INFRASTRUCTURE SYSTEMS INSTITUTE

Aggregators as digital intermediaries to local electricity markets

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ENERGY TRANSITION #1 - Renewables and flexibility mechanisms

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CATAPULT Energy Systems

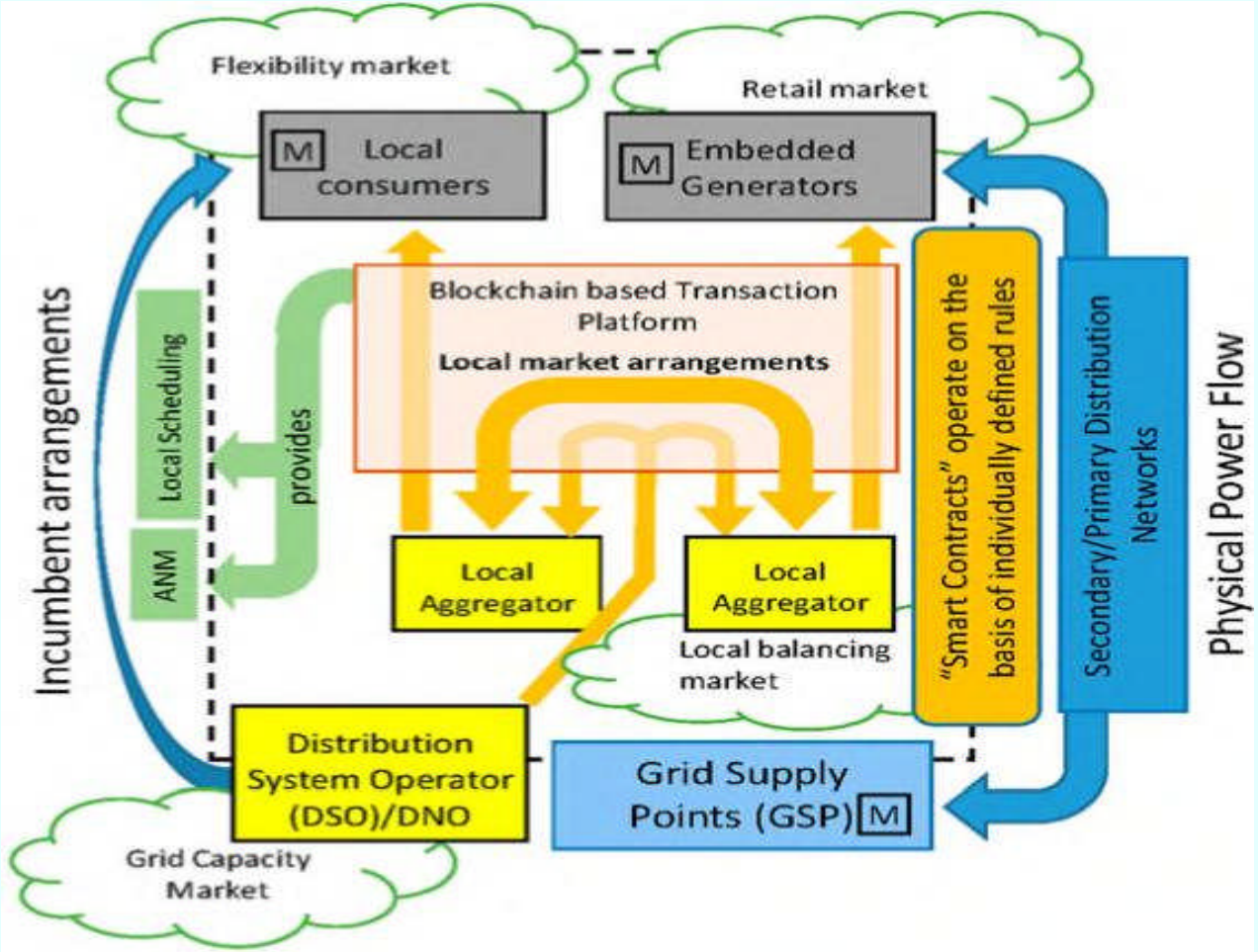
Aims

- **Decarbonise the energy system by using micro-scale renewable energy assets and vehicle to grid technologies**
    - **To reduce grid energy demand**
    - **To prepare for electric vehicle adoption**

Problems to be solved

- Organise a large number of distributed energy assets
- Know the physical network constraints
- Support the energy market to know about demand
- Verify there is a digital aggregation business model

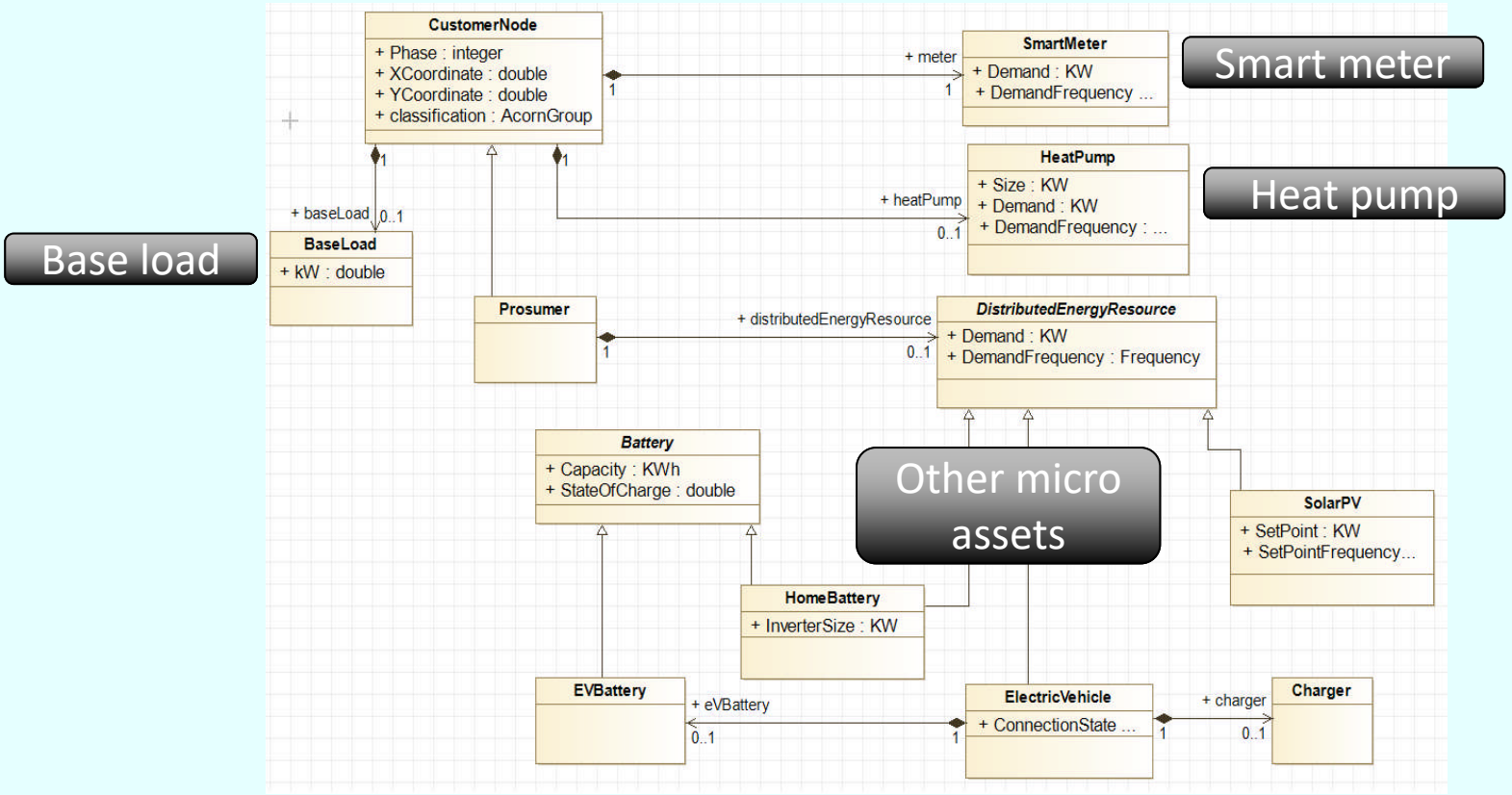
Integrated digital platform



Contract types – aggregator to prosumer

- **Direct coordination:**
  - **bidirectional aggregator-to-agents communication**
- **Incentive signals:**
  - **unidirectional communication and indirect control**

UML representation of DERs offered by prosumers



Agents as assets characterisation

- **Challenge:**
  - **Characterise prosumers and their assets (flexible and inflexible)**

- **Methods:**
  - **linear state-of-charge model to construct constraints for optimisation algorithms**
  - **distributed convex optimisation algorithms such as alternating directions method of multipliers (ADMM) (Morstyn, Hredzak, and Agelidis 2018)**

Low-voltage feeder congestion

- **Operationally:**
  - actual history of network congestion
- **For generic insight:**
  - Probabilistic approaches on 3 phase low voltage network
  - Scenario based approaches for low carbon technologies' diffusion
- **Load forecasting:**
  - Widely applied to aggregated national demand
  - Gap on forecasting individual prosumer demand

Network congestion heuristic

- **Challenge:**
  - Estimate the probability of network constraints (thermal or voltage violations)
  - Estimate adjustments to remove these constraints

- **Result:**
  - Know the sensitivities of each agent to any constraints
  - Make adjustments to the agents based on their impact on the constraints

- **Test scenarios:**
  - A generalised day, e.g. a summer weekend
  - A given forecast, e.g. based on day-ahead or intra-day measurements of demand
  - Different feeders, and networks, from a range of representative feeders
  - A range of micro-assets and ‘agent’ penetrations and clusters

The probabilities of agent adjustments

- The P95 and P5 represent 95th and 5th percentiles of the aggregated adjustments required by the network operator to relieve constraints for the sampled half hours

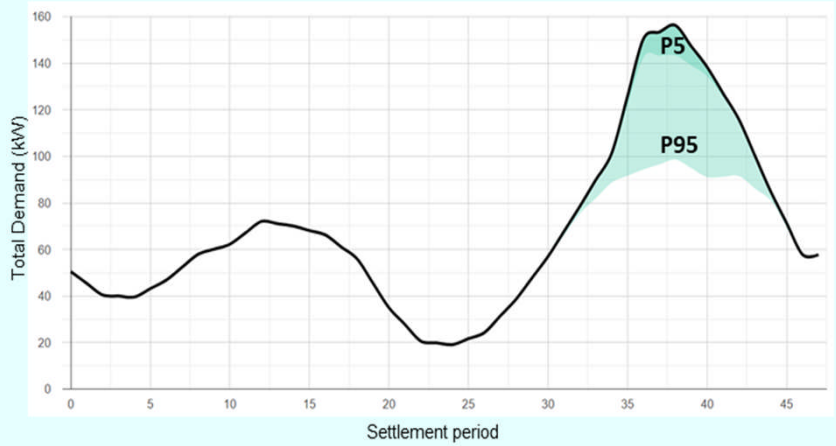


Figure: Probability of total agent adjustments (**kilowatt**), for a typical winter day based on simulation of 90 winter days, with **100%** of homes having solar panels and electric vehicles

Conclusions

- **High fidelity low voltage network and agent population:**
  - Coherence of solar energy generation and weather
  - Uncertainties of electric vehicle charging (not always from home)

- **Agent and Network optimization:**
  - Ready for market integration and aggregator business model verification

- **Quantification for various scenarios:**
  - Indication of the number of kilowatt per agent and half-hour period
  - Estimation of the value of flexibility for local communities

Thank you for your attention