CASE ÅLAND

100% RENEWABLE SCENARIOS

Åland FLEXe demo – Final Seminar
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WÄRTSILÄ

Purpose of power system modeling in Wärtsilä

1. Understand operation and fundamentals of power systems

- In regulated and open electricity markets
- Illustrate future challenges of power systems

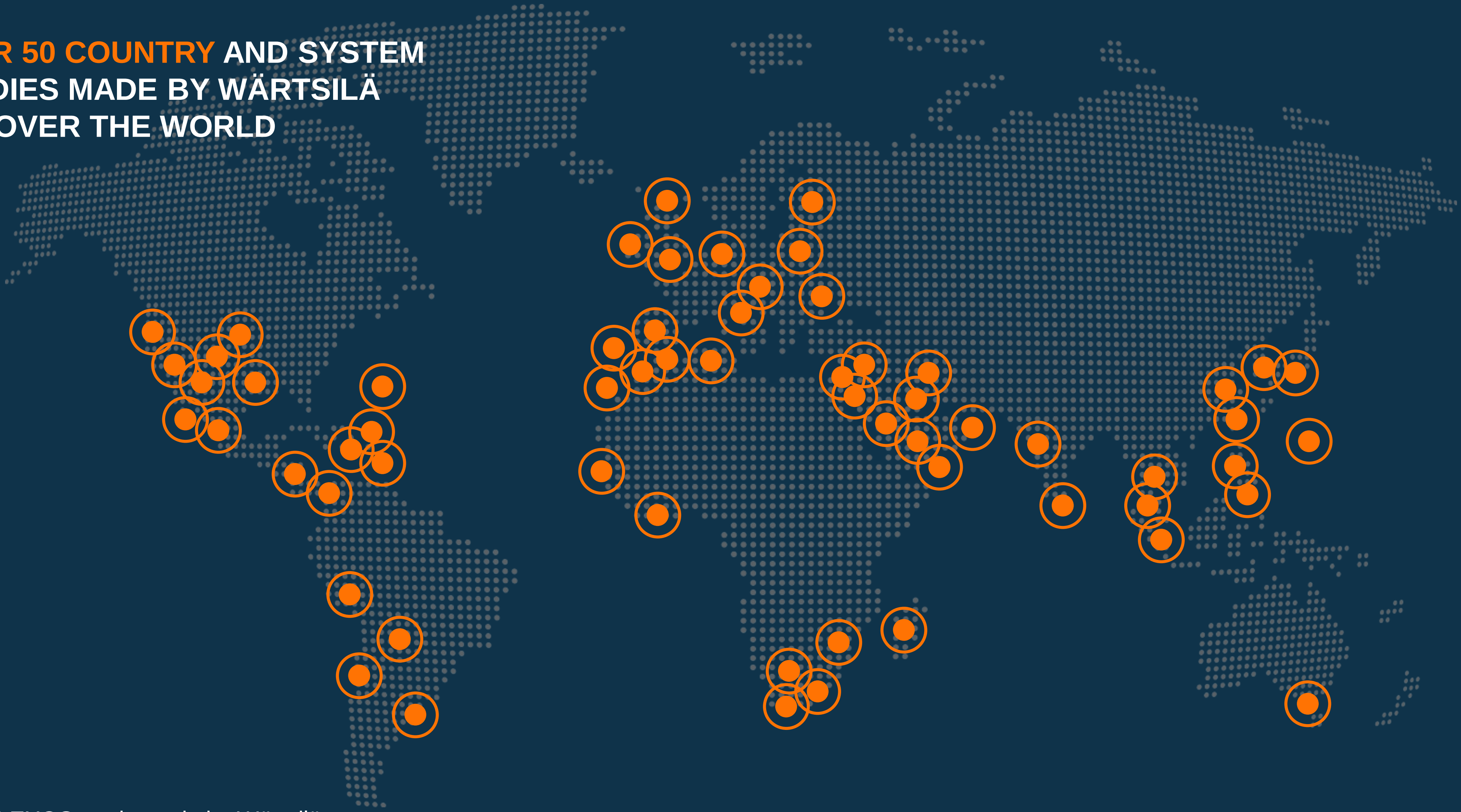
2. Quantify system level benefits of different power plants

- Optimizing system total cost
- Understand value of flexibility in a system
- Finding optimal capacity mix

3. Understand and promote high quality modeling

- Co-optimization of energy and operation reserves
- High detail & resolution
- Transparent modeling
- Actively developing new modelling methods

OVER 50 COUNTRY AND SYSTEM STUDIES MADE BY WÄRTSILÄ ALL OVER THE WORLD



= PLEXOS study made by Wärtsilä

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INPUTS

Scenarios:
- CO_2 targets
- RES learning curves
- Political system planning
- Forced new builds

System data:
- Transmission
- Fuels
- Demand + Growth rate
- Reserves

Fleet data:
- Power plants
- Dispatch constraints
- Renewable/hydro profiles

Candidates:
- New build candidates with CAPEX

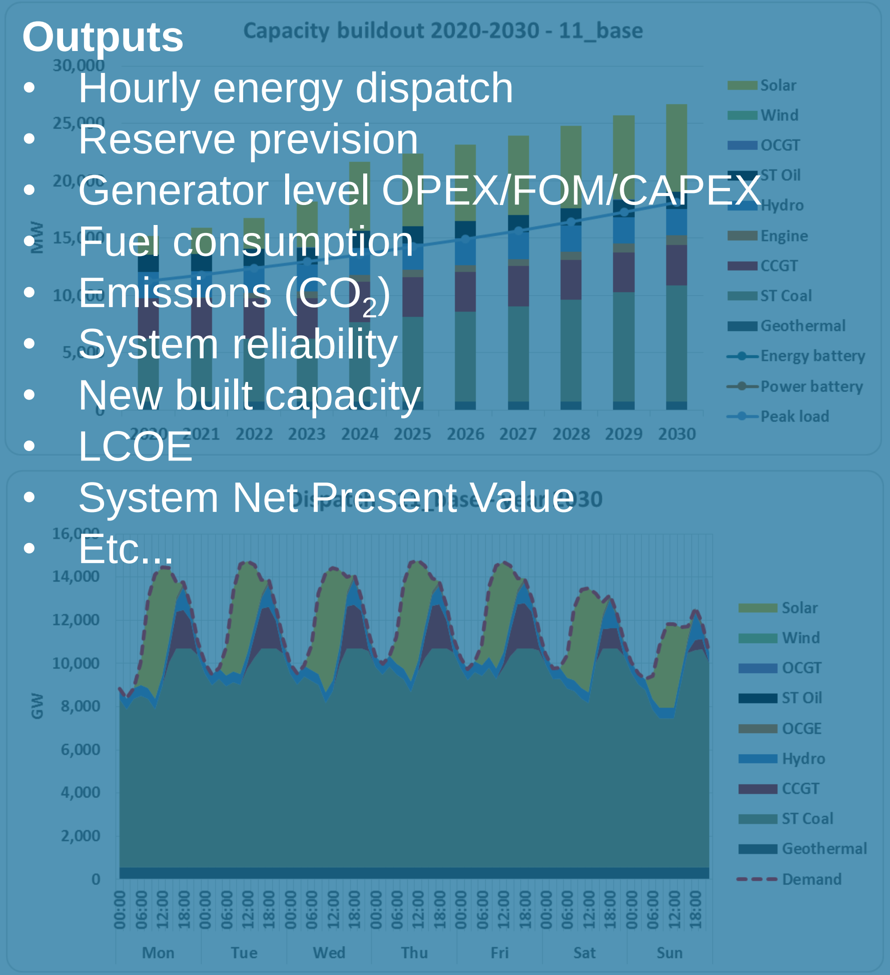
MODEL

With input data and scenario definitions power system mathematical problems are formulated in PLEXOS platform

System optimizer by PLEXOS

PLEXOS solver optimises i.e. finds the lowest cost solutions for defined scenarios. In optimisation process all defined real life constraints are considered. Hourly dispatch and capacity additions.

OUTPUTS



Outputs
- Hourly energy dispatch
- Reserve prevision
- Generator level OPEX/FOM/CAPEX
- Fuel consumption
- Emissions (CO_2)
- System reliability
- New built capacity
- LCOE
- System Net Present Value
- Etc...

Base Case

Link to Sweden maintained

New capacity added on a lowest cost basis

100% RES scenario (Power-to-Gas)

Link to Sweden gradually ”cut” by 2030

New capacity added on a lowest cost basis

Options for new capacity: Wind, Solar, Batteries and PtG (engine)

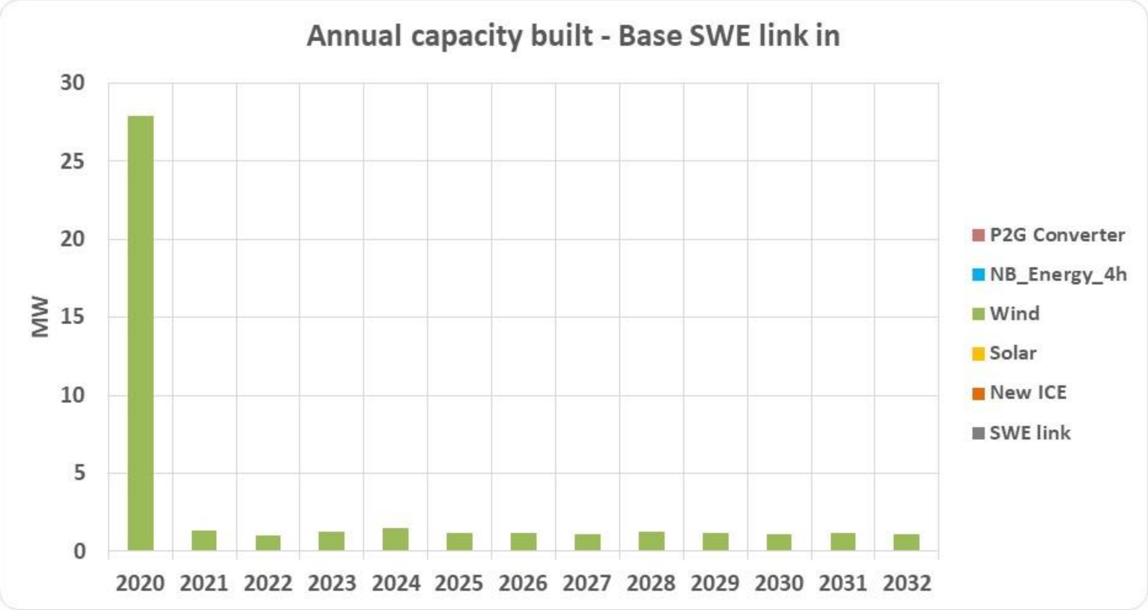
Target: Reach 100% RES share in Åland by 2030, link to Sweden gradually “cut” by 2030

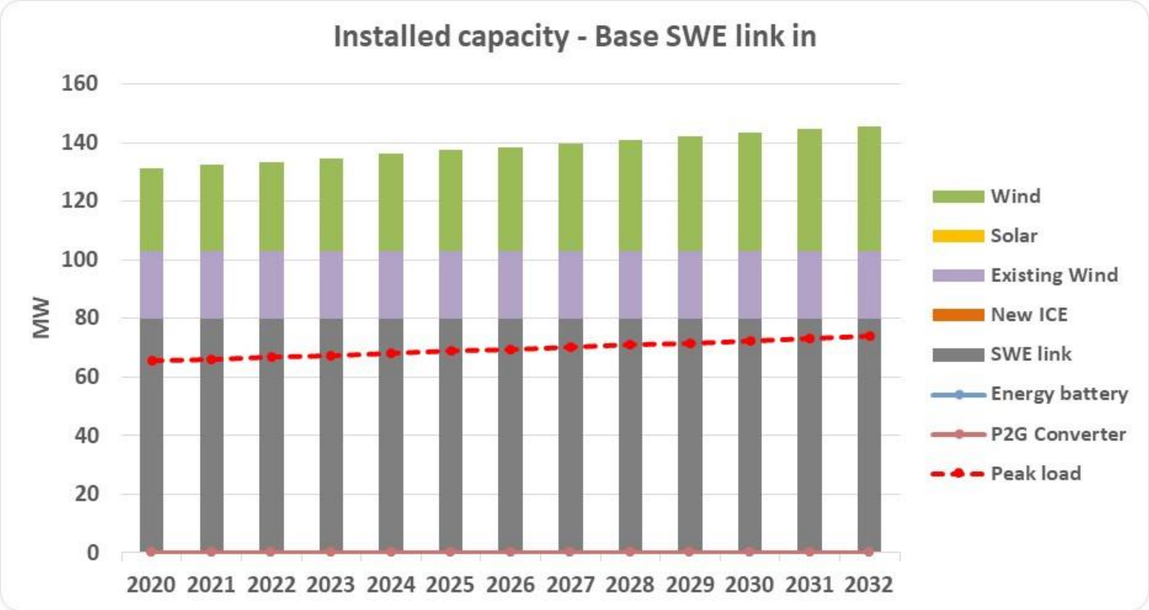
- Demand growth 1% p.a. starting from 300 GWh
- Existing generation fleet as-is (only wind)
- New capacity added on a lowest cost basis to meet the demand on hourly level (optimization on yearly level)
- Wind (new onshore capacity) cost 35 EUR/MWh, Solar cost 80 EUR/MWh (current price level)
  - Wind cost ~25 EUR/MWh in 2030, Solar cost ~45 EUR/MWh in 2030
  - Cost projections based on Bloomberg forecast
- *SWE link* electricity import price 50 EUR/MWh (full flexibility assumed)
- When *SWE link* “cut”, batteries and engine based PtG as options to provide flexibility
- No CHP included
- No demand response or EVs included
- No electricity sales outside Åland
- No optimization of investment timing
- No consideration where to locate new generation capacity, or how long the permitting process would take

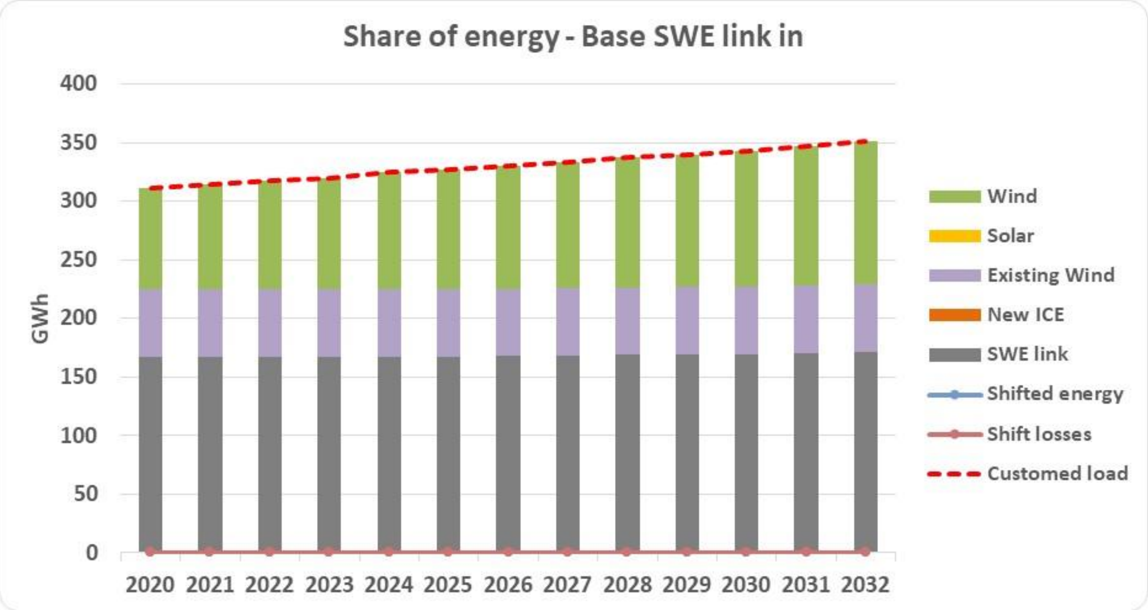
BASE CASE – LINK TO SWEDEN MAINTAINED, NEW CAPACITY ADDED ON A LOWEST COST BASIS

PRELIMINARY

- In the beginning imported electricity replaced by cheap wind, and thereafter increasing demand met by new wind capacity
- Low amount of curtailment (10–20%)
- **>50% RES** reached by 2030
- **Cheapest** option to increase RES share



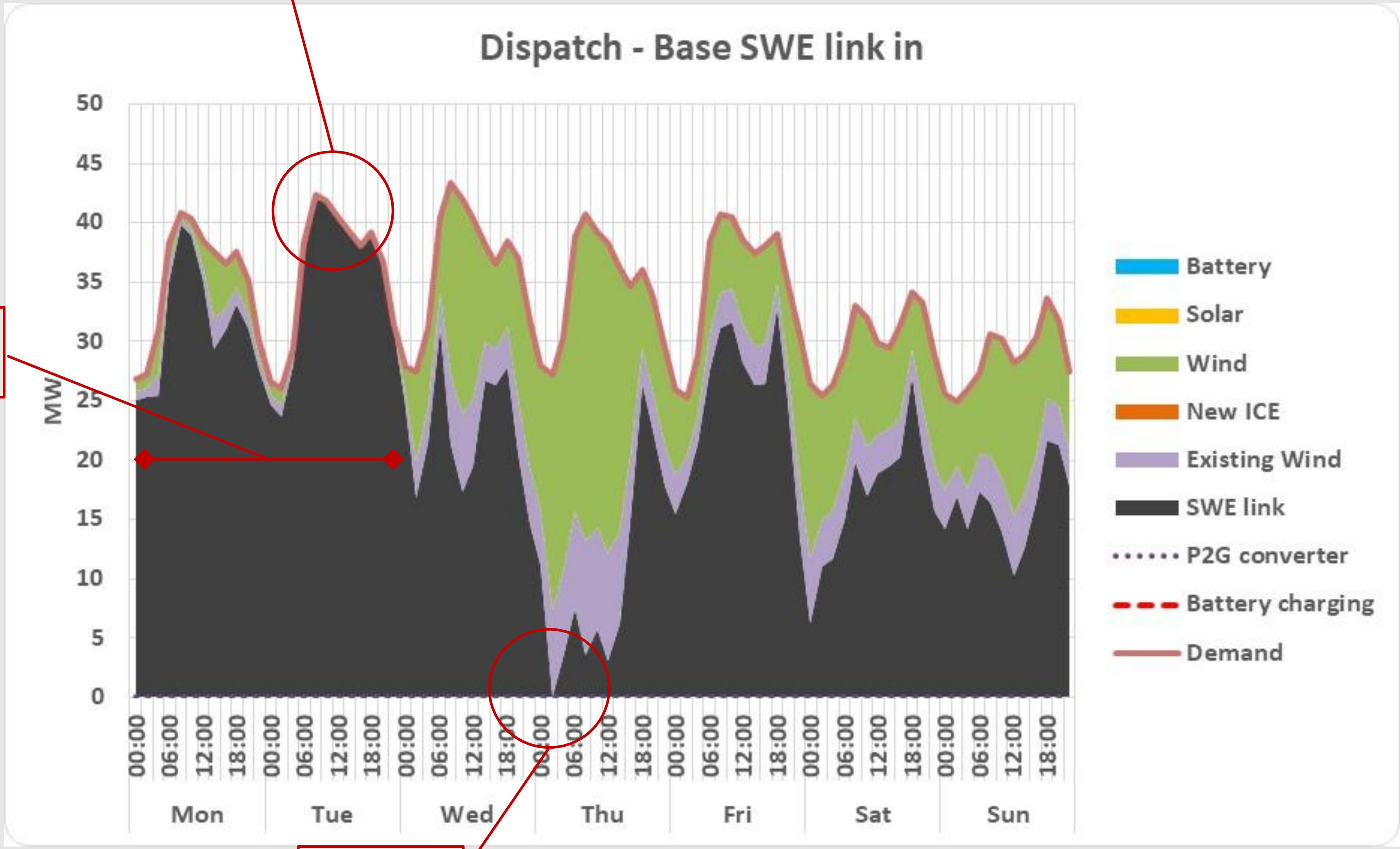




PRELIMINARY

No wind

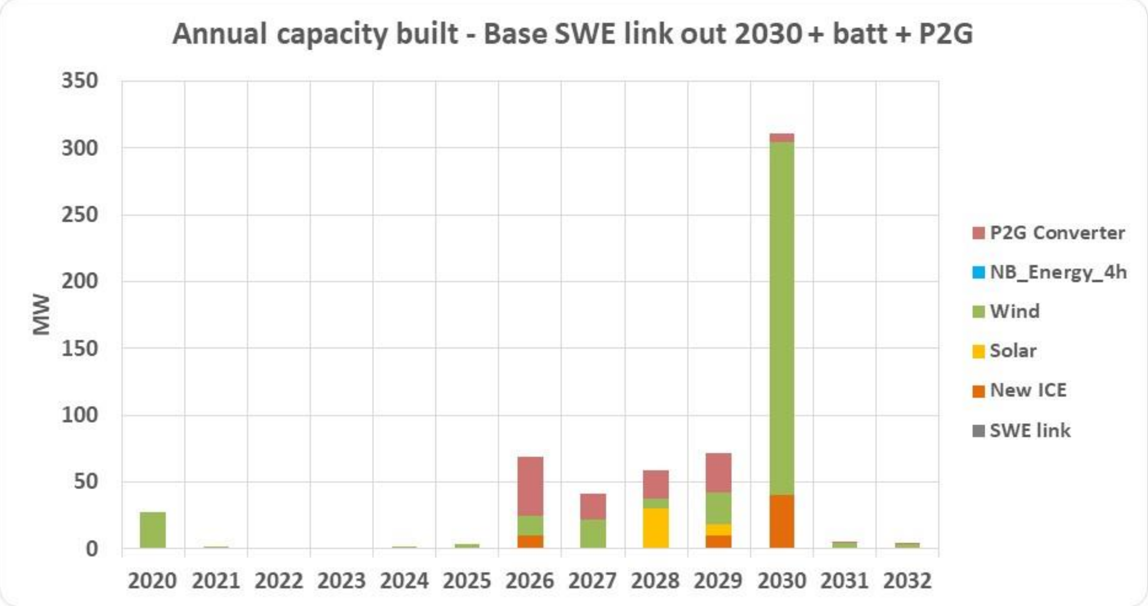
~2 days almost fully dependable on import

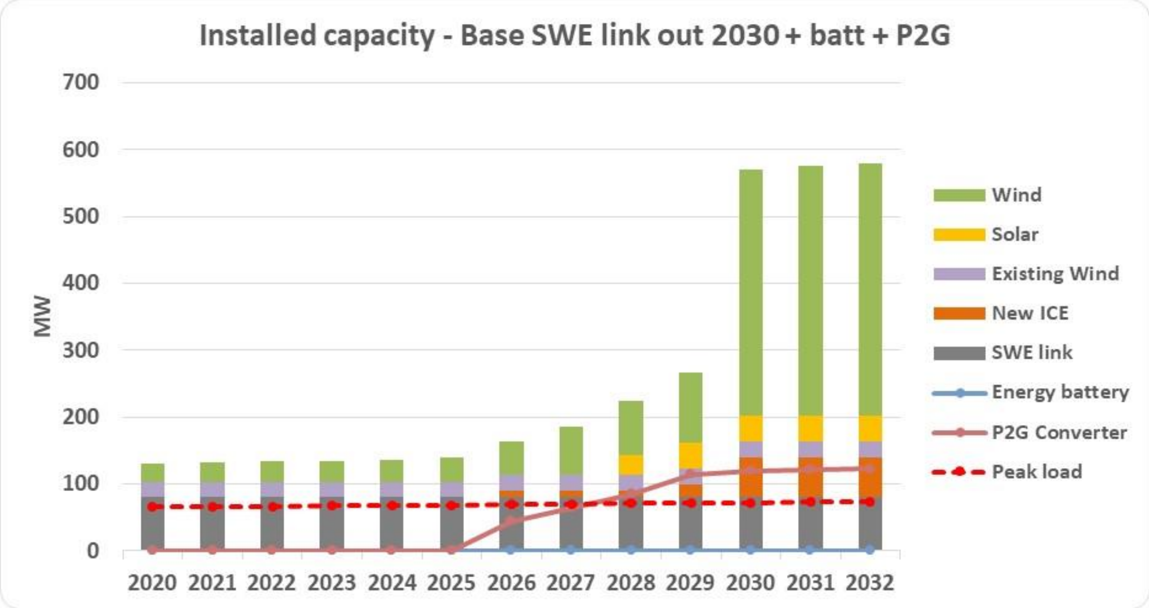


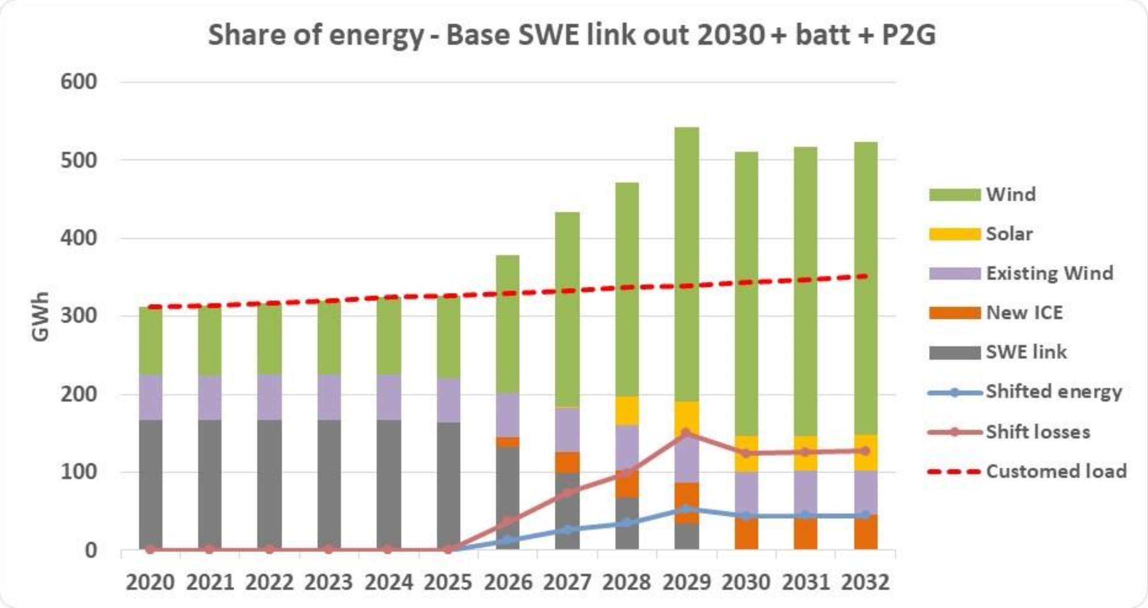
No import

PRELIMINARY

- New capacity based on wind (**370 MW**), solar (**40 MW**) and closer to final “cut” PtG (**60 MW**)
- High amount of curtailment (60–70%)
- Lot of additional capacity needed for PtG
- 100% RES reached by 2030
- **System cost increases up to 7X**
  - Assume fixed cost for PtG conversion
  - Assume no sales of excess electricity

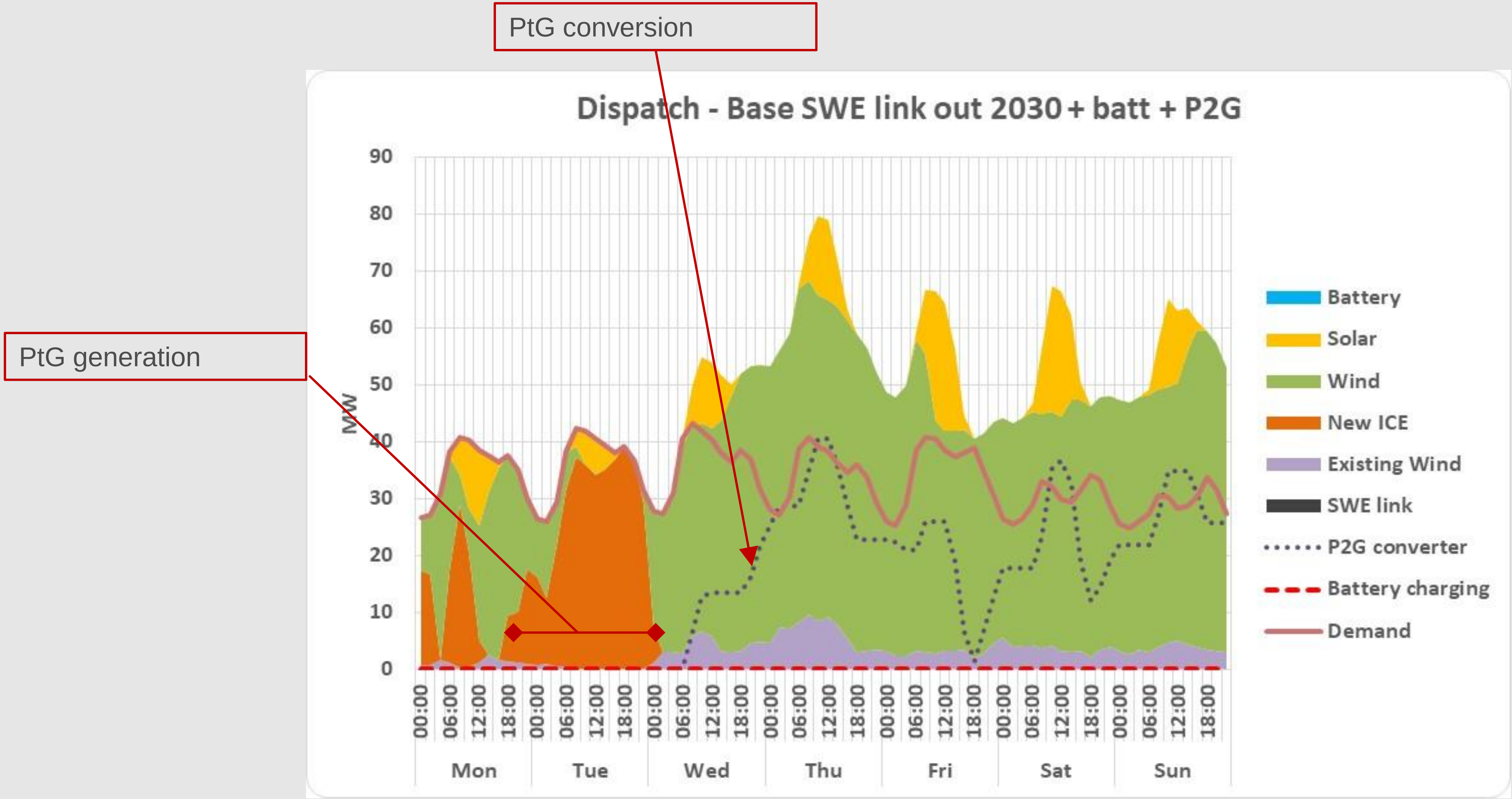






100% RES – EXAMPLE OF DISPATCHING (ONE WEEK IN 2030)

PRELIMINARY



Steps to 100% renewable power system in Åland

- **Step 1**: RES 50% is the optimum from cost perspective, and achieved by just adding wind and some curtailing
- **Step 2**: ”Forced” RES 80% achieved by curtailing wind --> system cost increases 50–100%
- **Step 3**: ”Forced” RES 100% achieved with PtG --> system cost increases up to 7X
  - Cost development of PtG technology not known yet
- **Note.** Selling curtailed electricity to Sweden (or Finland) could improve the business cases significantly

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