Åland Smart Energy Platform

Feasibility study May – August, 2015

kraftnät åland

åea Ålands Elandelslag

Marlehamns ELNÄT

MARIEHAMNS energi

ALLWINDS

HÖGSKOLAN PÅ ÅLAND

Open your mind. LUT.
Lappeenranta University of Technology

VTT

TAMPEREEN TEKNILLINEN YLIOPISTO

ABB

WÄRTSILÄ

EMPOWER

Fortum

CLEEN
Cluster for Energy and Environment

ÅTC Ålands Teknologicentrum
ÅLANDS LANDSKAPSREGERING

Ålands landskapsregering

Contents

- Vision, targets and future challenges
- Uniqueness of Åland
- Demonstration platform
- Summary and conclusions

VISION, TARGET AND FUTURE CHALLENGES

Key idea of the demonstration platform

Demonstration platform of

smart energy system to enable

fossil free energy system

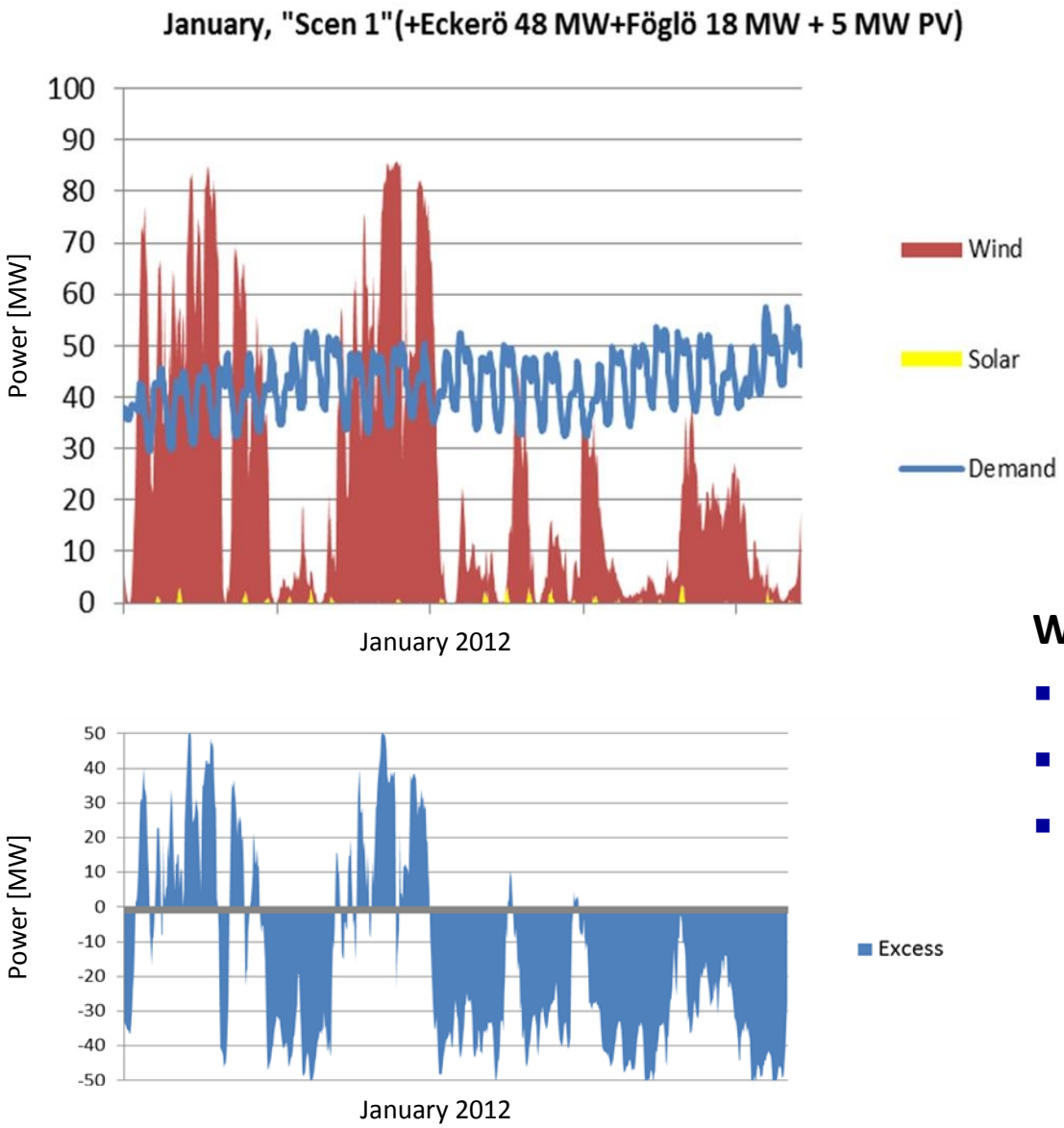
delivering customer value

Åland Smart Energy Platform - Target

Platform for demonstrations enabling 100 % renewable energy system

- **How to solve the challenge**: Fundamental change in power system operation
  - From variable loads to variable generation
  - Increase flexibility by novel technology, management and design principles by cost efficient solutions
- **Holistic viewpoint**
  - Not about finding one silver bullet but connecting all solutions to study interactions of solutions
  - All energy sectors, actors and technologies are linked together to increase flexibility
- **Leverage of unique local advantages**: Small enough local system, agility, all actors
- Stakeholder value. **Upscaling in global markets**.

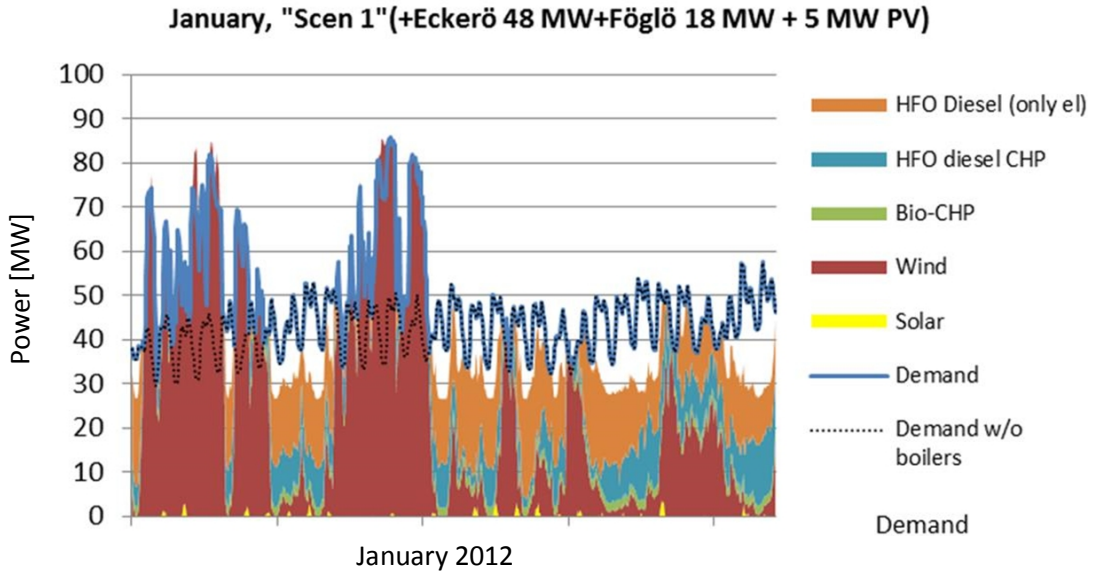
Challenge - Ways to manage excess and deficit energy

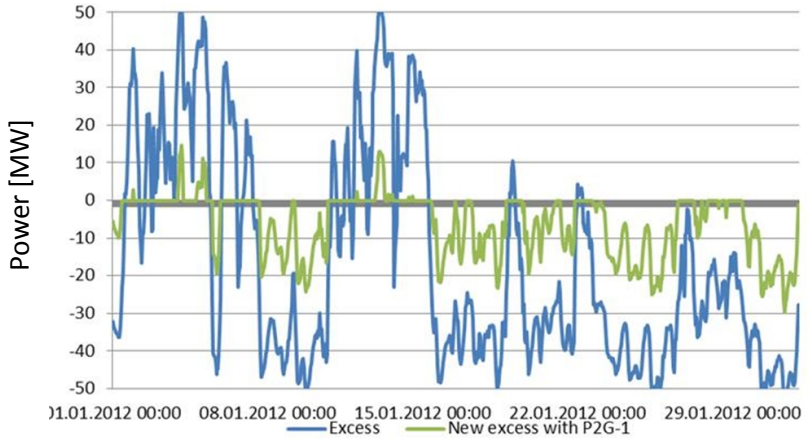


Wind + PV exceeds demand annually:

- During 2670 hours
- Max 57 MW
- 53 GWh

Example of heat and gas mitigating excess energy





Excess electricity

- With diesel CHP generation and
- only el generation
- And exemplary P2G generation (30 MW, 34292 MWh annual electricity use)

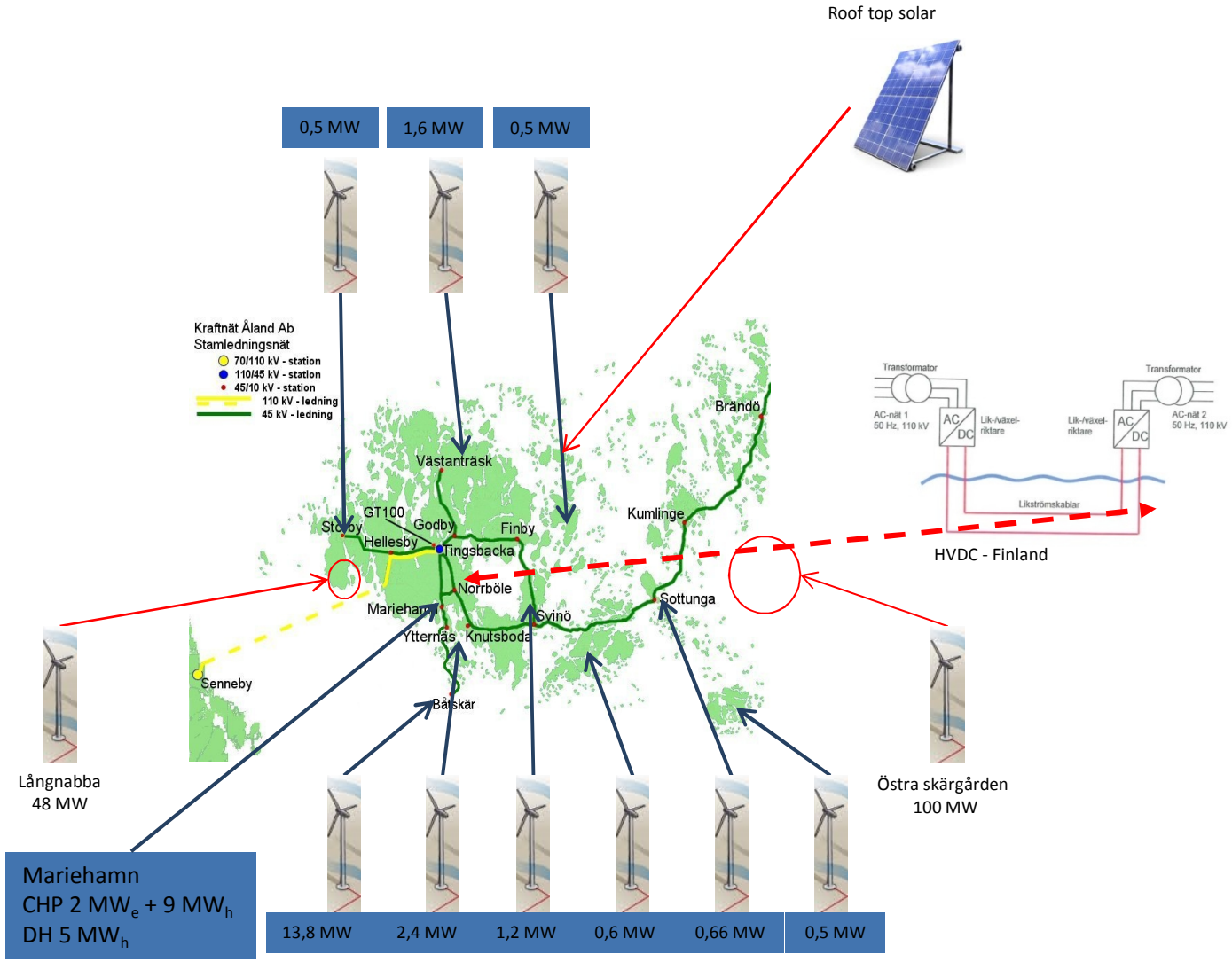
Challenge - Market design for 100% RES

Market is enabler - How to design flexibility promoting market for an area with 100 % renewable energy?

- Key research questions worldwide
  - How to promote **optimal cross-border energy flows**
  - High share of RES => **need and high value for flexibility** => requirement for **novel energy market design**
- Related issues that need to be considered
  - **Network tariff structure** – needs and possibilities for novel tariff design
  - **Incentives for customer participation**, sharing of costs and benefits
  - **Role of stakeholders and conflict of interests**; customers, TSO, DSO, retailers, aggregators, new market players from other domains?
  - **Role of microgrids / energy communities** from market perspective
  - **Role of CHP, gas and heating** (district heating, heat pumps, electric heating)

UNIQUENESS OF ÅLAND

Åland energy system

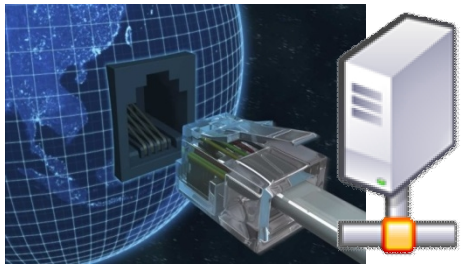


Platform to test solutions for managing high renewables energy system

Market design

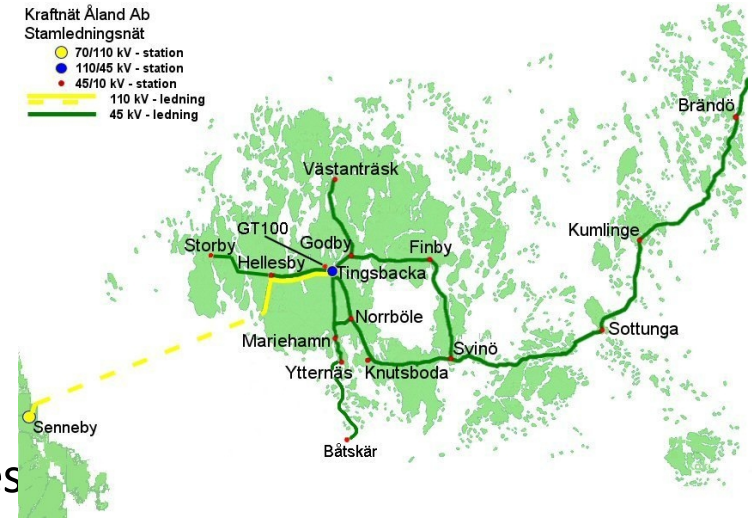
Smart charging of EV

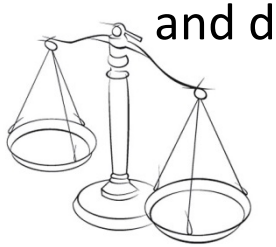
Smart homes and PV



System management and design

Microgrids
Energy communities





Balancing

Distribution automation

Storage

Power to gas

Aggregator

Controllable loads and energy efficiency

Advanced monitoring

Åland – unique possibilities for becoming world leading smart energy platform

Linking separate technology demonstrations to collaborative system wide demonstrations by different industrial actors

- **Small but large enough system**
  - Whole value chain of energy system presented in Åland
  - Enabling different flexibilities simultaneously, studies of synergy benefits and conflicts
  - Future challenges already visible in Åland
  - Organization of demonstrations easier thanks to tight co-operation
  - System level impacts of demonstrations do not require enormous investments compared to large systems
  - Customers can be involved in system level issues and whole value chain
- **Linking electricity with heat, and gas options**
  - Bioeconomy options
  - Electric boilers, heat pumps and heat storages
  - Transport sector: electric vehicles, power to gas options

Åland – unique possibilities for becoming world leading smart energy platform

- Electricity markets
  - Situated **between two price areas,** opens for cross border trading and additional flexibility
  - **Smart market demonstrations options**: active customers, new tariff constructions, capacity mechanisms, real-time markets
- Energy production
  - The share of **renewable electricity production is already significant** and plans to significantly increase it exists
  - **Potential for bioenergy production**
  - **Heating and transportation sectors** require shift from fossil to locally produced renewable energy
- Energy delivery
  - **Islanding** possibility
  - **Constraints** in physical infrastructure
  - **District heating and electricity network overlap** in Mariehamn, no gas infrastructure at the moment

Åland – unique possibilities for becoming world leading smart energy platform

- Energy usage
  - Mostly residential → **Willingness to participate** in demonstrations is expected to be high
  - **Potential for creating communication channels to consumers and prosumers**
  - Many **potential areas for microgrids and energy communities**
- Digitalization of the electricity system management
  - Holistic **distribution network automation** testing site
  - Aggregator / Flexibility operator / Microgrid (Energy community) / Home **energy management testing possibilities**
  - Possibilities for becoming **test site of datahub functionalities**
  - **Testbed for 5G, etc. communication network and services** utilizing these networks

Interest to demonstrate - examples

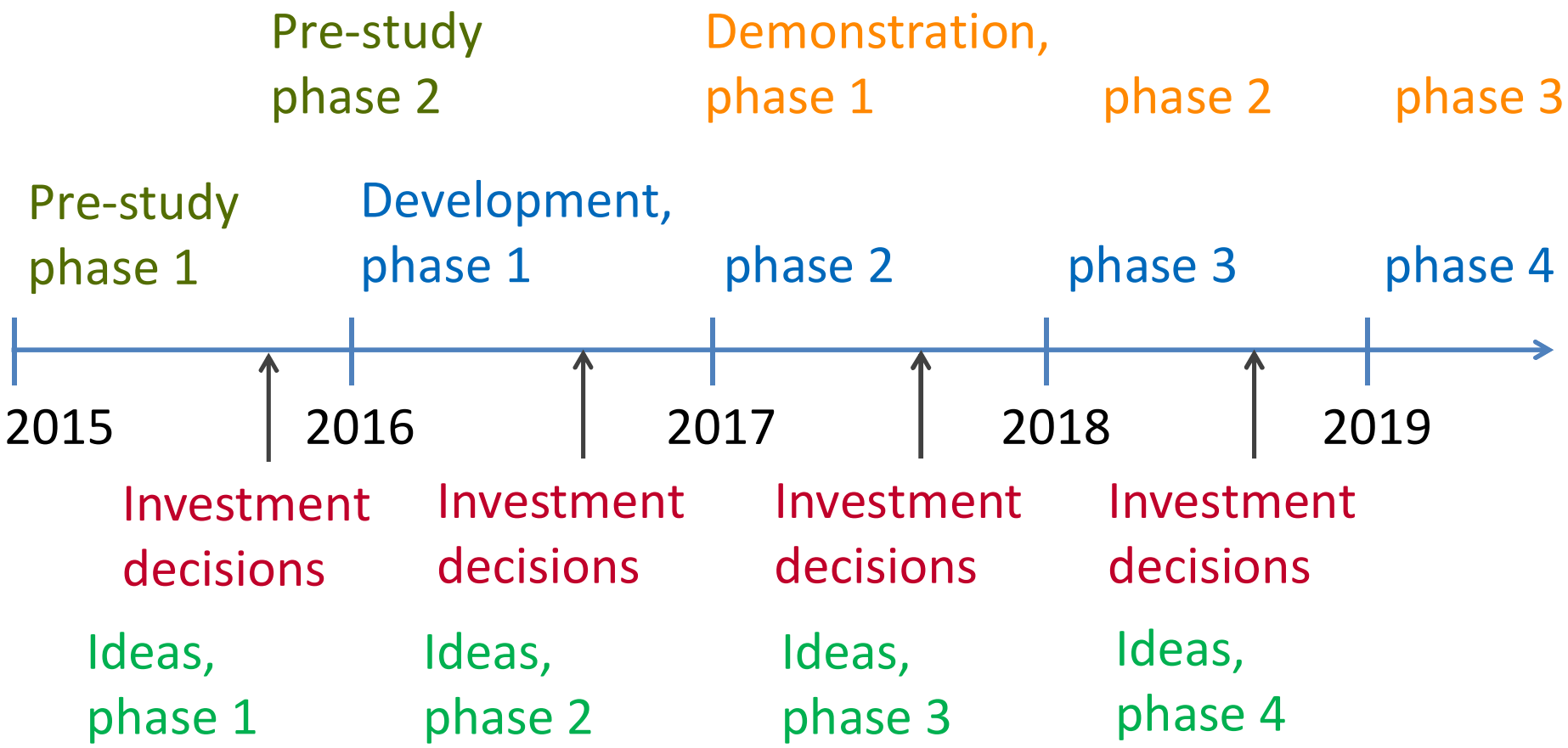
Company	Technologies	Functionalities
Fortum	• Electric vehicles: EV charging infra, energy metering for EV, information transfer • Electrifying ferries and boating • Large battery storage (>1 MWh) in conjunction with wind/PV	• Utilising the data • temporary EV battery usage for the grid • Benefit of battery storage and PV electricity • Balancing / Frequency regulation
EMPOWER	• Energy market information management hub	• Electricity market operation practices and processes
WÄRTSILÄ	• ”Synchronous condenser” option to provide electricity and stability in disturbance situations • LNG terminal / distribution • Biogas liquidification plant for fuel distribution	• Gas engine as reserve power • Ensuring gas fuel for consumers (until biogas/power2gas options self sufficient)
ABB	• Smart apparatuses for MV, substation automation and SCADA/DMS • Microgrids (for LV and MV networks) • PV power plant (~1MW) • Residential PV for public and private houses (interconnected to LV grid) • Fast EV charging infra • Battery Energy Storage (~1 MW)	• Self-healing distribution grids • Frequency regulation

Examples of currently identified projects/project areas in Åland

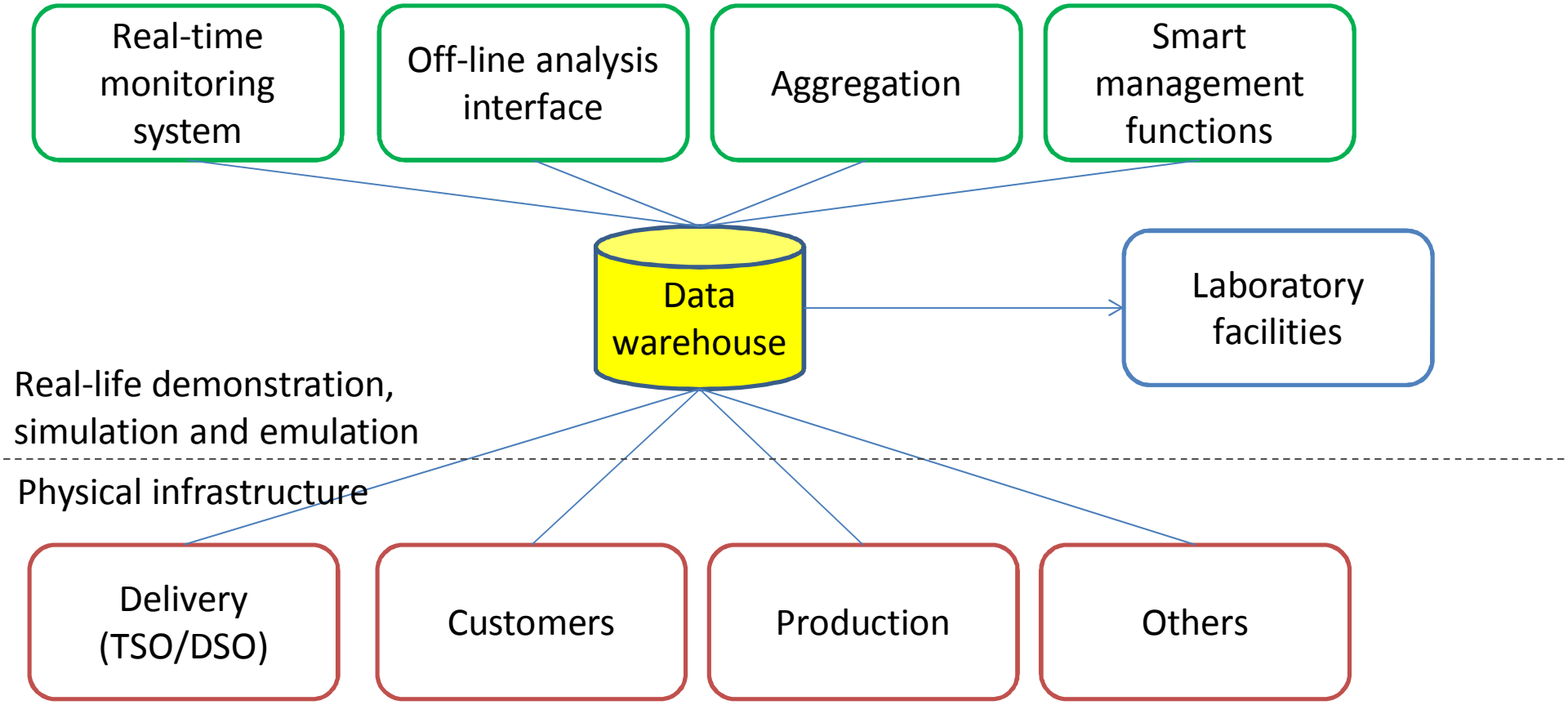
- **Smart homes**: technologies for flexibility / control / services / new business possibilities
- **Smart Grid**: advanced distribution automation, self-healing network, network congestion management, island operation
- **Smart production**: technical, economical viability, new system services/requirements
- **Power system management**: Balance management and secure operation of very stochastic system
- **Electric vehicles/transport**: Private / Bus / Local line ferries / Local ground transport
- **Energy efficiency and modernisation**: households and enterprises
- **Energy advisory and information**: Build, live, commute
- Realizing **bioenergy** potential as part of holistic energy supply: Forestry sector development, energyplantations as part of environmental protection zones, future biogas options...

DEMONSTRATION PLATFORM

Modular open design proposed to enable implementation over time



Utilization of data for demonstrations and operations



Phase 1 of the platform

- Collect data from existing IT and automation systems
- Store data to data warehouse
  - System wide data from real system
  - Collection and storing data from demonstrations
- Utilization of data in real-life demonstrations, simulations and emulations
  - Identification and modelling of new phenomena
  - Testing of novel functionalities and their interactions
- Example of laboratory facility: Real-Time Digital Simulator
  - Åland power system model in RTDS
  - Protection, control and management actions within hardware and software-in-the-loop simulation
  - Simulation scenarios based on real-time data or historical events
  - Simulation of communication issues

Costs of platform (phase 1, 5 years)

- Fixed costs
  - IT equipment
  - Automation equipment

  ~ 0.5-1 M€
  - Upgrades/modifications of interconnection devices of RES and DER
  - Power system hardware: production units, grid components, etc.
  - Show room: real and virtual capabilities ~ 100-200 k€
- Variable costs
  - Active customer (DER) incentives
  - Communication services ~ 10-50 k€/a
  - Personnel cost to maintain/develop platform
    - IT person to develop SCADA, etc. systems
    - Contracting, management, etc.

    ~ 200 k€/a

The cost of platform without demo components ~ 2 M€

Demonstration infrastructure costs

- **Final costs come out from investment decisions**

	Investments options supporting platform	Platform cost
Wind PV	Wind farm investments • Eckerö ~70 M€, Sottunga 100-150 M€ Investment cost for rooftop PV • 1 MW by 2018 (1.3 M€) • 10 MW by 2025 (10 M€)	• Production curtailment (1 % means 50 k€ with 30 €/MWh) • Incentive for rooftop PV (e.g. investment subsidy 15-30 % -> 200 - 400 k€ for the first 1 MW) • Extra voltage and frequency regulation capacity • Surveillance and control for flexibility features
Microgrid	Wind + PV + Storages, heat pumps	”Extra cost” of the management system roughly 100 – 200 k€?
Gas engine	• Replacing older plants • LNG storage	• Gas engine 620-650 €/kWe
Storage	• Small-scale battery • Large-scale battery	• 3500 $ / 10 kWh (Tesla Powerwall) not including all components: ~50 k€ for 100 kWh storage to be provided by platform
EV	• More EVs to show visible effects • Public charging points	• Investment incentive • 0.5-1 M€ depending on number and type of charging stations
Distribution automation	• SCADA • DMS • NIS+CIS+MDMS • SCADA communication • Substation automation • IED • AMR meter, industrial meter	• 300 k€ + 10 k€/ substation + 2 k€/ secondary substation • 44 k€ + 2 k€/ substation + 0.5 k€/ secondary substation • 120 k€ + 75 k€ + 140 k€ • 90 k€ + 5.5 k€/ substation • 23 k€ • 8 k€ • 200 €, 600 €
District heating system	• Thermal storage to CHP • Changing fuels (oil to biomass) • Electric boiler, Heat storage	Surveillance and control for flexibility features (thermal storage when excess wind/PV electricity)
Heat pumps		Surveillance and control for flexibility features (controlling of heat pumps / heat demand)
Biogas and Power2gas	Small/scattered biogas possibilities, support to power2gas with a gas pipelines	Not estimated

Next project: planning of platform

1. **Specification and implementation plan of platform**
   - Measurements, communication and IT and automation systems
   - Data warehouse and replica of control centre
   - Laboratory facilities (real-time simulators)
2. **Specification of detailed demonstration areas and functionalities including investment plan**
   - Selection of functionalities to be demonstrated in first phase
   - Simulations of scenarios and functionalities
     - Cost efficiency of options throughout the energy system
     - Optimized scheduling of flexibility services (KOPTI VTT)
     - Analysis of pathways towards 100% RES, support for target setting (EnergyPlan LUT)
     - How to get stakeholders involved? (incentives, sharing of costs and benefits)
     - Market simulation model specifications
     - Grid impacts
   - Feasibility analysis of possible demonstration areas (urban/rural, strong/weak, large/small)

Next phases of demonstration platform

Platform to analyze the interaction of technologies and functionalities

- **Energy management of**
  - Prosumers (consumer + producer + flexibility)
  - Energy community (group of prosumers, production, storage and flexibility)
  - Power to heat and Power to gas
  - Retailer portfolio
- **Technical test-beds for technologies and functionalities**
  - Storage
  - Controllable and system friendly inverters
  - Demand response
  - Microgrid
  - Balancing and stabilization
  - Advanced control centre systems, and substation and distribution automation
- **Digitalization test-beds**
  - DataHUB including demand response
  - Communication networks and services
  - Distributed architectures for automation and management

Steps forward

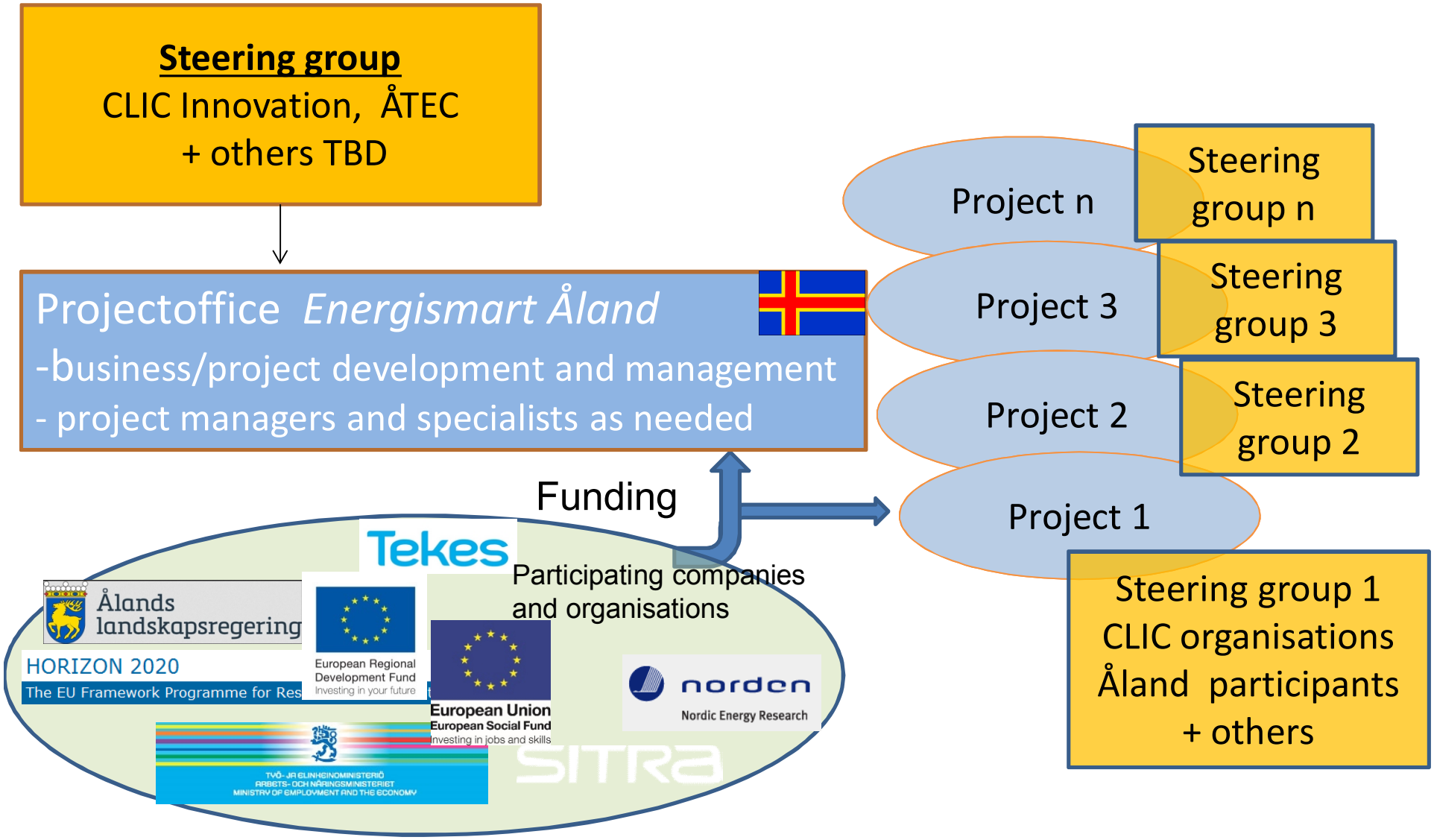
Feasibility and investigations

- **September 2015**
  - Presentation of feasibility results, Mariehamn
  - Åland Energy Portal feasibility study: consumer tools and communication channel, serving platform information needs
- **October 2015**
  - Energy Portal feasibility study evaluation in “energy cluster”
  - EnergyPlan work initiated
  - Planning for demonstrations…
- **December 2015**
  - Energy Plan analysis work by LUT first results

Funding

- **September-October 2015**
  - Apply for funding from Tekes Digital business as well as SITRA
  - Planning for demonstrations
  - Discussion on inclusion in TEM spearhed project, covering both platform and demonstration funding
- **October 2015**
  - Start preparation for application for funding from Horizon2020 LCE call for 2017-2020,
- **April 2016:**
  - Application submission for funding from Horizon2020 LCE call for 2017-2020, demonstrations and supporting R&D

Proposed organization setup for project *Energismart Åland*



Thank you

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