Distribution Planning Working Group Deliverables and Hosting Capacity Improvements

Distribution Planning Working Group

December 4, 2019

Hawaiian Electric
Maui Electric
Hawaiʻi Electric Light

Agenda

- Soft Launch Update
- Introduction & Objectives – Where we are in the DPWG process
- DPWG Deliverables
- Where the DPWG deliverables fit within the overall IGP Process
- Start discussion on forecasts and inputs
- Stakeholder Feedback
- Hosting Capacity Methodology Improvements

Soft Launch Update

- Soft Launch NWA RFP issued on November 8, 2019 and is currently open for proposals through January 7, 2020, 2:00 pm HST
- In order to submit a proposal you must register as a "Supplier" in Power Advocate's Sourcing Intelligence to access the RFP Event
    - Once registered, please request access to the RFP event from the Company via email
    - After you have been added to the event, you will receive an invitation to the RFP event
- The RFP and additional info available at the IGP website, which will also contain the link the Power Advocate Electronic Procurement Platform. Please see Appendices B and D of the RFP for more info.
- All questions or concerns regarding the RFP, while the RFP event is open, shall be submitted to the Company via email to response@hawaiianelectric.com, with the Independent Observer cc'd.

DPWG December 4th Meeting Objectives

- Clarify DPWG deliverables and where they fit within the IGP process
  - Seek stakeholder feedback
- Present hosting capacity improvements

DPWG – Meeting Topics & Schedule

Completed

- February 27, 2019
  - Intro and overview of DPWG and Grid Services, and soft launch
- March 26, 2019
  - Surveyed best practices across U.S. for NWA processes and methods for opportunity, identification, and procurements
- April 25, 2019
  - Grid needs assessment methodology and process and candidate NWA opportunities for Soft Launch
- June 19, 2019
  - High-level review of Soft Launch RFP
- July 17, 2019
  - Develop ongoing NWA process for identifying and evaluating opportunities, sourcing approaches and evaluation methods
- August 8, 2019
  - Detailed review of Soft Launch Opportunities
- September 9, 2019
  - Draft Soft Launch RFP released – review of RFP w/ stakeholder
- October 9, 2019
  - 2020 NWA Opportunities & Proposed Opportunity Evaluation Screen & Stakeholder information requirements

Upcoming (tentative)

- November 18, 2020
  - Proposed distribution planning methodology enhancements for 2020 IGP
  - **Issue Soft Launch RFP**
- **December**
  - **Hosting Capacity Methodology Improvements**
  - **Draft Deliverables Posted to Hawaiian Electric Companies' Website w/stakeholder outstanding comments noted**
    - **2020 NWA Opportunities Evaluation Framework**
    - **Distribution Planning Methods**
- January
  - Distribution planning load scenarios and sensitivities methodology
  - Distribution planning integration with Resource & Transmission planning process
  - Soft Launch RFP proposals due
- February
  - Revisit Topics / Review Deliverables
  - Finalize Deliverables

DPWG Deliverables

Working Group Deliverables

- **Non-Wires Alternatives Opportunity Evaluation Framework**
  - Document NWA Opportunity evaluation process, criteria and rationale
  - Document related NWA information requirements incorporating stakeholder feedback
- **Distribution Planning Methodology**
  - Includes hosting capacity and any new changes based on stakeholder discussion and comparative assessment of industry best practices
  - Distribution level forecasts and/or scenarios to be used for distribution planning
- **Integration of Distribution Planning with Resource and Transmission planning**
  - Joint deliverable with SEOWG – will be woven into above deliverables as well as SEOWG deliverables.

2020 IGP Process Deliverables (Outputs)

- Actual Forecasts
- 2020 Grid Needs Assessment

Current Distribution Planning Process

Forecast

- Collection of Historical Data
- Load & DER Forecasts
- Load & DER Profiles

Analysis

- Distribution Planning Criteria
- Hosting Capacity
- Contingency Analysis
- Grid Needs Identification

Solution Options

- Solution Requirements
- Wires Solutions
- Non-Wires Solutions

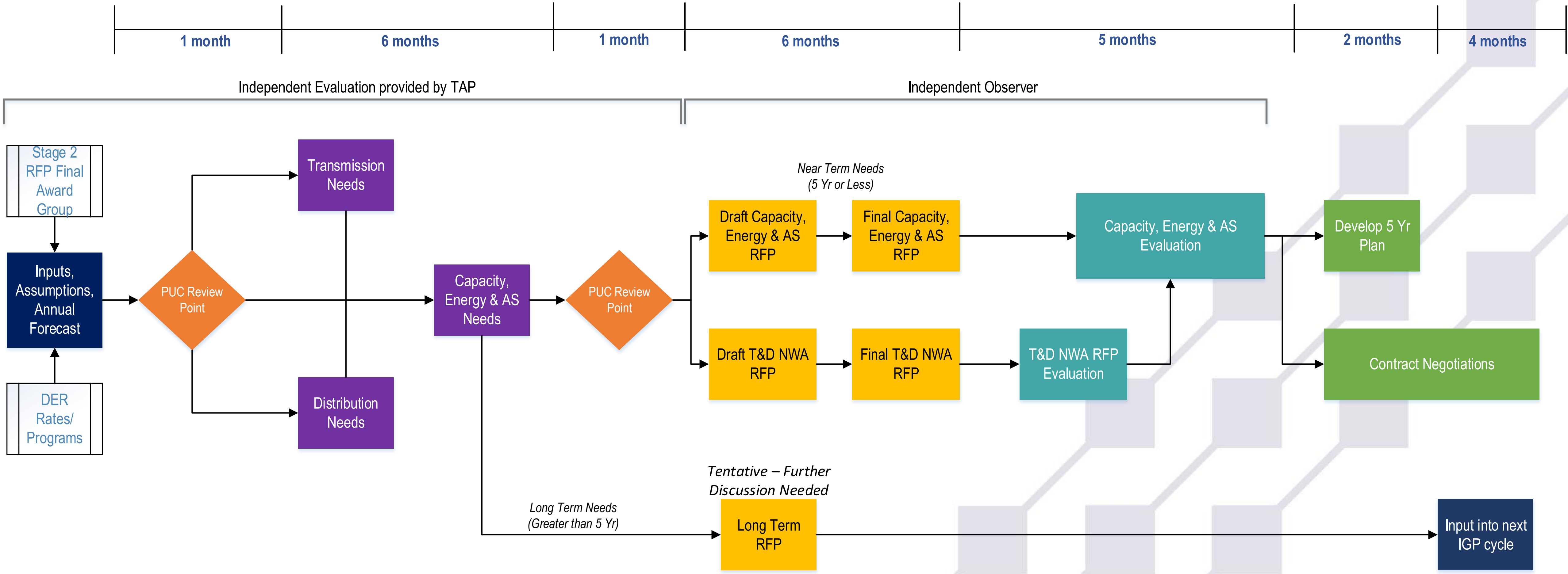
Evaluation

- Evaluation of Solutions
- Solution Sourcing
- Solution Selection

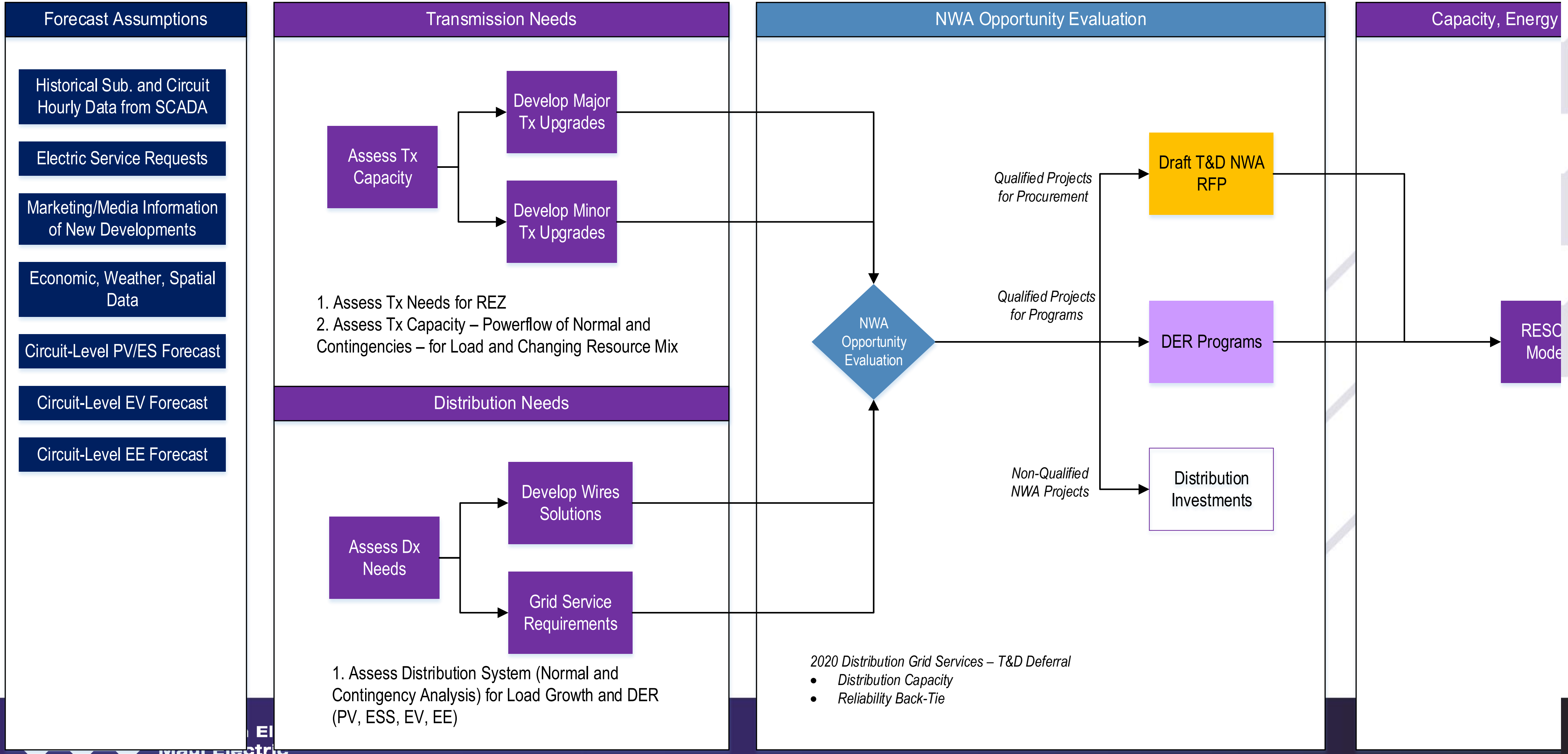
Solution Implementation

Revised IGP Process

Discussions on-going in the SEOWG



Integration of DPWG Deliverables with IGP



Distribution Capacity Service

Distribution Capacity – A supply and/or a load modifying service that DERs provide as required via the dispatch of power output for generators and electric storage, and/or reduction in load that is capable of reliably and consistently reducing net loading on desired distribution infrastructure. The distribution capacity grid service requirements are characterized by the following:

Resource	Peak Need	Delivery Timeframe	Duration	Delivery Days
Firm Generator Variable Generator Storage Load under control	MW	Months, Hours	Hours	Max # of days per year

Distribution Reliability (Back-Tie) Service

Distribution Reliability (Back-Tie) – A load modifying or supply service capable of improving local distribution reliability under abnormal conditions. Specifically, these services reduce contingent loading of grid infrastructure to enable operational flexibility to reconfigure the distribution system to restore electric service to customers in a safe and reliable manner. The distribution reliability (back-tie) grid service requirements are characterized by the following:

Resource	Peak Need	Delivery Timeframe	Duration	Delivery Days
Firm Generator Variable Generator Storage Load under control	MW	Months, Hours	Hours	Max # of days per year

Distribution Planning Process and Methodology Deliverable

- Distribution Planning Overview
  - Background
  - Scope of Work
- Distribution Planning Process
- Forecast
  - SCADAScrubber
  - LoadSEER - Forecasts
- Analysis
  - Distribution Planning Criteria
  - Grid Analysis and Modeling
  - Hosting Capacity
  - LoadSEER – Continency Analysis
  - Planning Criteria Violation
- Grid Needs Identification
- Solution Options

NWA Opportunity Evaluation Framework Deliverable

- Introduction
- Industry Practice Survey
  - Summarize findings from Survey (DPWG March 26 Mtg, among other research)
- NWA Opportunity
  - NWA Definition (from DPWG meetings)
    - Defined Grid Services (from DPWG Meetings)
  - NWA Opportunity Assessment Methodology (from DPWG meetings)
  - Stakeholder Feedback
  - NWA Opportunity Evaluation within IGP Process
- 2019-2020 NWA Opportunity Assessment
  - Grid Needs Assessment Template – Data/Information
  - Opportunity Evaluation Template – Data/Information
  - Stakeholder Feedback

Forecast Inputs and Scenarios

- Circuit level forecasts will be developed based on geospatial factors through LoadSEER
  - The forecasts may also be developed using an agent-based approach
- Circuit level DER forecasts will roll up to the corporate level market-based forecasts
  - DER forecasts will include PV (paired with BESS), EV, and EE
- The FAWG expected to have next WG meeting to go over preliminary forecasts in late January. DPWG will subsequently have a follow up meeting to discuss details of circuit level forecasts.
- Specific DER portfolios can be added, if necessary (i.e., local knowledge of a developer pre-installing homes with DER)

Discussion Point:
Are there any sensitivities or scenarios that should be considered in the Distribution Planning Process?

If so, what should the process be to choose one scenario for Grid Needs identification?

Stakeholder Discussion

- Please provide any additional feedback on how the DPWG deliverables can/should be integrated into the IGP process.
- What should be documented in the Distribution Grid Needs Documentation?
  - For example, summarize every feeder and substation transformer:

Division	Facility Type	Facility Name	Primary Driver	Distribution Service Required	Anticipated Need Date	Year 2018 (%)	Year 2019 (%)	Year 2020 (%)	Year 2021 (%)	Year 2022 (%)
Sierra	Bank	SHINGLE SPRINGS BANK 2	Demand Growth	Capacity	7/2018	104	103	102	101	100

  - From the above list, for the circuits or substations with an identified grid need (i.e., overload), are Slides 10 & 11 (similar to Soft Launch) sufficient for information to be provided?
- Is a 30 day review period sufficient to provide stakeholder feedback on deliverables?

Next Steps

- Schedule a meeting in January to further discuss Forecasts and Scenarios
- Look for draft WG deliverables within the 1-2 weeks for review. The Companies will notify stakeholders via e-mail when available for review.
  - Note: a full discussion around forecasts and scenarios will be added to the deliverable following additional stakeholder discussion in January.
  - When submitting comments, please note in your comments whether we should capture your comments with attribution (person or organization) or anonymously. We'd like to document feedback in the final deliverable.

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Time-Based Probabilistic Hosting Capacity

Forecasting Hosting Capacity (HC) with Load and DER Growth

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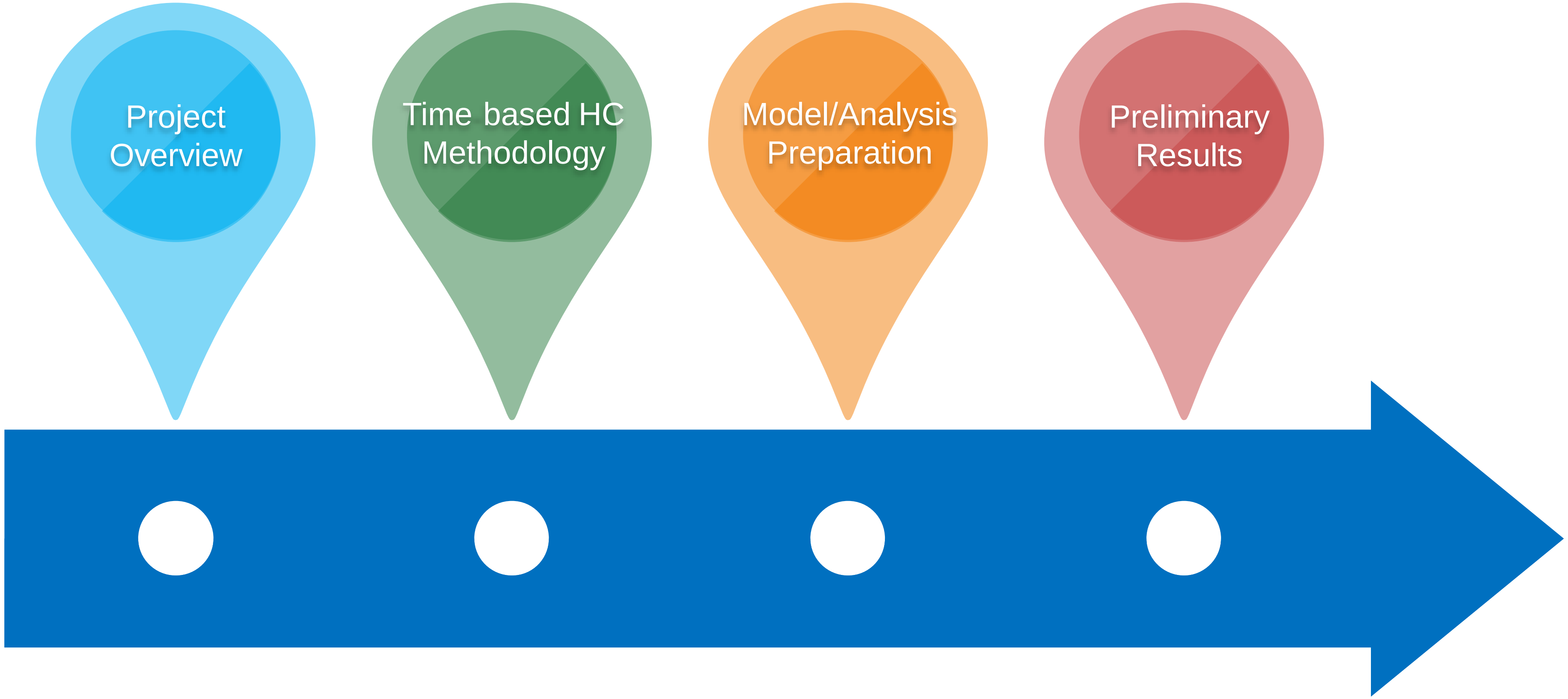
December 2, 2019

Agenda



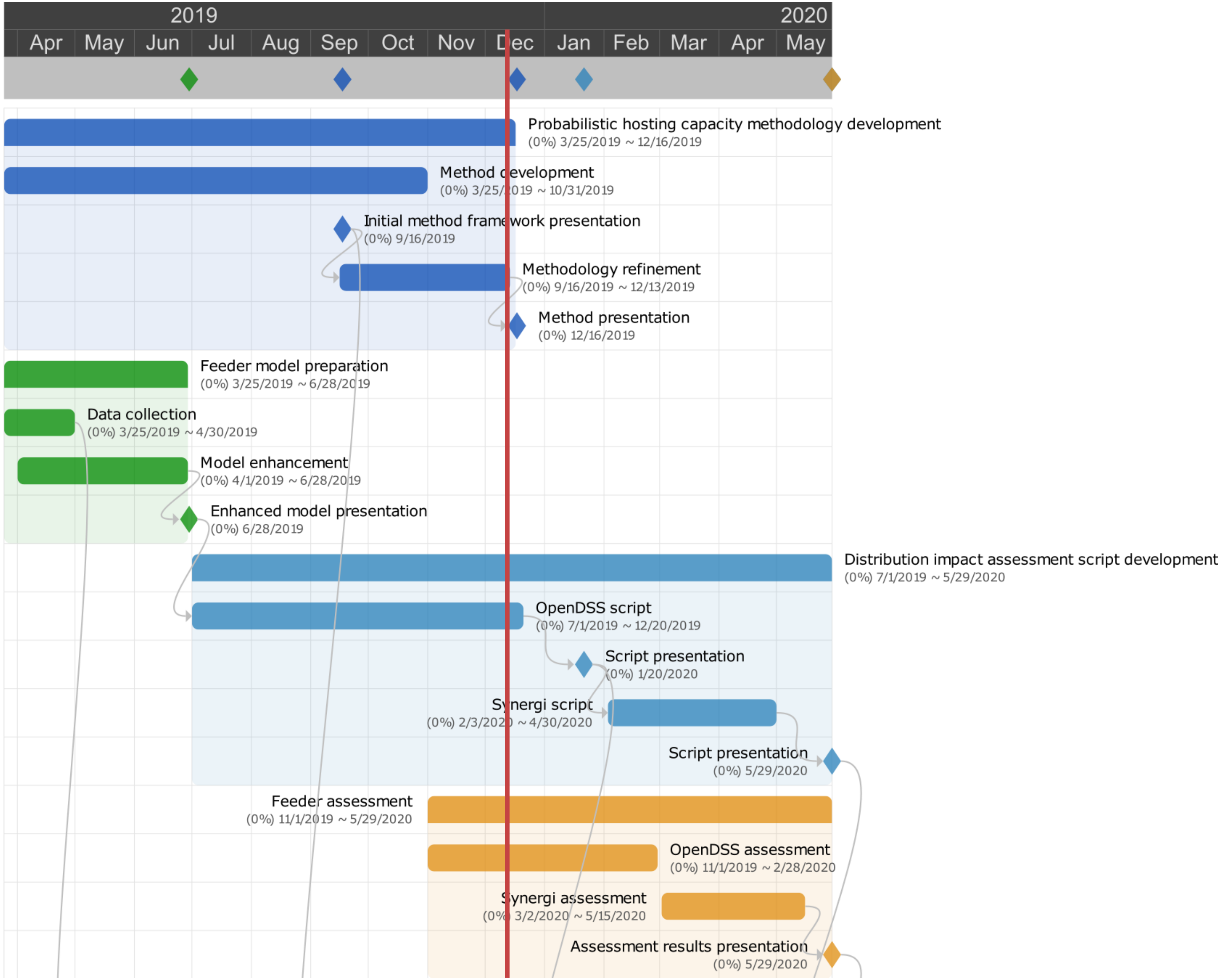
Project Overview
Time based HC Methodology
Model/Analysis Preparation
Preliminary Results

Project Goals

- Develop a time-based hosting capacity assessment to identify distribution needs for the integration of load & DER
  - Develop the methodology to determine the amount of distributed solar generation that can be accommodated over time as load and PV increases
  - Enabling distribution planning to retain a margin of hosting capacity for future non-forecasted PV
  - Determine best practices for model updates
- Calculate the probabilistic hosting capacity over the analyzed time horizon
  - Understand the hosting capacity of a feeder as time progresses
- Create python scripts to automate the analysis system-wide
  - Integrate with Synergi and LoadSEER.
  - Apply over 3 feeders in the project

Project Schedule

NO	TASK
1	**Probabilistic hosting capacity methodology development**
1.1	Method development
1.2	Initial method framework presentation
1.3	Methodology refinement
1.4	Method presentation
2	**Feeder model preparation**
2.1	Data collection
2.2	Model enhancement
2.3	Enhanced model presentation
3	**Distribution impact assessment script development**
3.1	OpenDSS script
3.2	Script presentation
3.3	Synergi script
3.4	Script presentation
4	**Feeder assessment**
4.1	OpenDSS assessment
4.2	Synergi assessment
4.3	Assessment results presentation

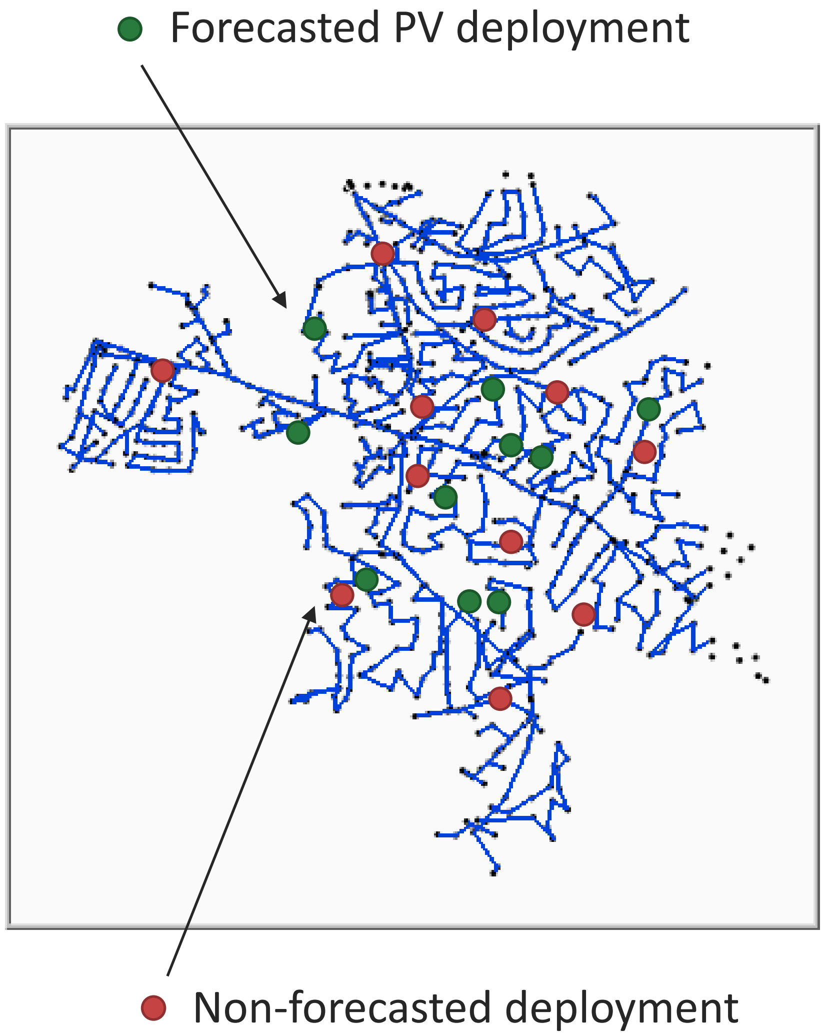


Time-based Hosting Capacity Methodology

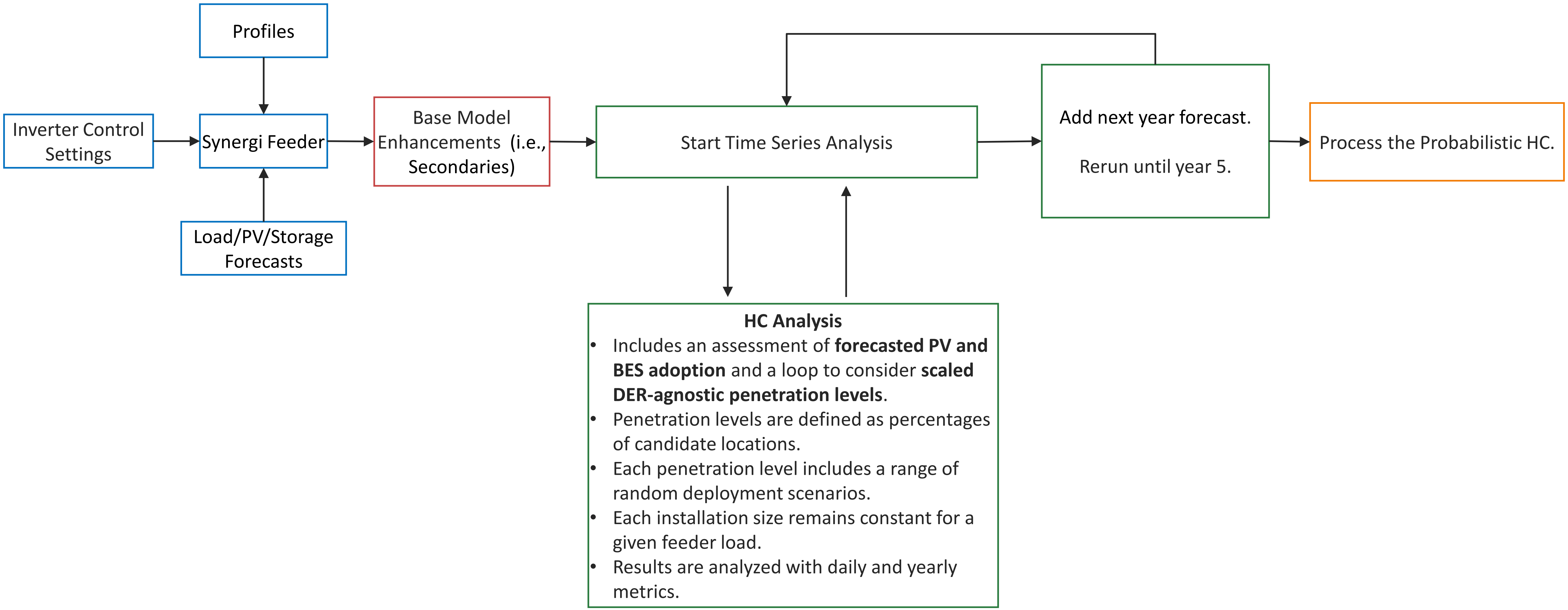
Distributed HC assessment

- Key factors:
  - Temporal variability of load and generation conditions
  - Unknown locations for future DER adoption
  - DER-sizes
  - Technology adoption
    - Battery energy storage
    - Smart inverter functions

- Key questions:
  - What are the effects of a given forecasted PV capacity in the feeder?
  - What is the remaining hosting capacity after the adoption of a given forecasted PV in the feeder?



Methodology Flowchart

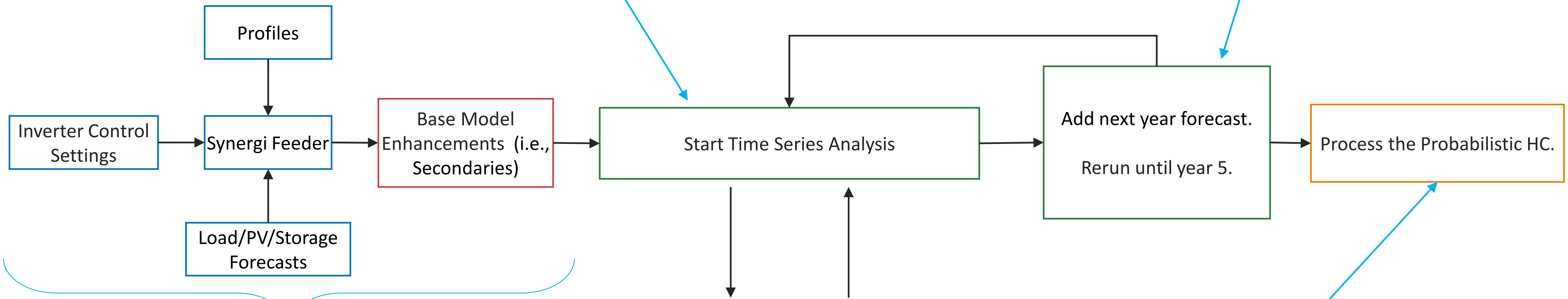


Methodology Flowchart

OpenDSS used for development and preliminary tests.
Conversion to Synergi is in progress.

Code development. Done.

Code development. Done.



Circuit conversion/validation. Done.
Data integration per feeder (576-h or 8760-h). Done.
Irradiance estimation (POA 576-h or 8760-h). Done.
Gross load estimation. Done.
DER Sizing. Done.
Non-export profiles. Done.
BES for smart exporters. Done.
Service lines included with firework topology. Done.
Smart inverter functions. In progress.

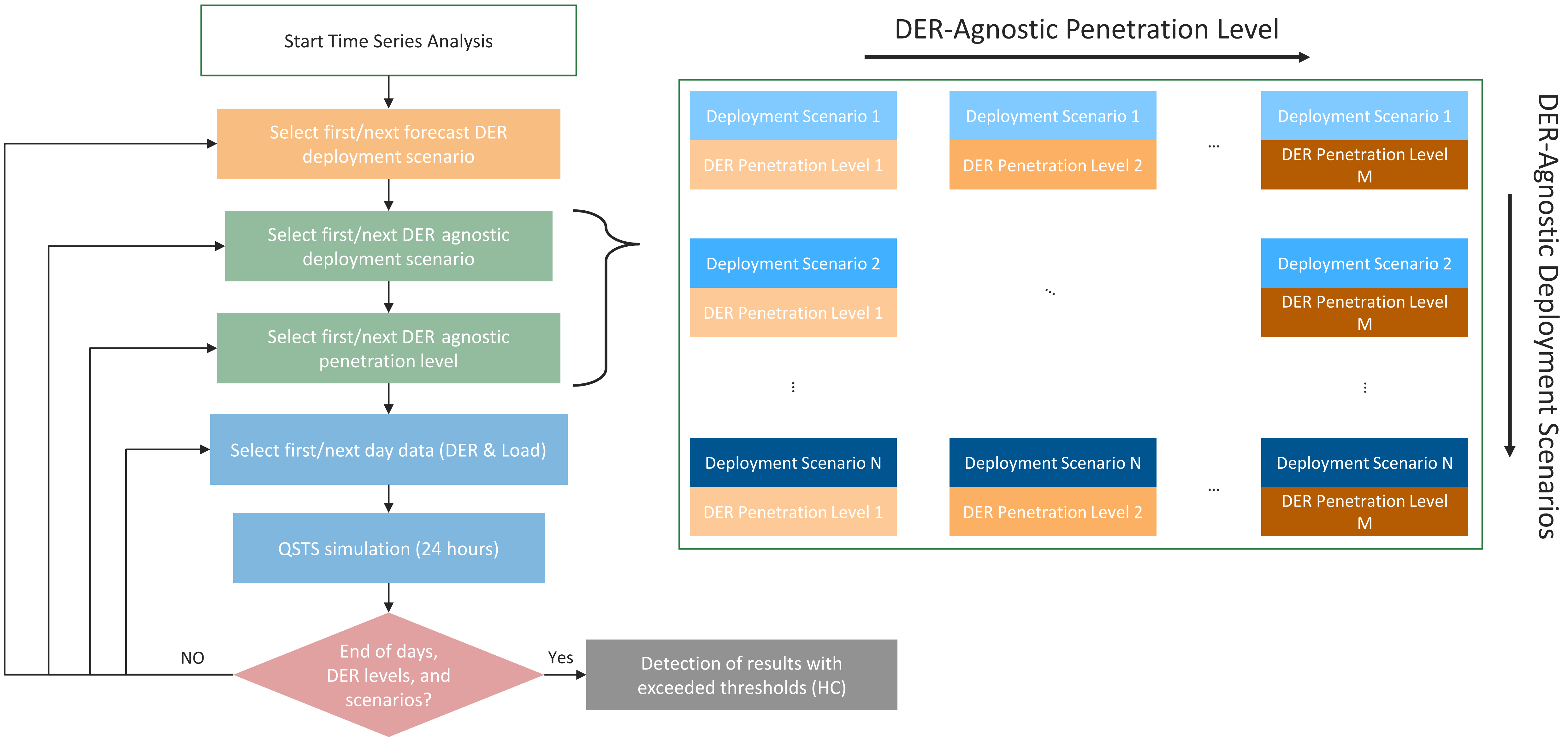
HC Analysis

- Includes an assessment of **forecasted PV and BES adoption** and a loop to consider **scaled DER-agnostic penetration levels**.
- Penetration levels are defined as percentages of candidate locations.
- Each penetration level includes a range of random deployment scenarios.
- Each installation size remains constant for a given feeder load.
- Results are analyzed with daily and yearly metrics.

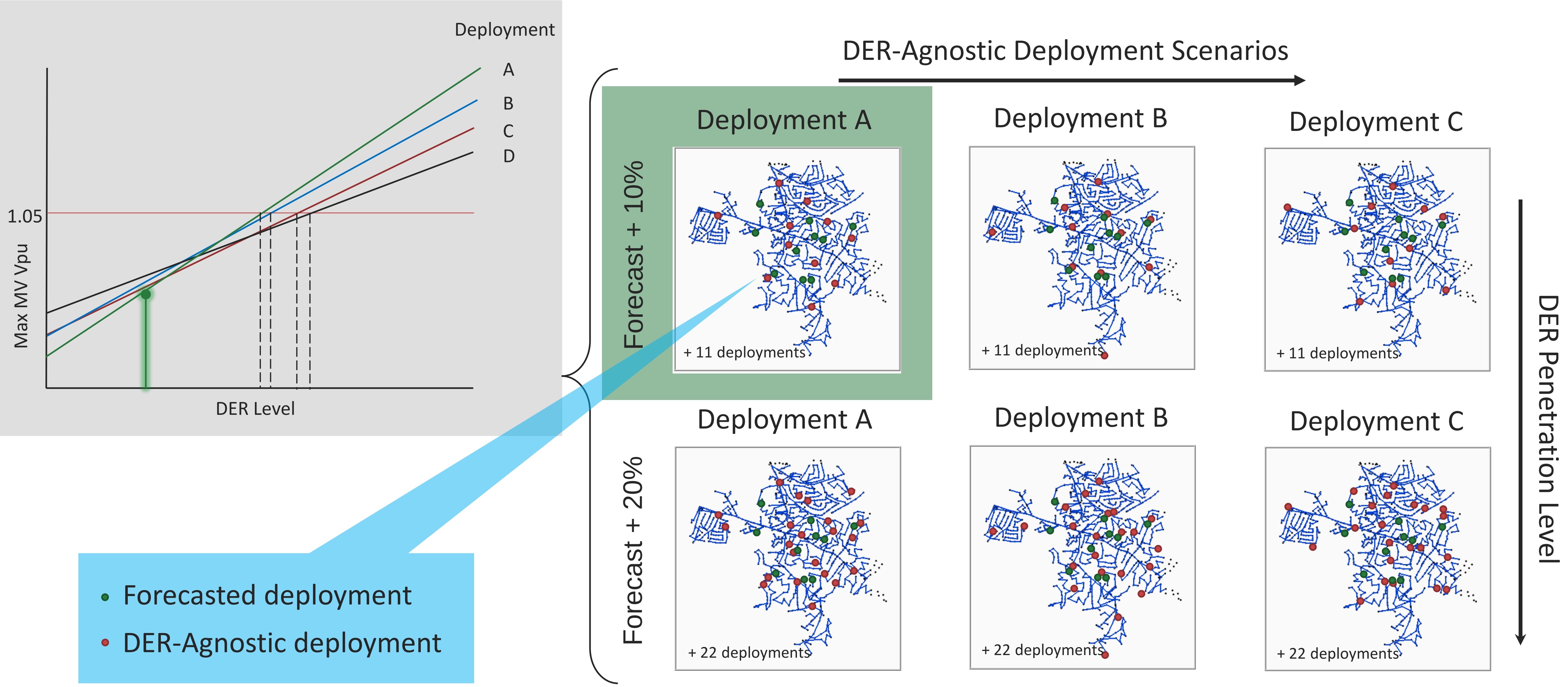
Initial data generation. Done.
Probabilistic data processing. In progress.
Data visualization. In progress.

Algorithm for deployment assignation. Done.
Code development for HC calculation. Done.
BES integration. Done.

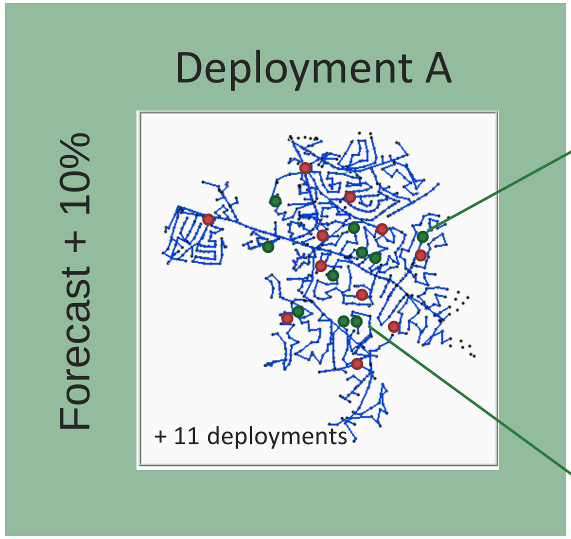
Simplified Flowchart of HC Analysis



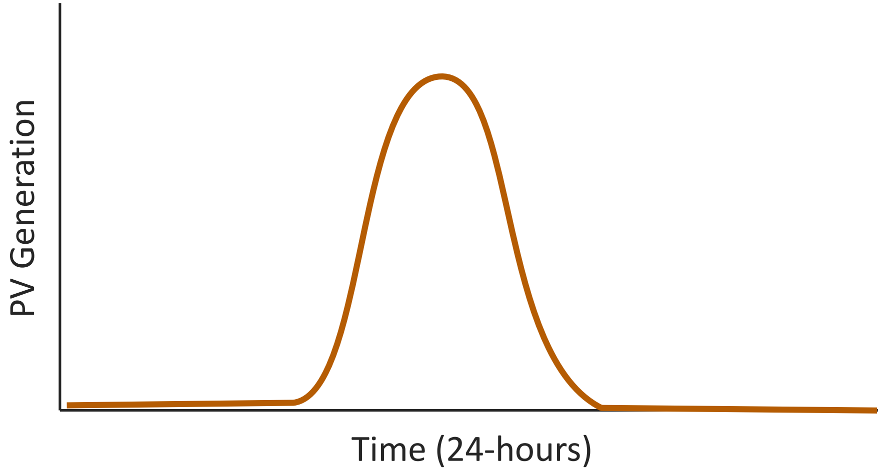
PV and BESS based on forecast + DER-agnostic loop



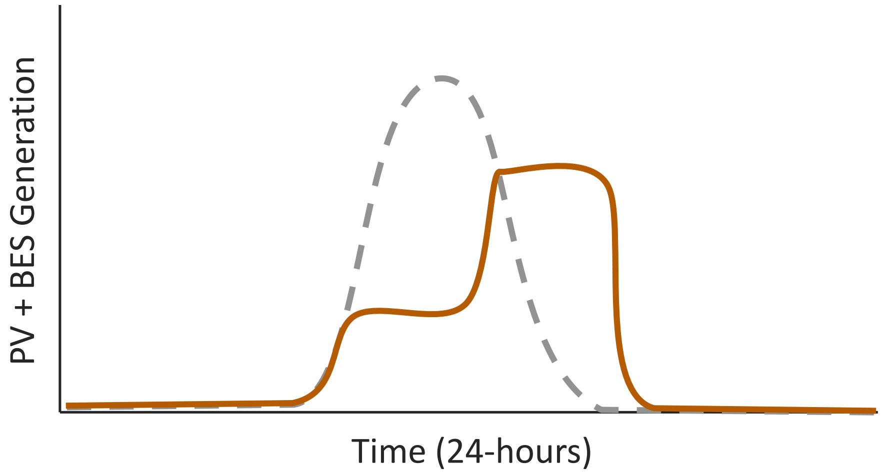
Time-based Output for Forecasted DER Profile



Customer 1: PV installation according to forecast



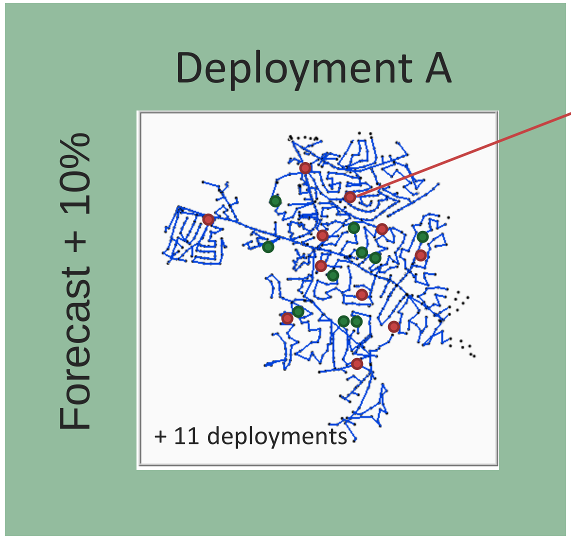
Customer 2: PV and BES installation according to forecast



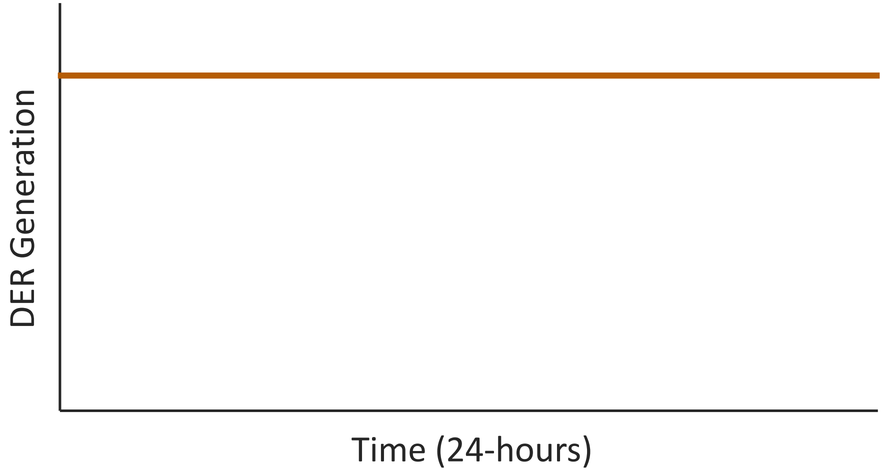
Possible deployment states:

- No DER
- PV
- PV + BESS

Time-based Output for DER-agnostic loop



Customer 3: DER-agnostic deployment



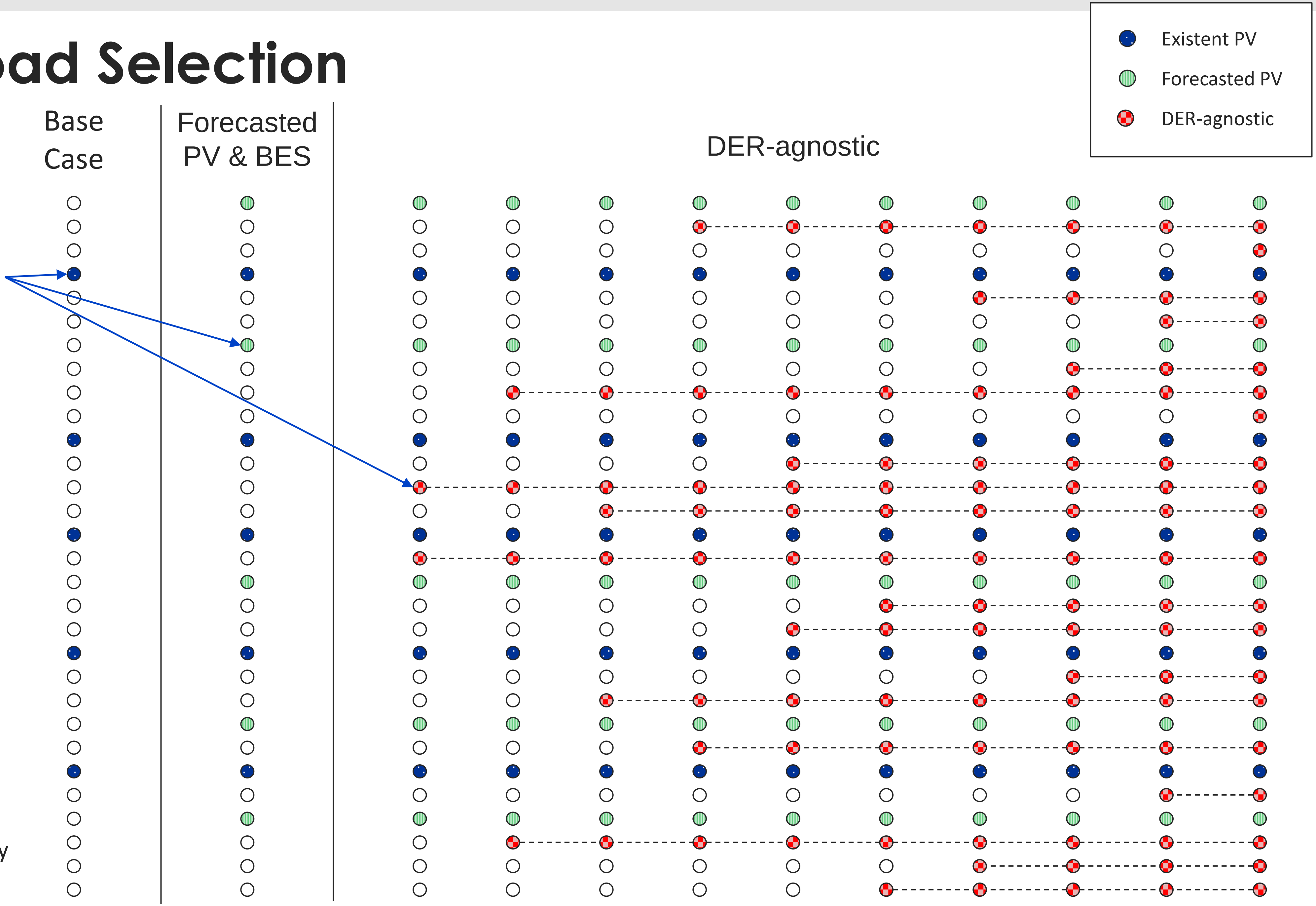
Possible deployment states:

- No DER
- DER (Flat generation profile according to max expected PV size)

Flat 24-hour profile is assumed because the DER type and output is unknown. All that is known is that the DER could be outputting max power.

Random Load Selection

For each year*, the **forecasted DER** is added on top of the **existing DER** and then the **agnostic** is added on top of that.



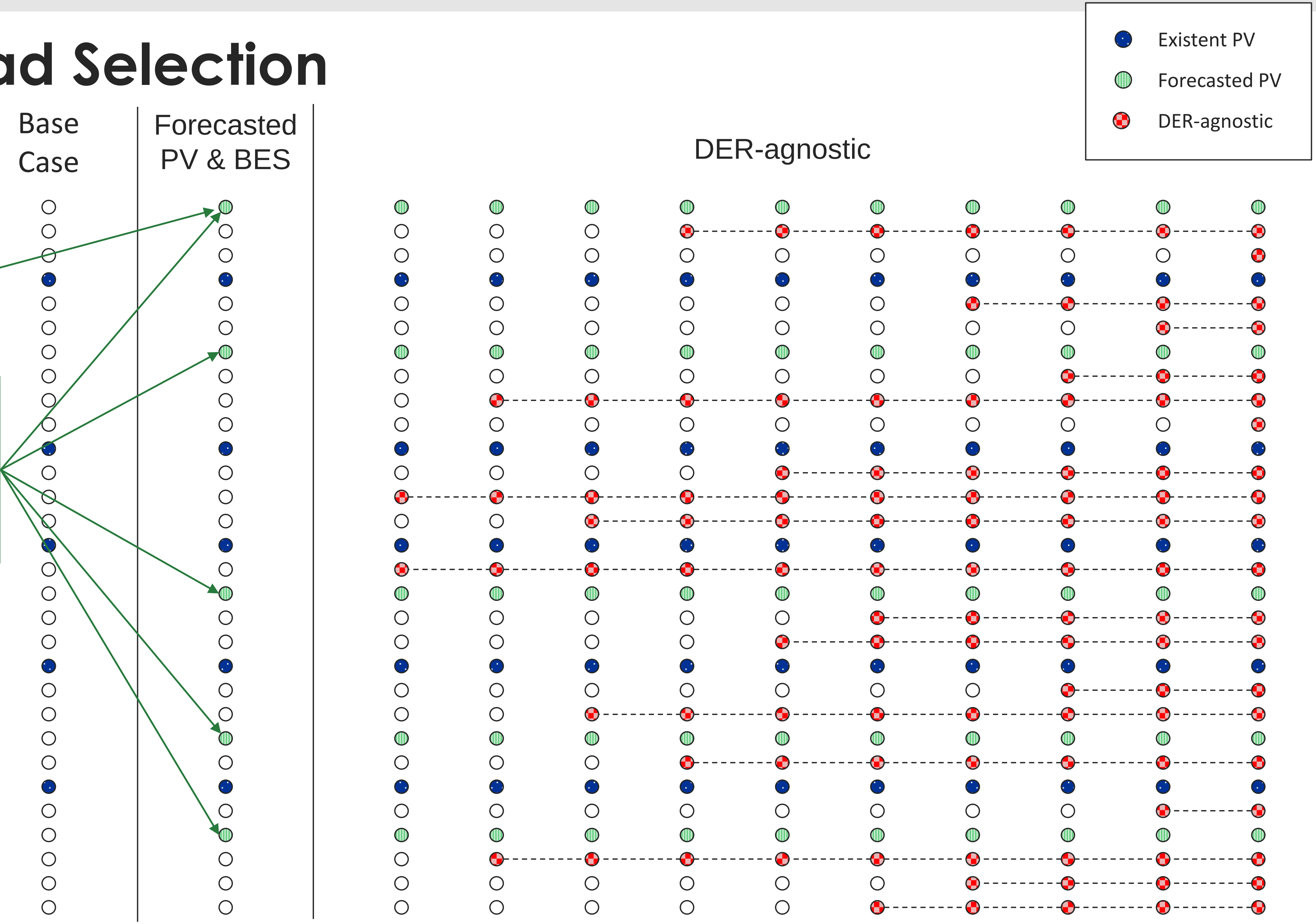
* In year 0, agnostic DER is directly added on top of existing DER.

Random Load Selection

Installed capacity for each customer is randomly selected and preserved constant across scenarios.

Random selection of customers to match a given forecasted installed capacity. Example: 5 customers to match 75 kW in this scenario.

This scenario will provide results for assessment of a given forecasted PV + BES adoption based on PV profiles.

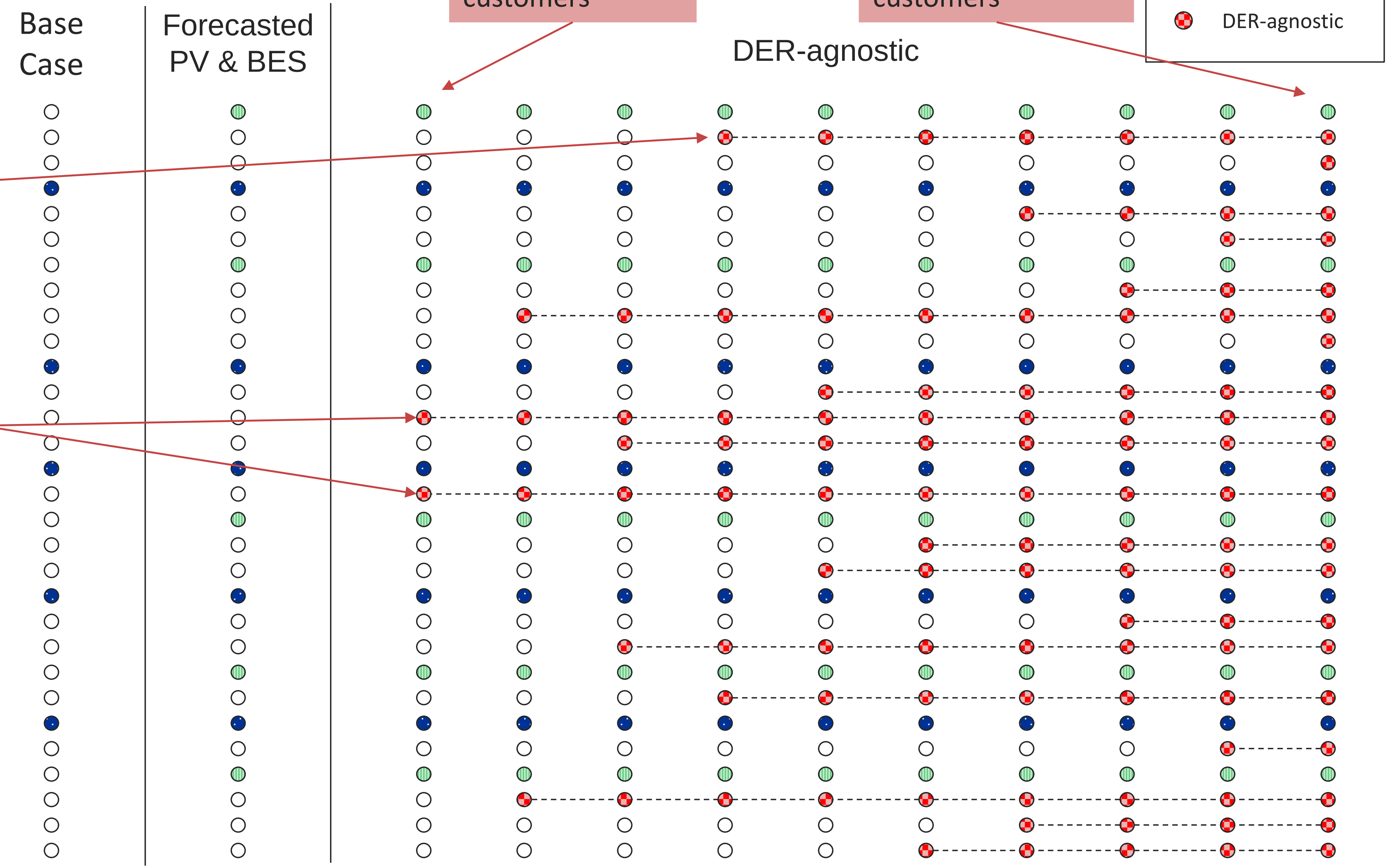


Random Load Selection

Installed capacity for each customer is randomly selected and preserved constant across scenarios.

Random selection of customers to match a given percentage of remaining customers.
Example: 2 customers to match 10% in this year and level.

This scenario will provide results to calculate the remaining HC at any hour of the day.



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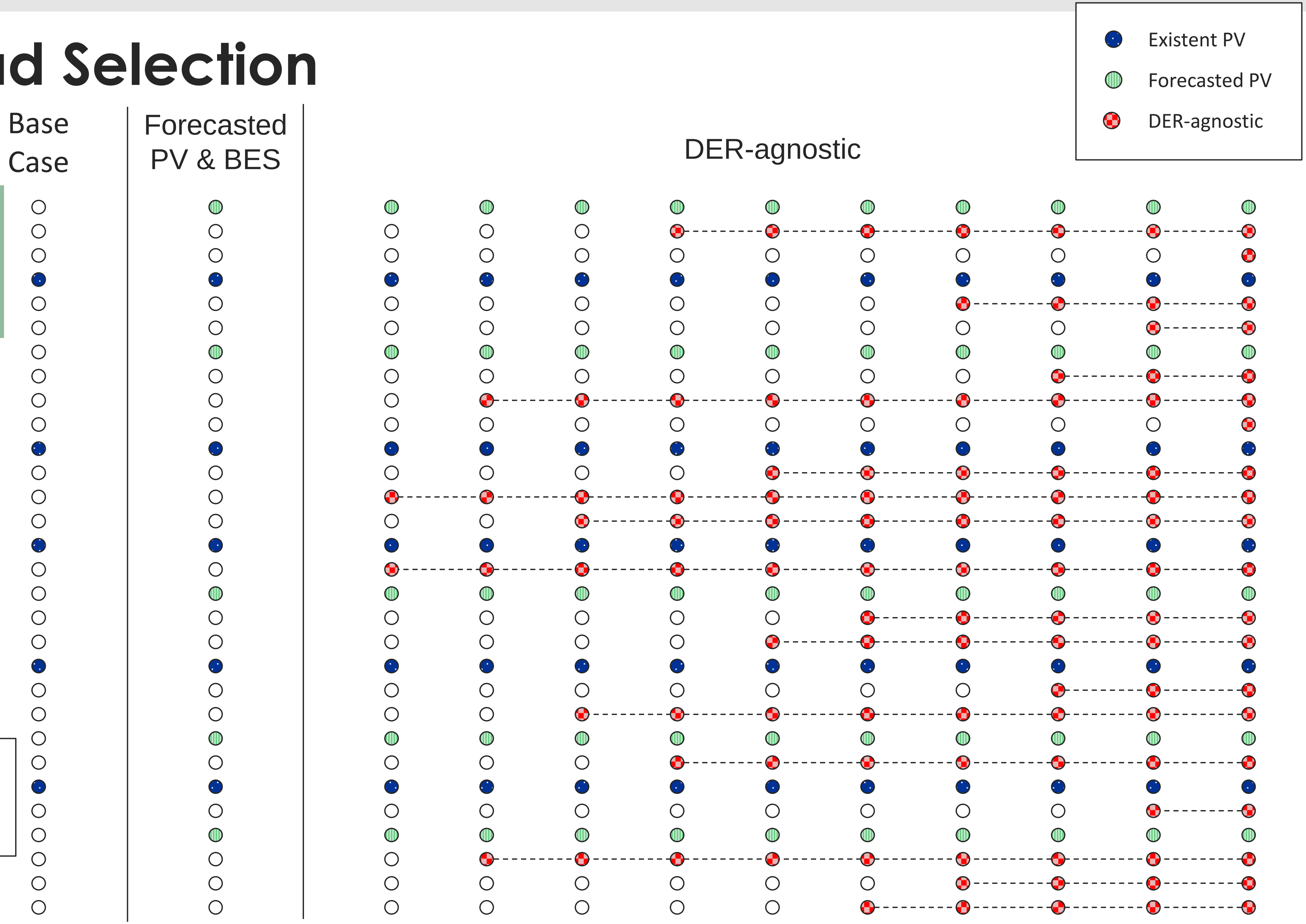
Random Load Selection

For each year, alternative random selections of PV & BES customers can be simulated (forecasted deployments).

For each forecasted deployment, alternative random selections of DER-agnostic installations can be simulated (DER-agnostic deployments).

Results are combined to explore:
1) Impact of forecasted PV & BES
2) Remaining distributed HC

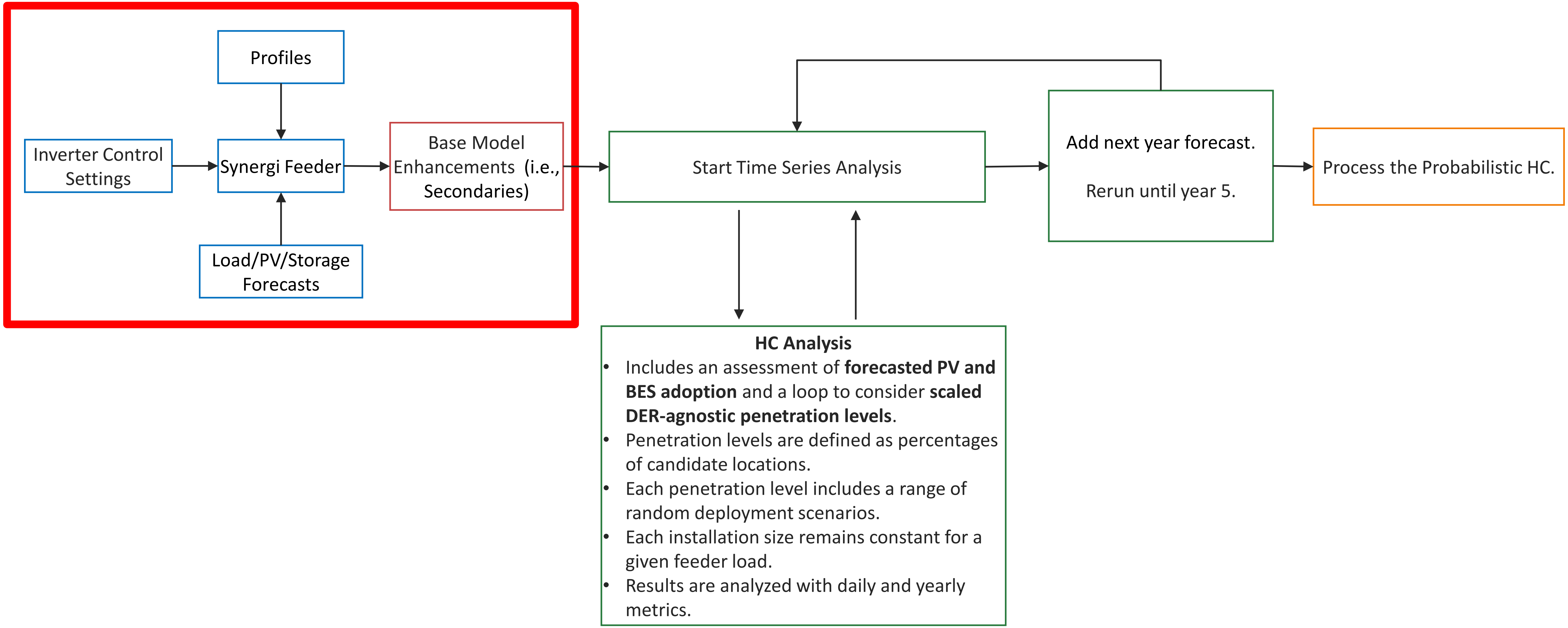


Open Questions

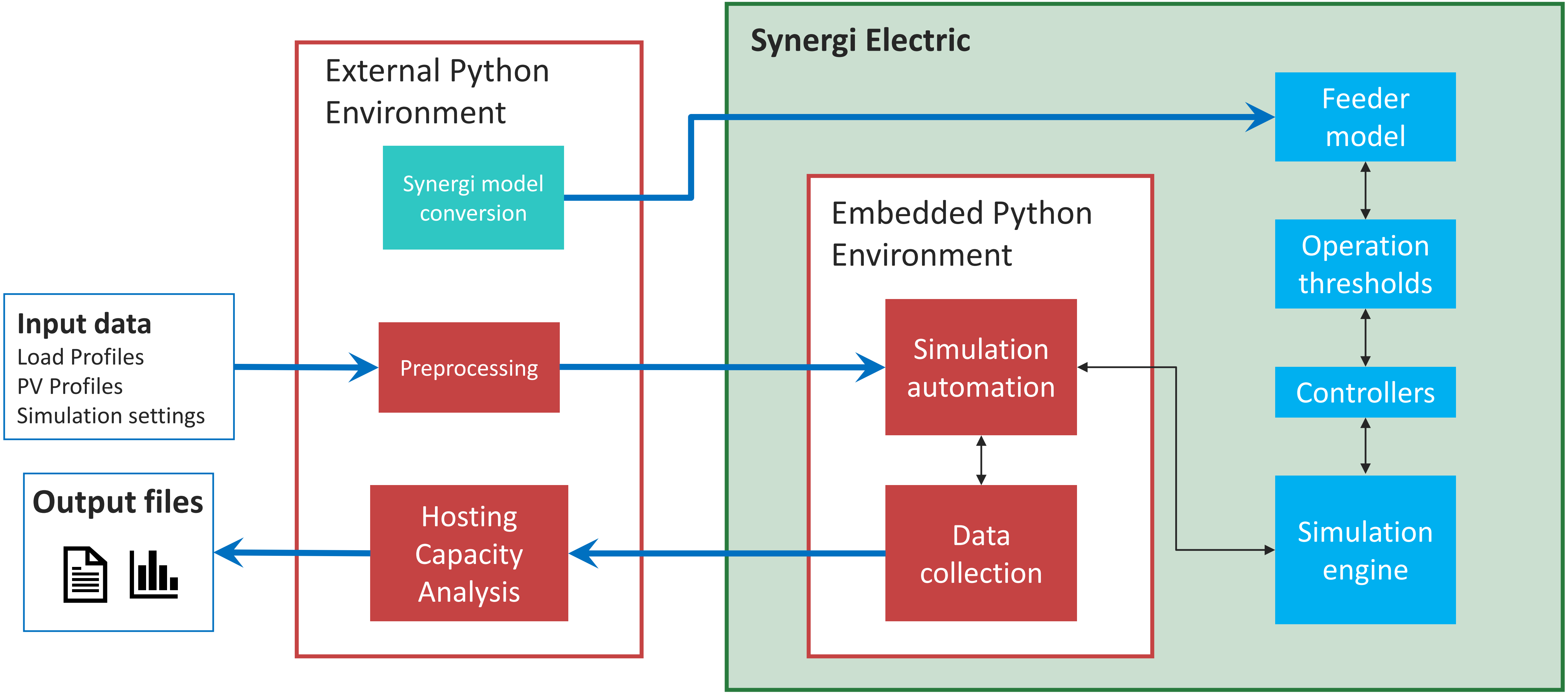
- How many forecasted scenarios are needed?
- How many agnostic deployments are needed?
- How many penetration levels should be analyzed?

Model/Analysis Preparation

Inputs and Setup for the Analysis



Analysis within Synergi Electric



Input Data | Simulation length and device settings

Feeder-specific simulation settings are defined through a CSV file with the following parameters.

Parameter	Description
Hours per year	• Hours to be included in each yearly simulation (576 or 8760).
Years	• Total count of years to be analyzed.
BES Capacity (kWh)	• Energy storage capacity in kWh for each unit.
BES Peak Power (kW)	• Maximum power in kW delivered by the energy storage system.
BES Efficiency (pct)	• Roundtrip efficiency for each energy storage system.
Individual DER size min (kW)	• Minimum DER size for each residential deployment. • The algorithm assigns the size of each DER installation with a uniform random distribution between min. and max. limits.
Individual DER size max (kW)	• Maximum DER size for each residential deployment. • The algorithm assigns the size of each DER installation with a uniform random distribution between min. and max. limits.
Min. Load Size for Commercial Loads (kW)	• Minimum active power to consider a modeled load as a commercial customer. • Loads with allocated active power exceeding this value will be assigned to hypothetical DER installation sizes as a factor of their active power (k factor).
Commercial DER size vs. loads size (pct)	• Commercial DER size as percentage of allocated load to be applied for commercial customers (k factor). • Commercial DER size = k/100 * Load kW

Input Data | Forecast and penetration levels

DER-Agnostic Penetration Levels - Year 0

- Number of penetration levels to assign new DER-agnostic installations at year 0 (base case).
- Count of levels between 0 % and 100% of remaining candidate customers (no existent PV).

DER-Agnostic Distribution Cases - Year 0

- Number of scenarios (deployments) to assign new DER-agnostic installations for each penetration level.
- The algorithm assigns random customers among candidate locations to match the corresponding penetration level.

DER Forecast (MW) - Year N

- Forecast (MW) of installed DER capacity for year N.
- This value includes existent PV capacity.

DER Forecast Distribution Cases - Year N

- Number of scenarios (deployments) to assign new PV installations that match the forecast capacity.
- The algorithm searches random customers among candidate locations to match the forecast within a 3% tolerance.

DER-Agnostic Penetration Levels - Year N

- Number of penetration levels to assign new DER-agnostic installations at year N.
- Count of levels between 0 % and 100% of remaining candidate customers (no existent nor forecasted PV).

DER-Agnostic Distribution Cases - Year N

- Number of scenarios (deployments) to assign new DER-agnostic installations for each penetration level.
- The algorithm assigns random customers among candidate locations to match the corresponding penetration level (no existent nor forecasted PV).

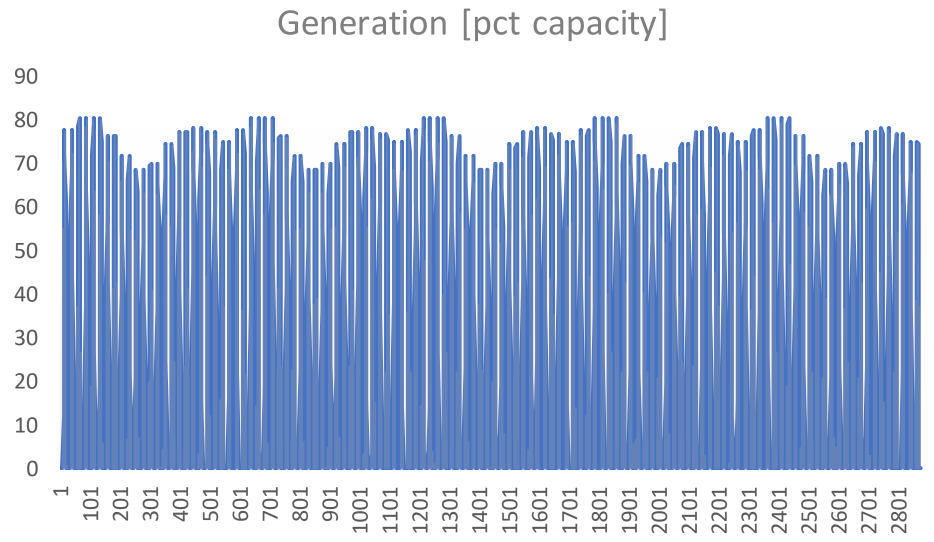
Input Data | Generation and load profiles

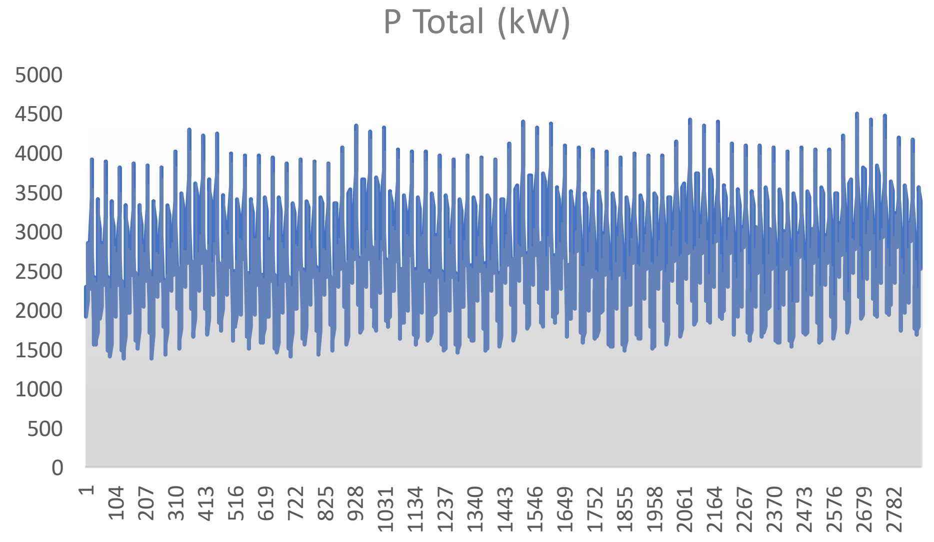
Generation.csv

- Normalized generation profile that is utilized for existent and future PV deployments.
- This profile is also employed for gross load calculation.

NetLoad.csv

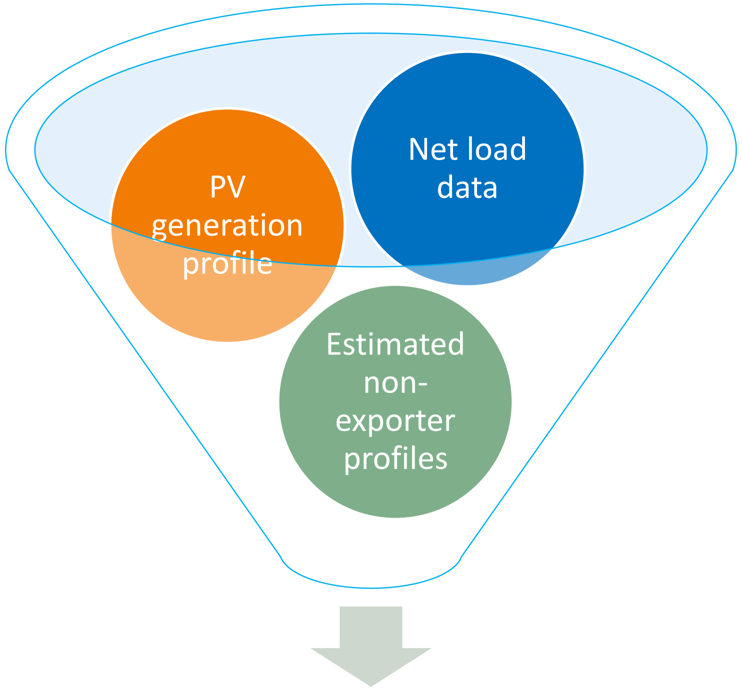
- Net load profile in kW and aggregated at feeder head.
- This profile must have the same length and resolution as the PV generation profile





Gross load estimation for each year

- Step 0: Conversion of original Synergi models to explicit customer models
- Step 1: Obtain input data
  - Generation/Irradiance profiles
  - Net load profiles
- Step 2: Estimate non-export profiles from simulations with net load
- Step 3: Estimate gross load from aggregated generation and net load
- Step 4: Update non-export estimate and calculate future BES + DER profiles based on gross load.
  - Populate Synergi warehouse with load and DER profiles for future deployments



Gross load profile

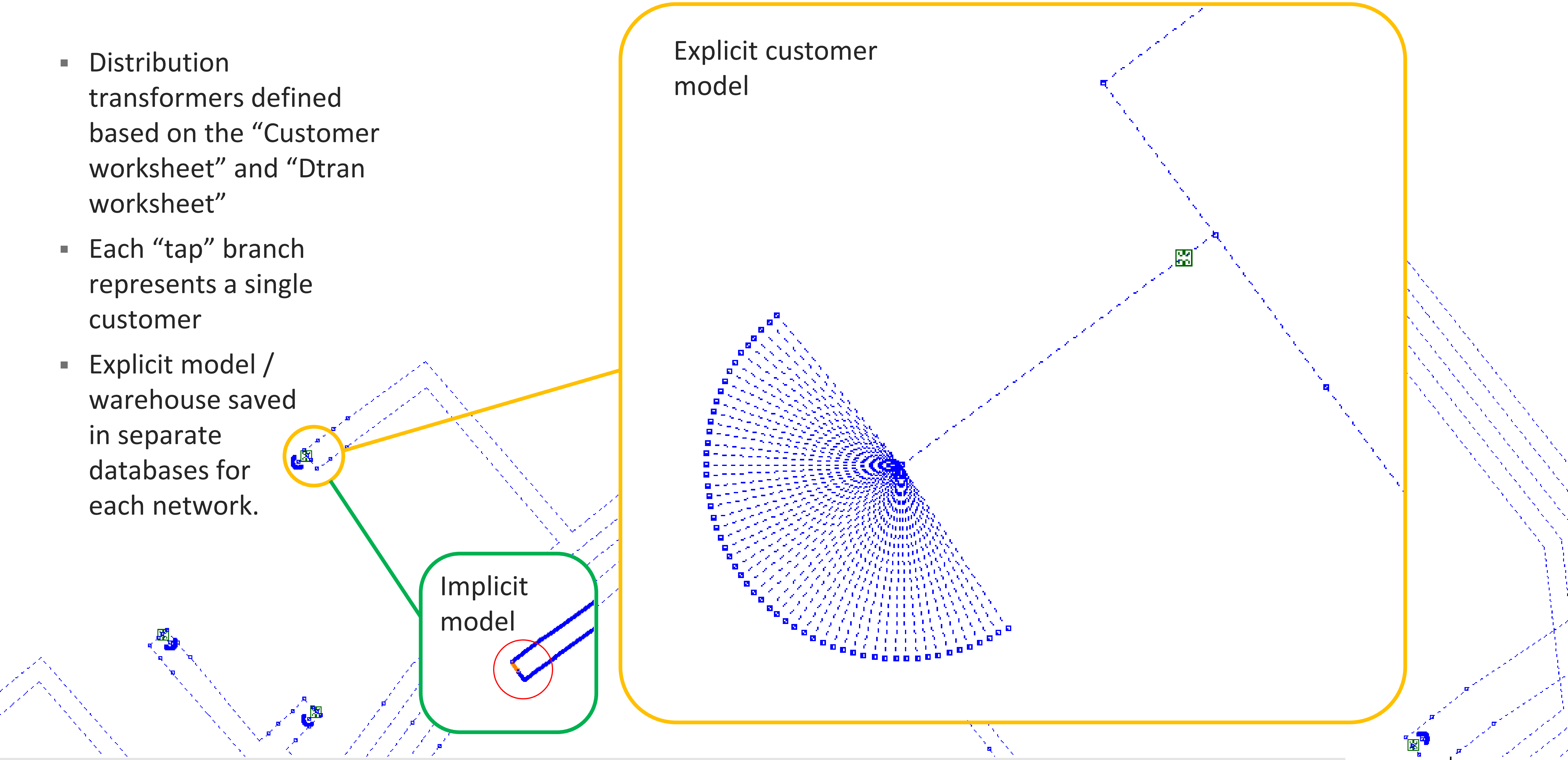
Feeder head gross load profile
- Loads (P)

PV Generation profile
- Existent PV
- Forecasted PV

Individual generation profiles
- Non-exporter PV
- BES devices
  - Non-exporter (ISE)
  - Forecasted PV w/ BES

Step 0: Feeder conversion - explicit customer secondaries

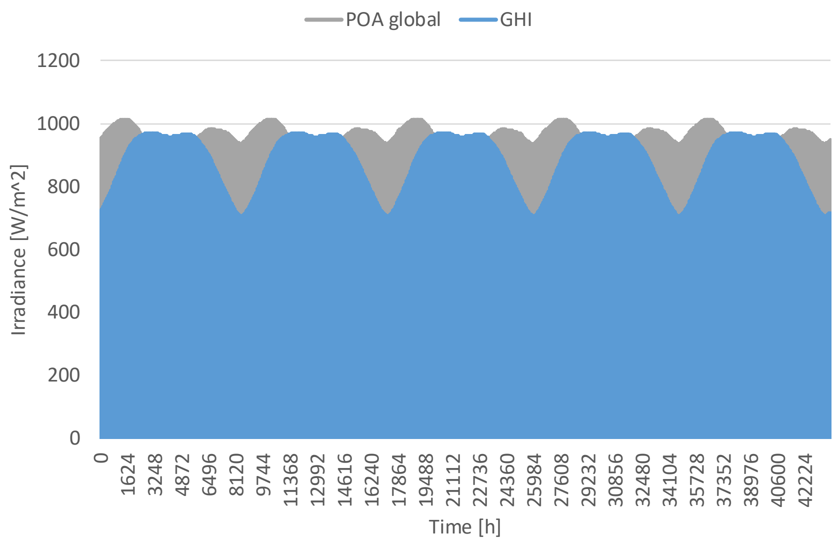
- Distribution transformers defined based on the “Customer worksheet” and “Dtran worksheet”
- Each “tap” branch represents a single customer
- Explicit model / warehouse saved in separate databases for each network.



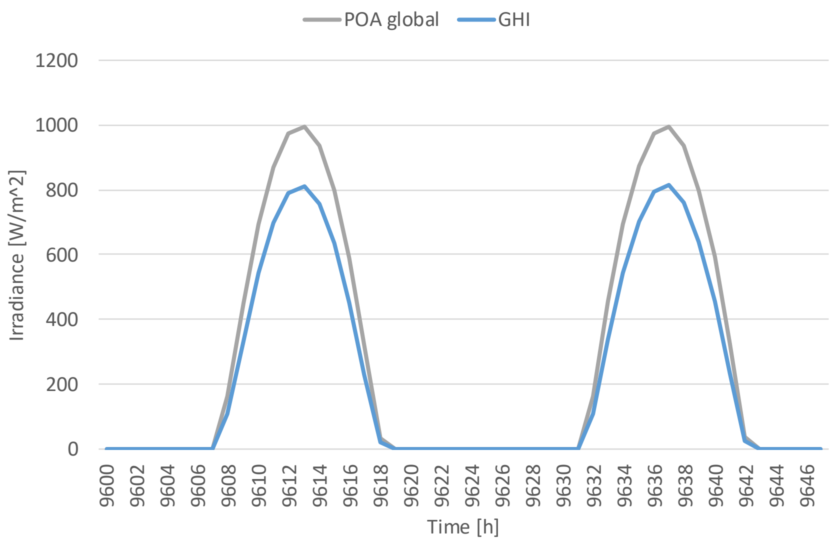
Step 1: Irradiance profile to estimate gross load

- Clear-sky solar generation estimated from south-facing POA irradiance with a tilt of 26.57 decimal degrees. Calculated with [1]
- 576-hour profiles generated with two days of average daily profile per month.

5 Years clear sky irradiance profile

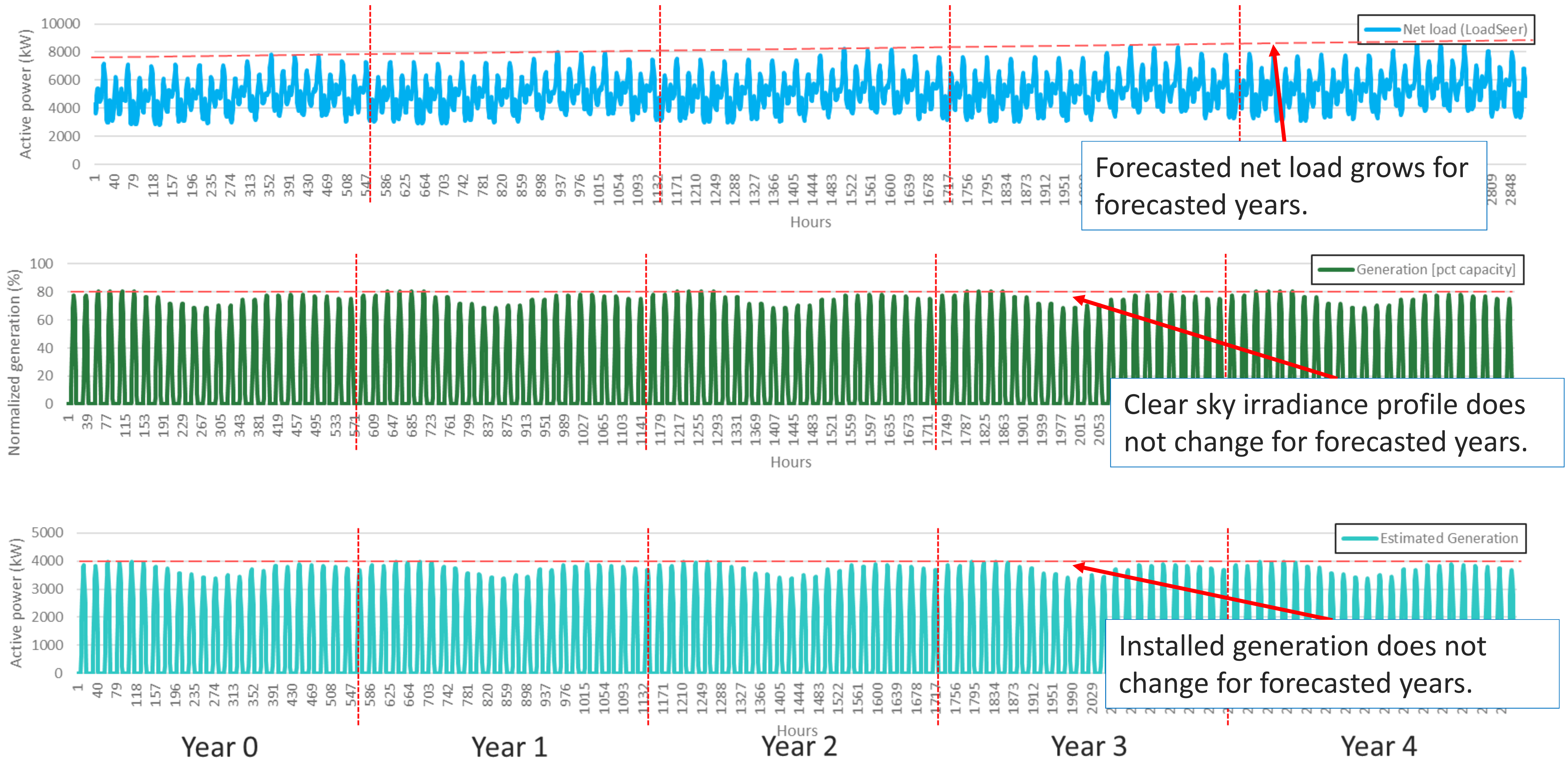


Sample days



[1] William F. Holmgren, Clifford W. Hansen, and Mark A. Mikofski. “pvlib python: a python package for modeling solar energy systems.” Journal of Open Source Software, 3(29), 884, (2018). https://doi.org/10.21105/joss.00884

Step 3: Gross Load Estimated Based on Net Load and Generation



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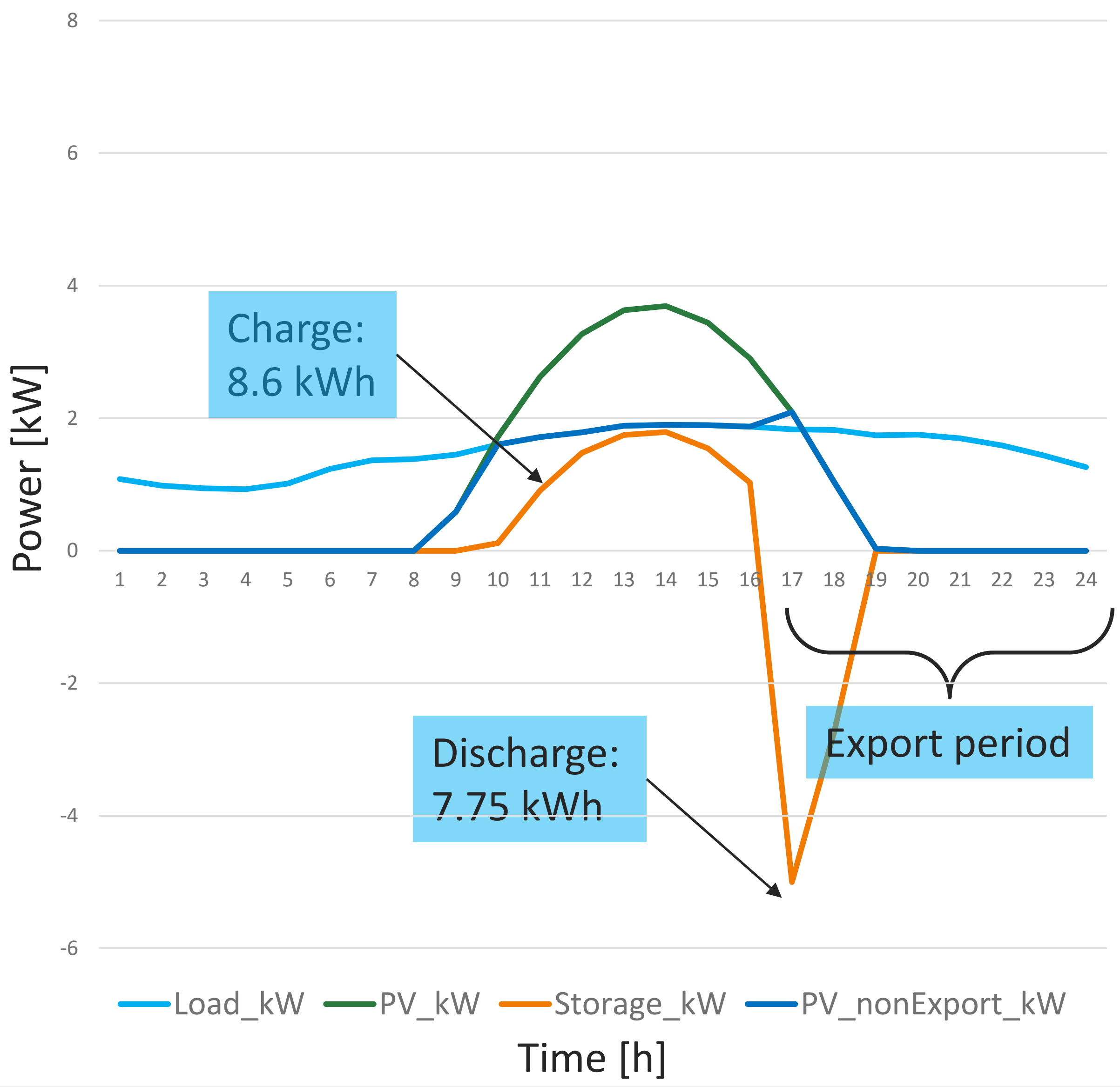
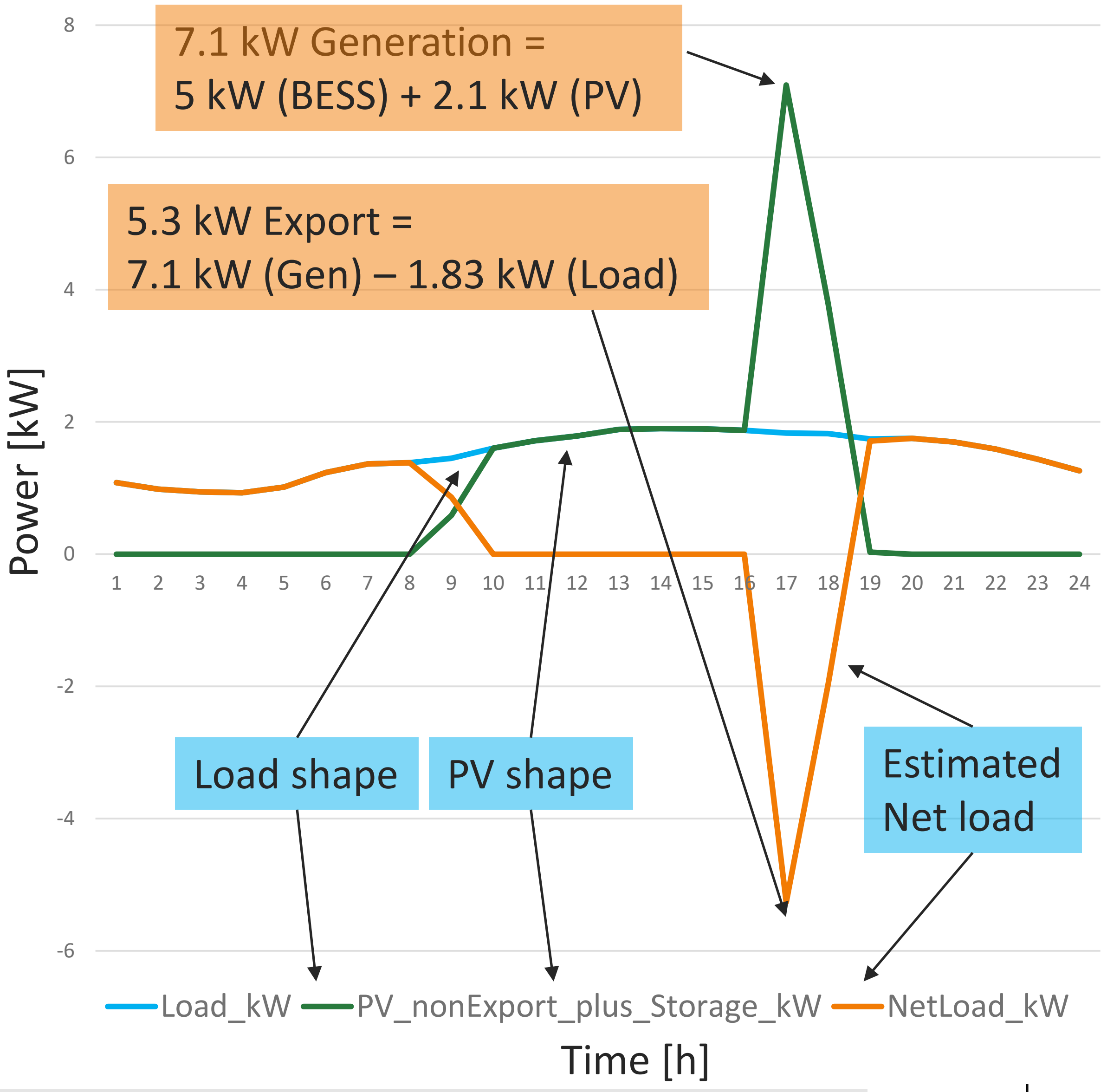
Step 2 & 4: Approach for BES sizing and dispatch for non-exporters

BES dispatch is pre-calculated by following the “smart exporter” rules.

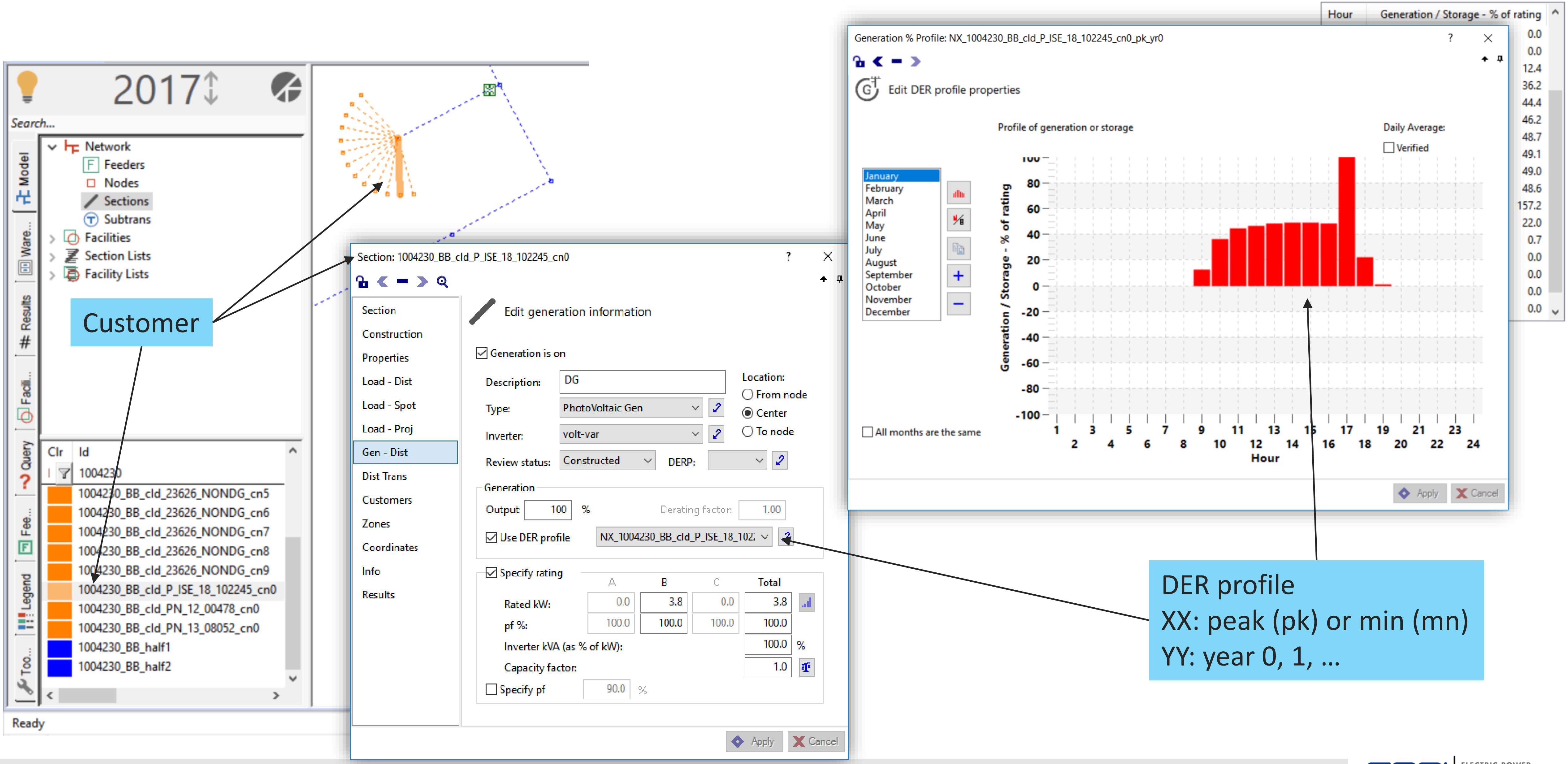
- Storage unit of 12 kWh, 5 kW unit (90% roundtrip efficiency)
  - Parameters included in the input settings file.
- Rules for energy storage operation:
  - BES can only charge by drawing from PV
  - Smart exporters (ISE Program) charge from the generation surplus
  - BES can export to the grid during discharge (export at max power output)
- Intraday storage dispatch:
  - Discharge is allowed from 4pm to 12am
  - BES starts charging as soon as surplus generation is available until <u>full</u> OR until <u>capacity equal to the max export between 4pm to 12am</u>
- PV kW, ES kW/kWh and load consumption defines customer operation
  - PV generation profile estimated from irradiance profile
  - BES operation calculated from PV generation and calculated consumption profile
  - BES operation and PV generation finally combined into the <u>‘adjusted’ generation profile</u>

BES Example | ISE Customer





BES Example | ISE Customer | Synergi implementation



Open Comments and Questions

- Results will be dependent on the applied load and existing/forecasted PV profiles
- Suggestions on volt-var control applied
- Model detail vs. analysis efficiency

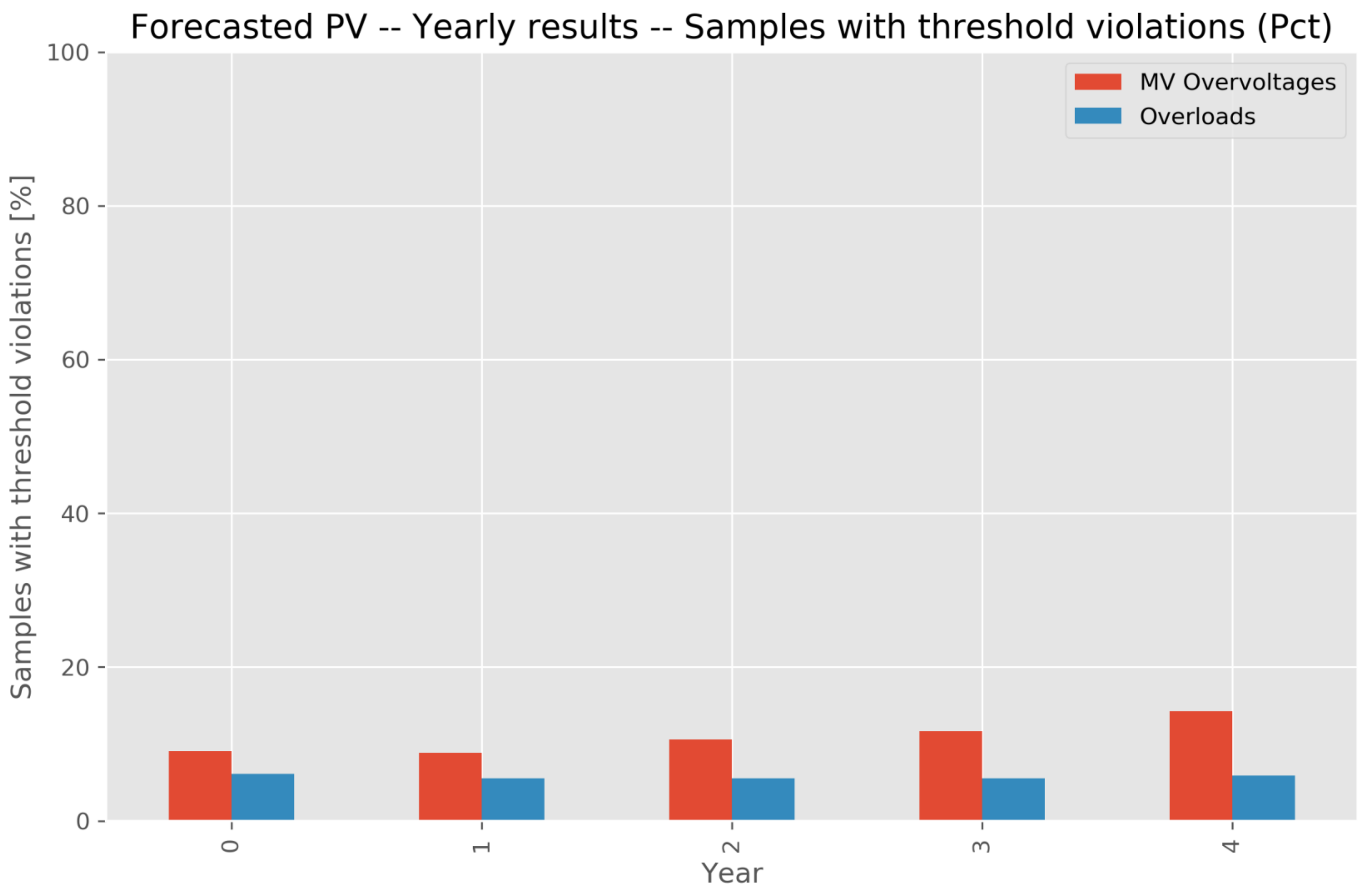
Time-series power flow simulation in Synergi v6.4

Item \ Options	Hourly (576) Synergi load flows
Granularity	High
Available data	• Voltage and loading exceptions per hour, per equipment (lines, transformers)
Time consumption	High Observed time for 576 load flows including data storage • Kahala: ~2.9 min • Ft Weaver: ~9.8 min • Iwilei: ~2.7 min
Main drawbacks	Time consuming: 10 DER penetration levels with 5 DER distributions may take ~1.8 days to solve 5 years for the largest model (Ft weaver) and ~0.5 days for the smallest case (Iwilei)
Main advantages	Granularity, option to filter exceptions, exceptions reported directly to Access DB (SQL queries)
Fixes	To increase speed: html reporting disabled, step by step execution using *Synergi recipe* scripts instead of python (fixes already included in time estimation)

Preliminary Results

Yearly metric-specific threshold violations

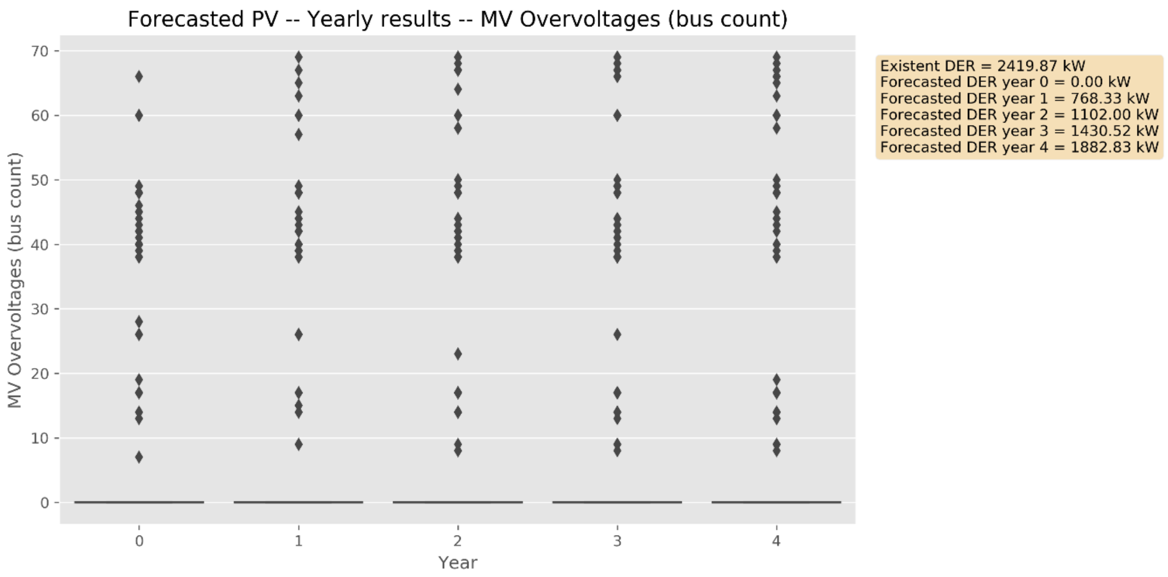
Forecast assessment
(PV and BES deployments)

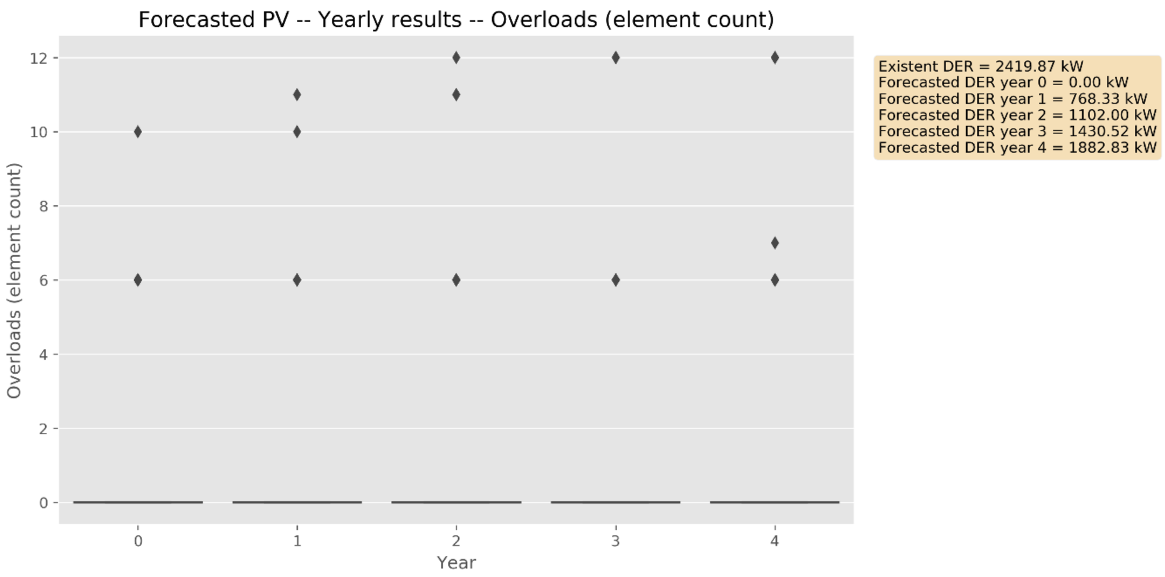


Existent DER = 2419.87 kW
Forecasted DER year 0 = 0.00 kW
Forecasted DER year 1 = 768.33 kW
Forecasted DER year 2 = 1102.00 kW
Forecasted DER year 3 = 1430.52 kW
Forecasted DER year 4 = 1882.83 kW

Yearly impact of threshold violations

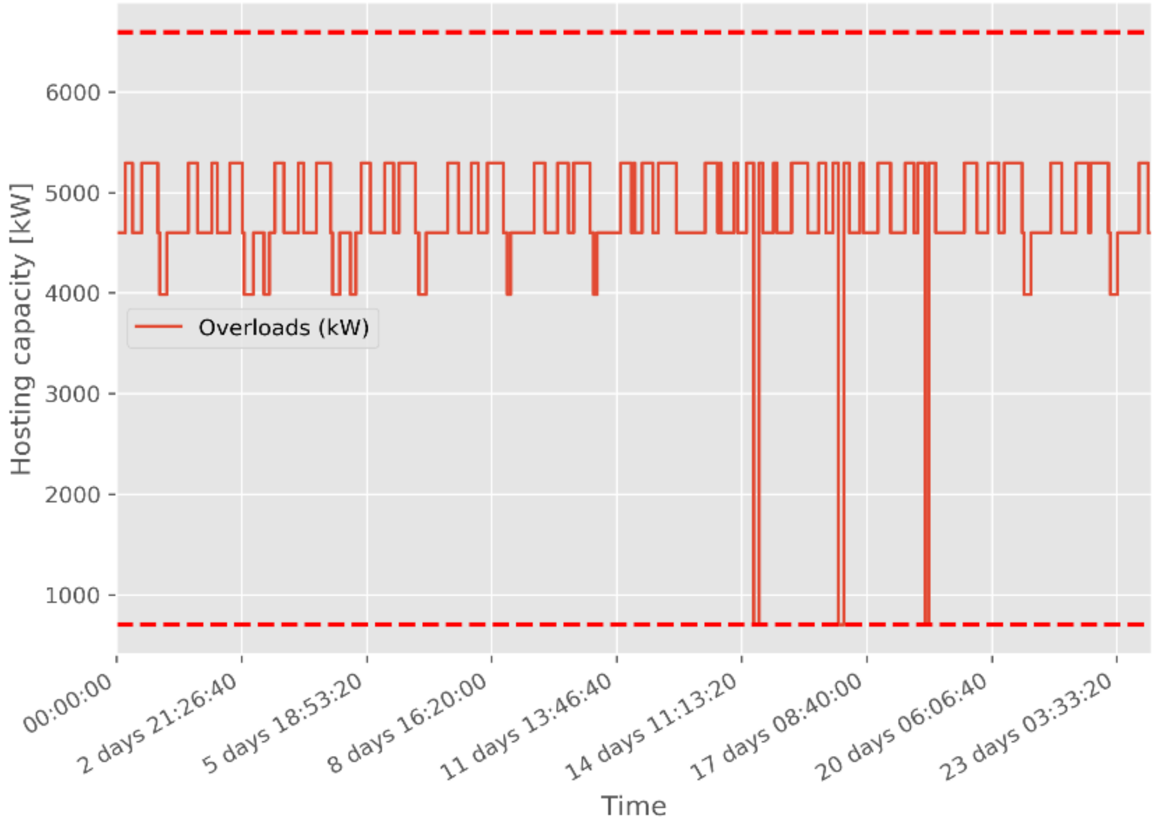
Forecast assessment
(PV and BES deployments)



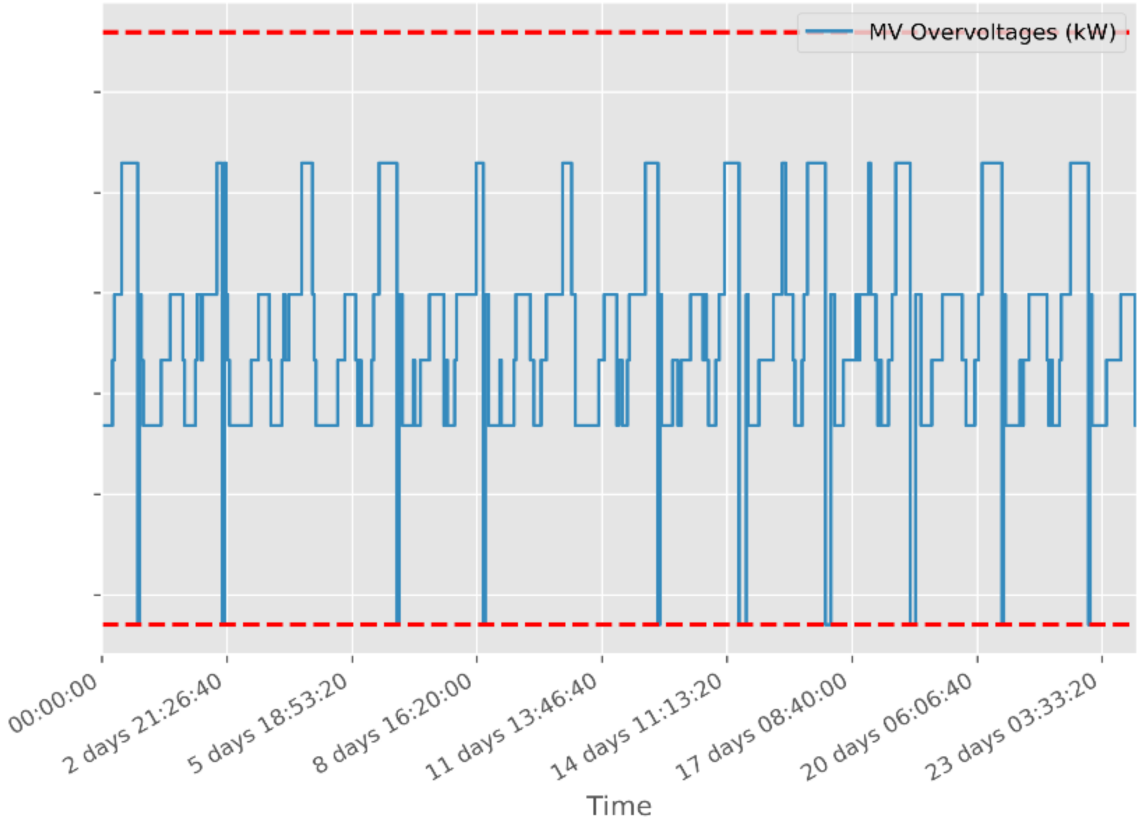


Scenario-Consolidated HC Values

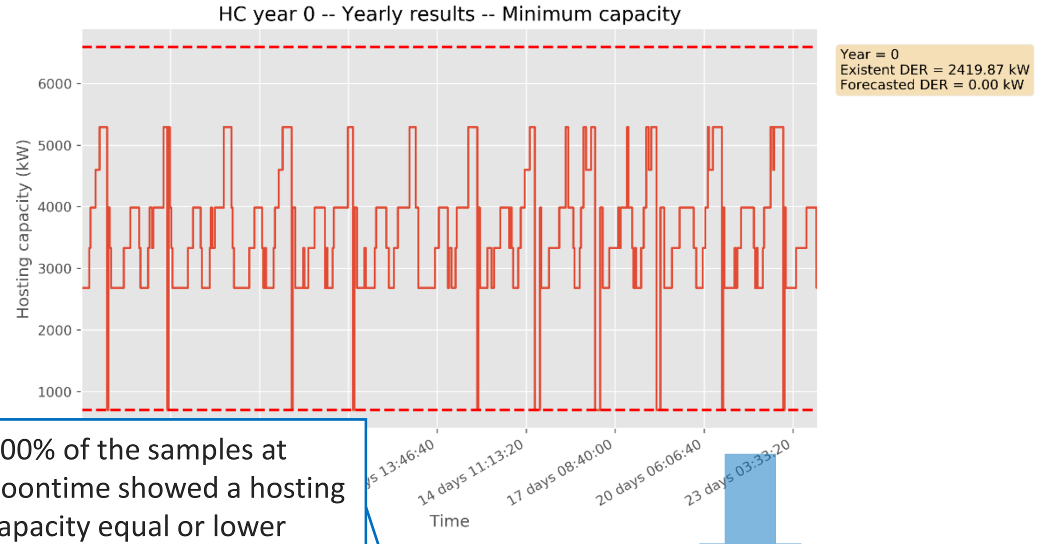
Thermal



Voltage



Daily HC Values

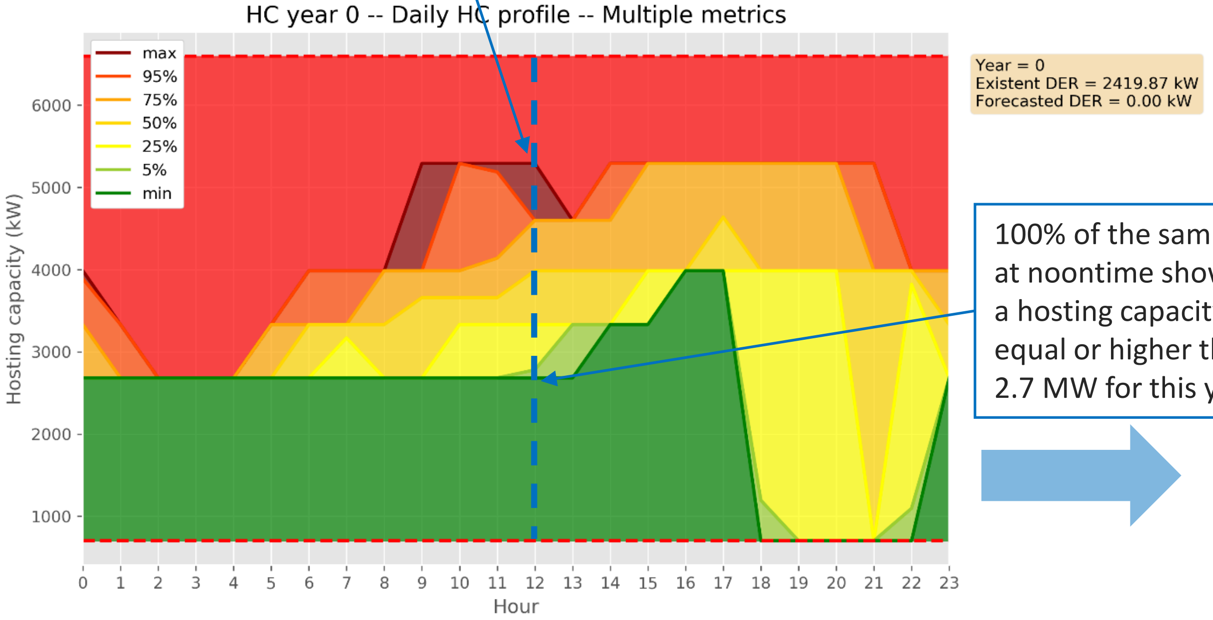


The final HC value is calculated as the minimum value for a given hour when the individual criteria were considered.

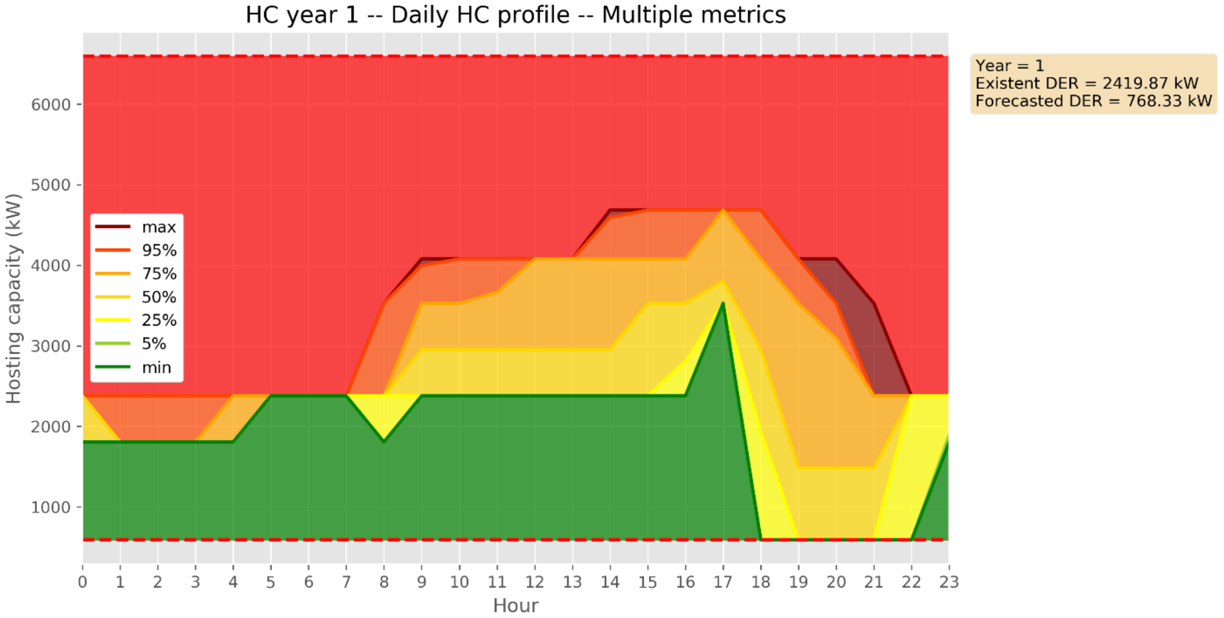
Year-long hosting capacity values were summarized in daily profiles by means of descriptive statistics.

- Samples from every hour of the year were processed to calculate the 95th, 75th, 50th, 25th, 5th, max., and min. values.
- This information can be presented as a contour plot with the daily HC profile, or as a box plot.

100% of the samples at noontime showed a hosting capacity equal or lower than 5.3 MW for this year

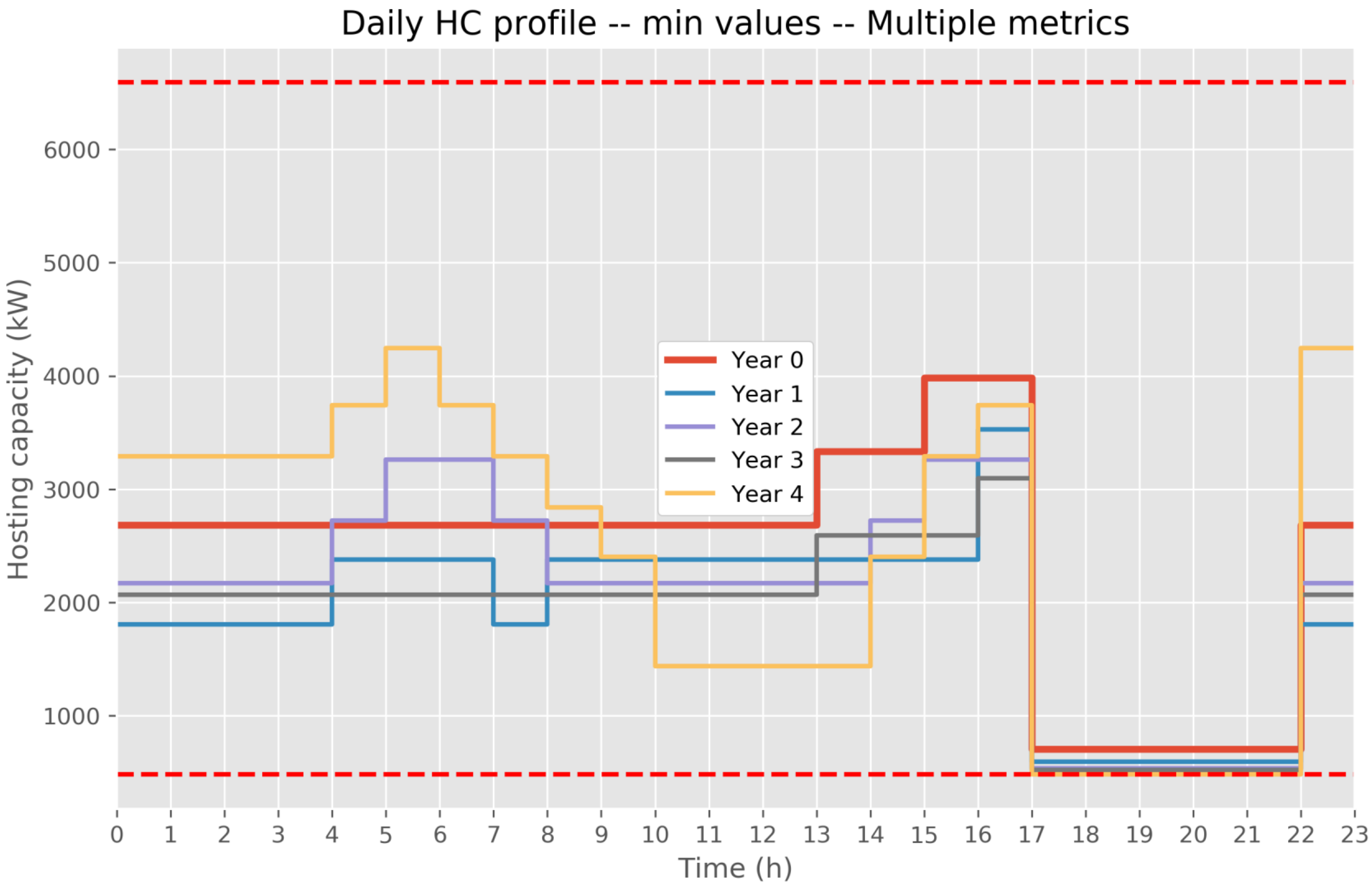


100% of the samples at noontime showed a hosting capacity equal or higher than 2.7 MW for this year



Daily minimum HC values

Remaining HC (DER agnostic loop)



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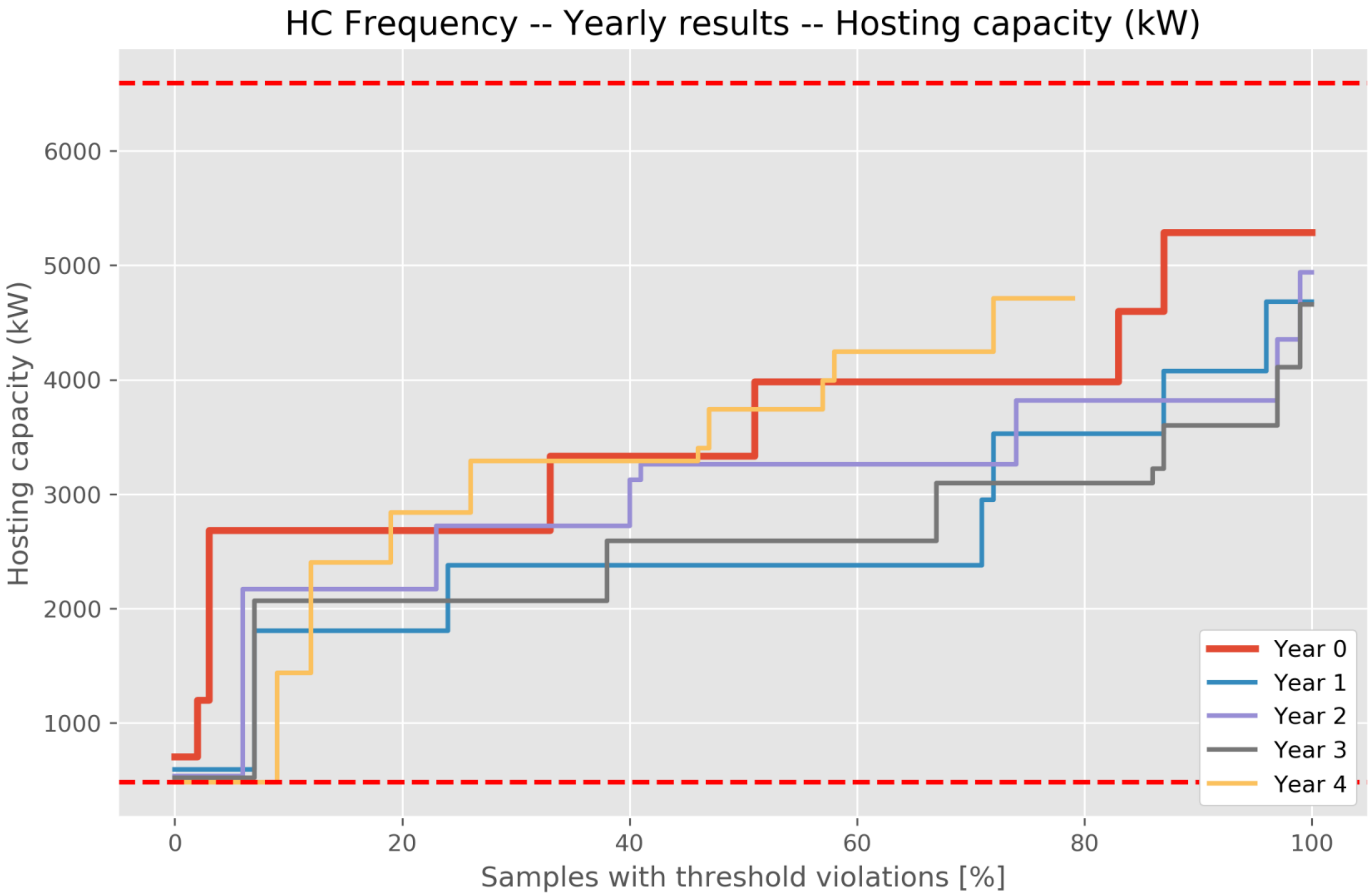
Forecasted DER year 4 = 1882.83 kW

HC values in this figure consider MV overvoltages, and MV overloads.

Yearly HC values

Remaining HC (DER agnostic loop)



Existent DER = 2419.87 kW
Forecasted DER year 0 = 0.00 kW
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Forecasted DER year 2 = 1102.00 kW
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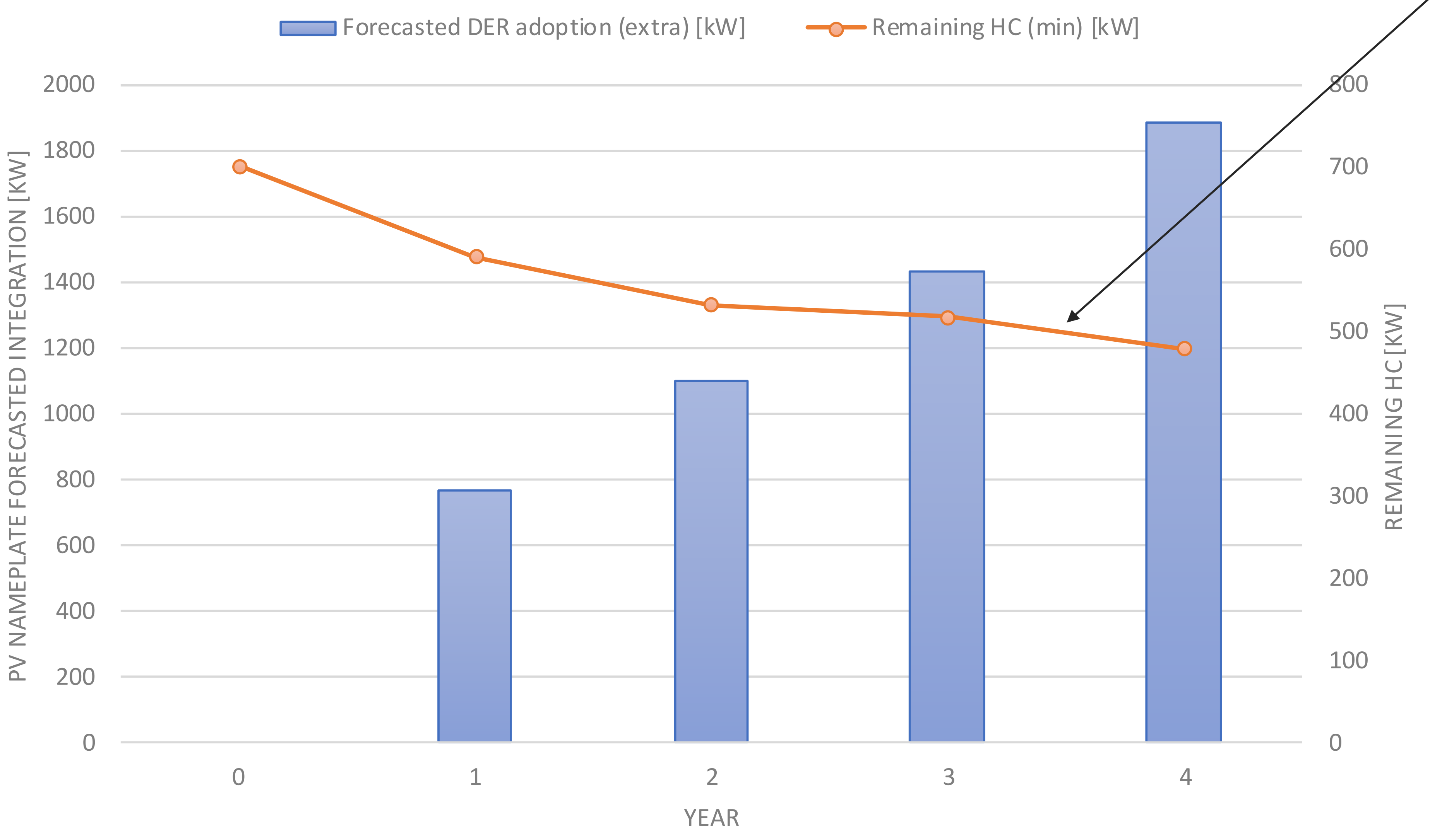
Forecasted DER year 4 = 1882.83 kW

HC values in this figure consider MV overvoltages, and MV overloads.

Summary for Remaining HC

Other HC values to be included (percentiles)



Open Comments and Questions

- How else should results be quantified?

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