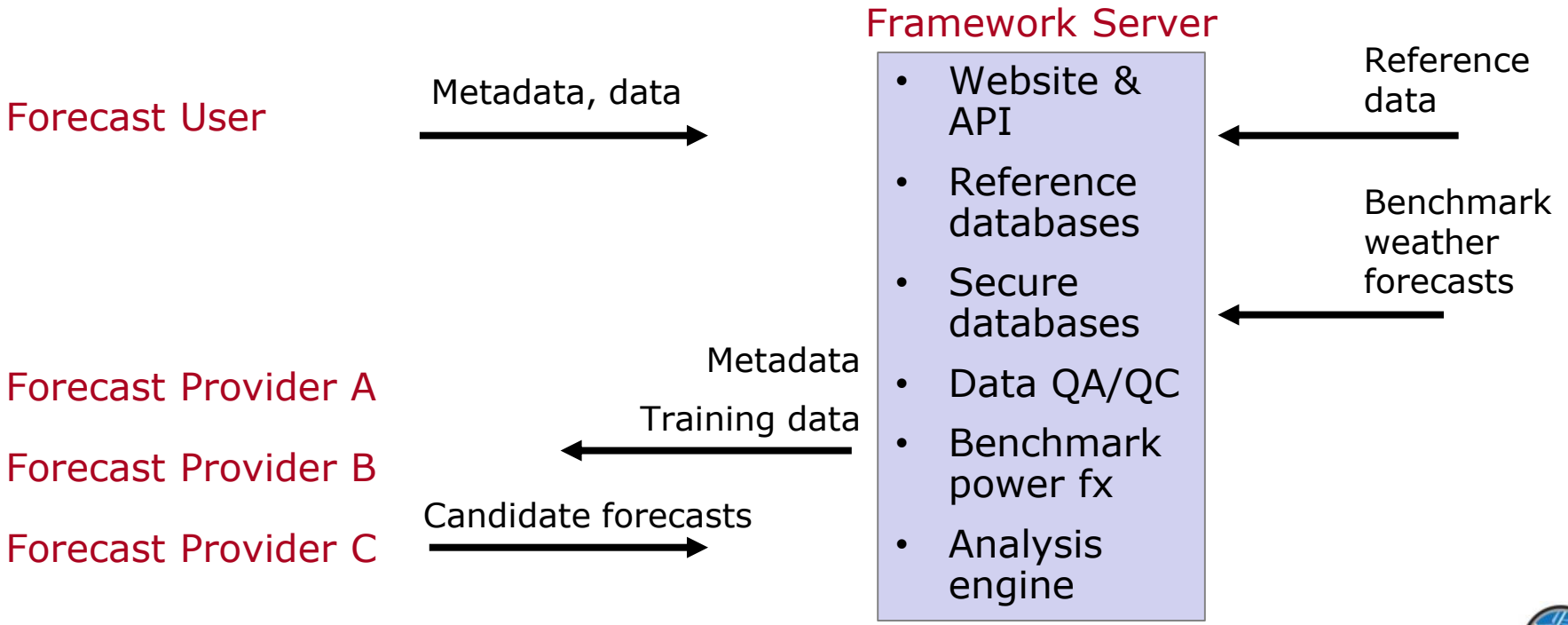
Forecast Provider B

Forecast Provider C

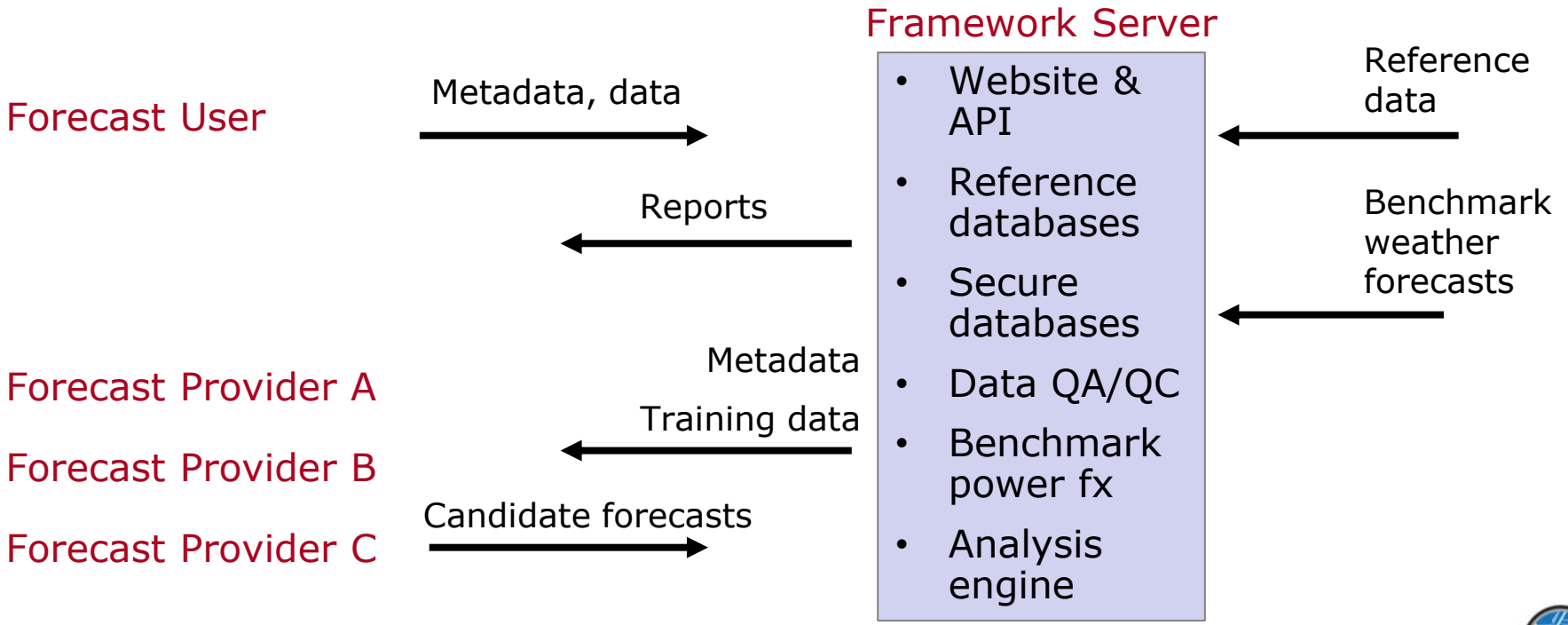
Sketch of Forecast Trial Use Case



Sketch of Forecast Trial Use Case



Sketch of Forecast Trial Use Case



Possible Use Cases

A. Hindcasting Reference Data

Forecast providers/researchers will want to forecast reference data to measure forecast accuracy or to quantify impacts of new methodologies.

B. Public Forecast Trial

Facilitates anonymous comparison of operational forecast capability for public data.

C. Private Forecast Trial

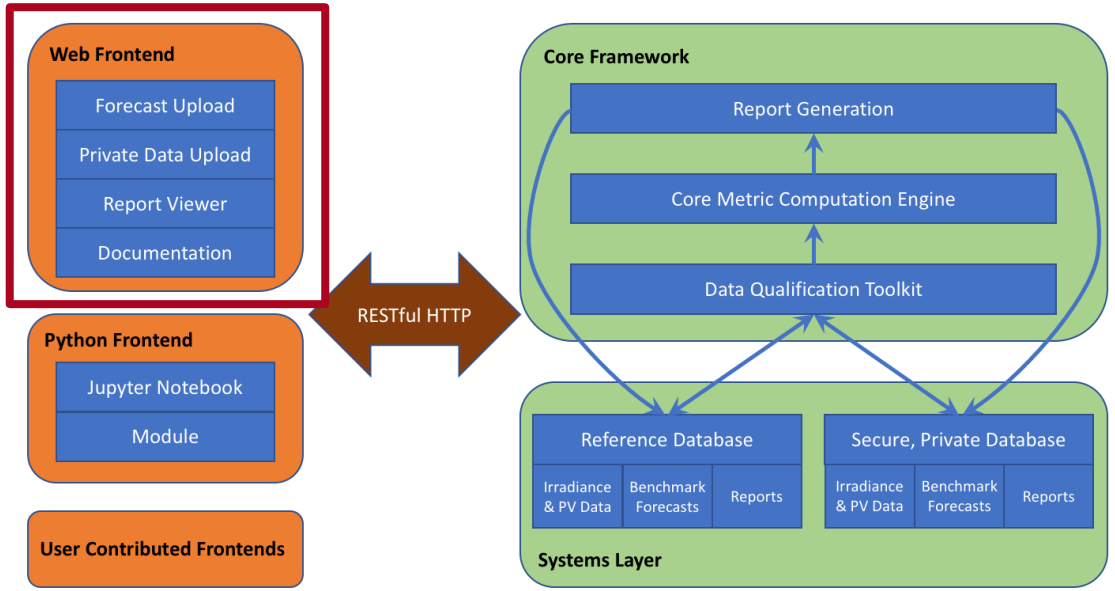
A forecast user may use our framework to compare among forecasts to determine which forecast to purchase.

Framework architecture proposed with these use cases in mind

Framework Architecture

Web portal

- Primary means of user interaction with the framework
- Landing page with login form
- Options for submitting reference data, submitting forecasts, and starting a forecasting trial
- Additional pages include:
  - Help
  - Metrics definitions, examples
  - How to contribute

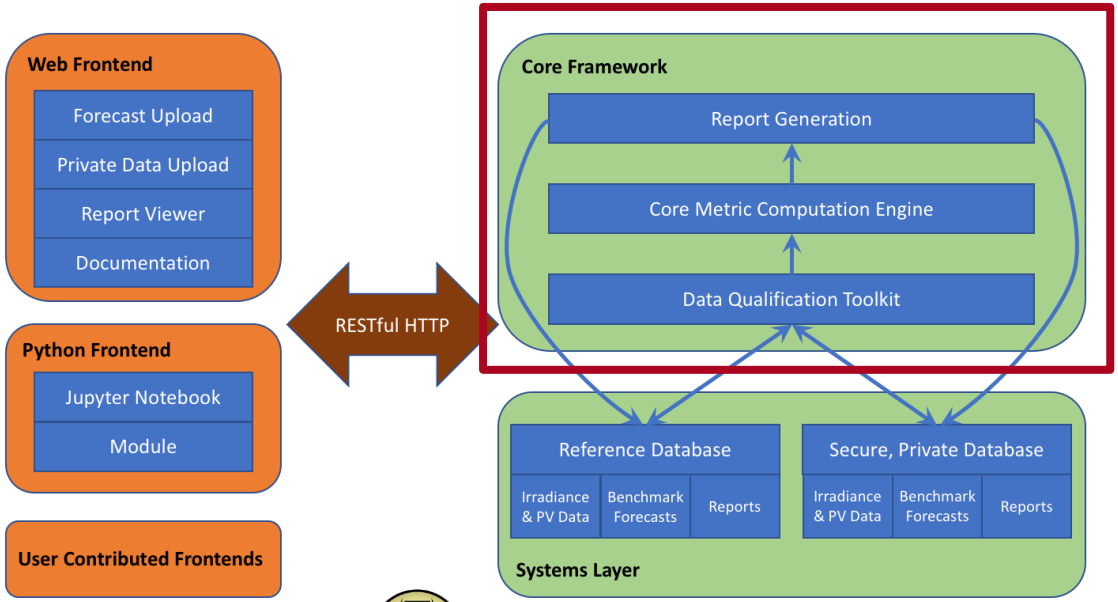


Framework Architecture

Core Framework

The core framework tasks are:

1. Accept point data of varying types and qualities
2. Calculate PV power from weather inputs and system metadata
3. Compare measurements, test forecasts, benchmark forecasts
4. Generate reports



NUMFOCUS
OPEN CODE = BETTER SCIENCE

PVPerformance MODELING COLLABORATIVE

Read the Docs
Create, host, and browse documentation.

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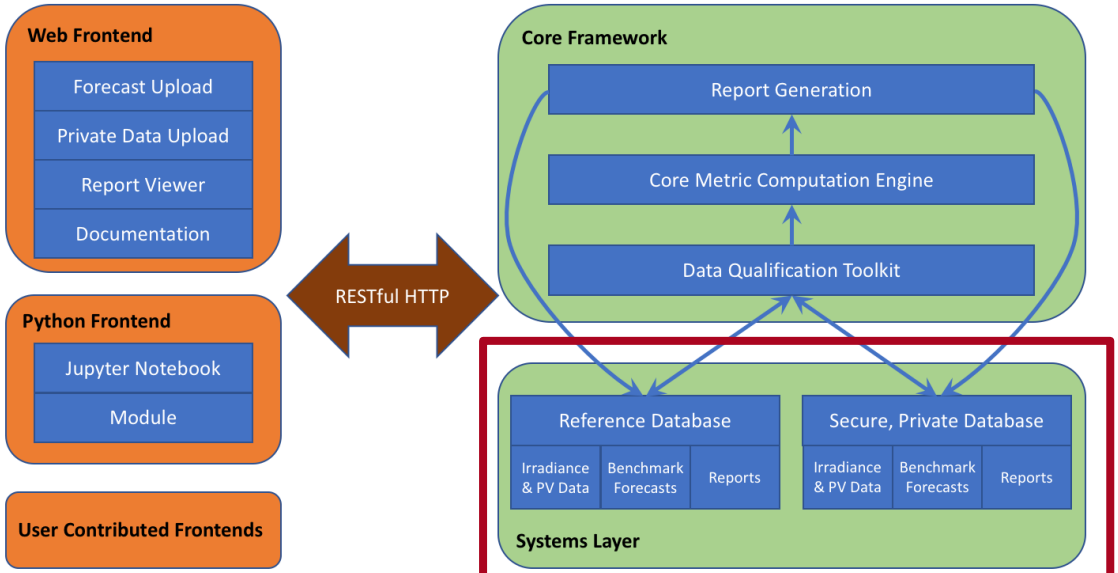
Framework Architecture

Systems Layer

- Operating system, web server, databases
- Built using Open Shift, virtual machines, and Vagrant files
- Enables users to install the entire framework on their own machines (private data not included)
- Ensures that the framework can be maintained beyond the initial funding period



CentOS Vagrant RED HAT OPENSHIFT

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Validation and Reference Data Sources

Reference Data

- NOAA SURFRAD
- Sandia
- NREL
- EPRI
- DOE RTC
- Stakeholders

User Data

- Stakeholder supplied
- Owner controls access
- Commitments: TEP, Abengoa, Southern Co.
- Working with: GroundWork Renewables, First Solar
- **We need your help**

Benchmark Forecasts

Proposed Attributes

- Available throughout the US
- Freely accessible or easily implemented
- Provide quantities of interest to both forecast users and providers
- Stakeholder buy-in

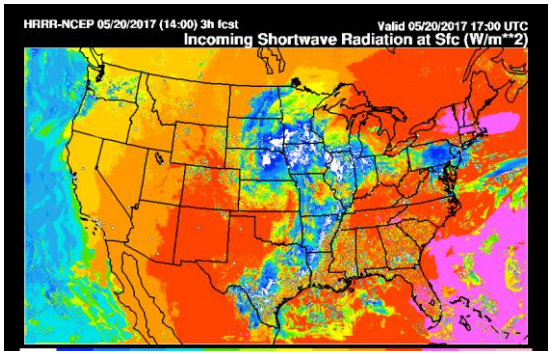
What attributes would you specify?

What benchmarks did you plan on in your scope of work?

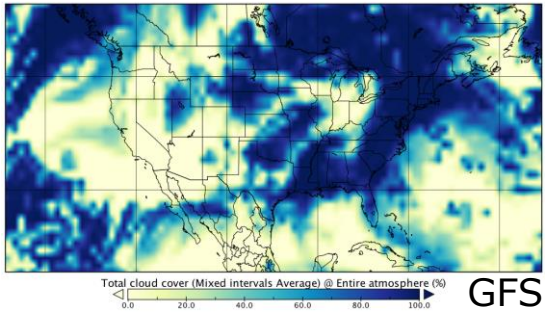
WRF Solar v1? Persistence?

Benchmark Forecasts

- For 1 hour – 7 day ahead and longer horizons:
  - NOAA operational models forecast irradiance, cloud cover, weather
  - Most operational NWP irradiance forecasts have known limitations
    a) Derive irradiance or PV power from cloud cover
    b) Bias correction
- For intrahour horizons:
  - Persistence, persistence of the clear sky index
  - An ARMA model fitted to site-specific data
- For net load:
  - Net load = True load – BTM PV
  - Use regression w/weather obs for true load? Use NWP for BTM PV?
- Probabilistic? Aggregates?



Total cloud cover (Mixed intervals Average) @ Entire atmosphere



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Reports and Metrics

Reports

- Design templates with stakeholder input
- Framework uses templates to automatically generate custom reports

- Time series plots, scatter plots, reliability diagrams, etc.
- Standard and "advanced" error metrics
- Enable direct comparisons between anonymized vendors or researchers and benchmarks

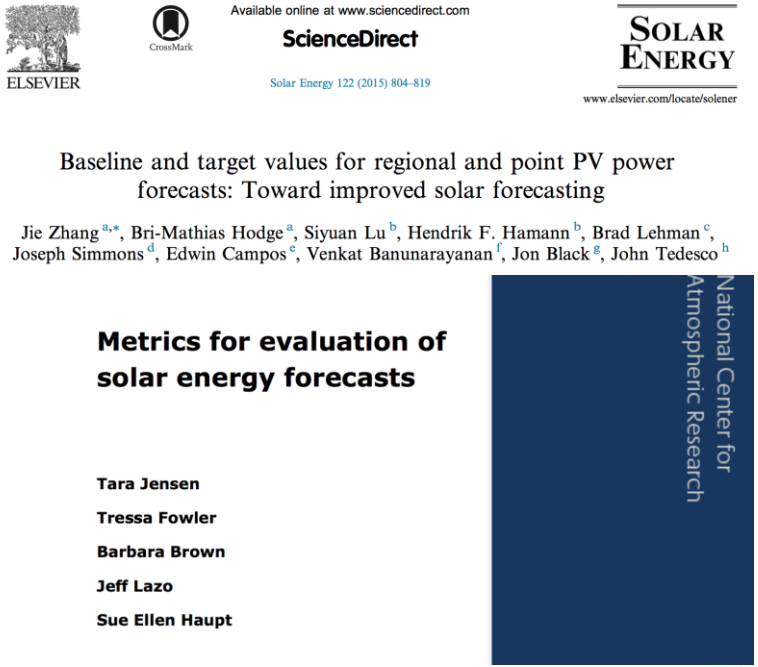
- Options for analyses based on conditions (time of day/year, events, etc.)

Reports and Metrics

Metrics

- Choose default metrics with stakeholder input
- Depending on use case, users have final control over metrics selection

- Build on DOE Solar Forecasting I metrics results
- Standard metrics (MAE, MAPE, RMSE, MBE)
- Advanced metrics (KSI, Renyi entropy)
- Probabilistic metrics (Brier, RPS)
- Forecast skill metrics to directly compare test and benchmark forecasts



Reports and Metrics

Cost metrics

1. User supplied fixed $/MW
2. User supplied time of day $/MW
3. User supplied time series of $/MW
4. User supplied time series of $/MW for predefined error bins

- Report includes cost saved or incurred relative to benchmark forecasts

What happens after DOE funding ends?

EPRI User's Group Model

- Most North American utilities and all ISOs are EPRI members
- Self sustaining models for ongoing support research deliverables
- Updates/maintenance supported by member funds

Independently operated business

- Forecast vendors and utilities pay for live forecast trials and data brokering services
- Validation services may extend to include wind and load forecasting

All contributed data will be deleted at the end of the DOE funding period by default.

Project Timeline

Year 1 – Design, build, test and demonstrate the framework.

Year 2 – Refine the framework and host two operational forecast competitions.

Year 3 – Support evaluations for Solar Forecasting II Topic 2 and Topic 3 awardees. Transition framework to new operator.

Summary

- Open source, reproducible, transparent framework
- Stakeholder engagement
- Need your help to compile reference data
- Benchmark forecast capability
- Automated reports that go beyond the metrics
- Ideas for post-DOE funding survival

- Contact us sooner than later with questions/ideas!