Future tamper-proof Demand response framework through self-configured, self-optimized and collaborative virtual distributed energy nodes

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DELTA Project Identity Card

Future tamper-proof Demand response framework through self-configured, self-optimized and collaborative virtual distributed energy nodes

- H2020 Call:**H2020-LCE-2016-2017**,
  - Topic:**LCE-01-2016-2017**

- Funding Instrument: **RIA** (Research and Innovation Action)

- Duration: **36 Months** (Started on 1 May 2018)

- **10 Partners** from **8 countries**

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DELTA Vision & Concept

A new energy distribution structure

Today

- Demand Aggregators having DR contracts with large customers/businesses
- Inconvenient, semi-automated explicit DR
- Unreliable implicit DR
- Single-point, Centralized Management of Assets
- Fragmented standards/protocols for building monitoring & control systems

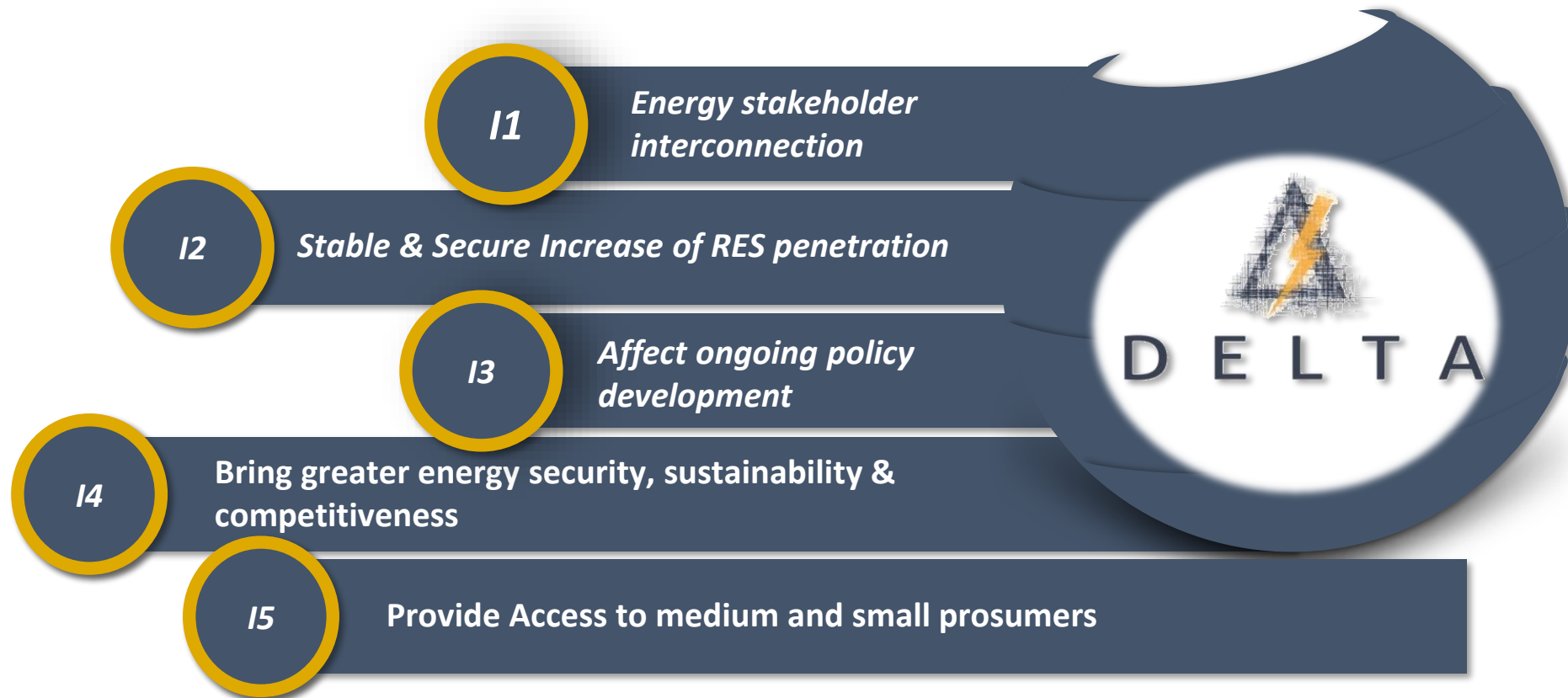### Tomorrow

- Exploit the untapped flexibility of small/medium prosumers, through a **novel, secure DR Management Platform**
- Ease Aggregator's computational effort through a **distributed intelligence** Architecture
- Engage prosumers in both explicit and implicit DR through a **social collaboration and incentivization platform** and personalized interfaces
- Achieve end-to-end interoperability through using/extending **open source protocols** (e.g. OpenADR)
- Propose new **business models** and **recommendations for policy makers** to accelerate market adoption
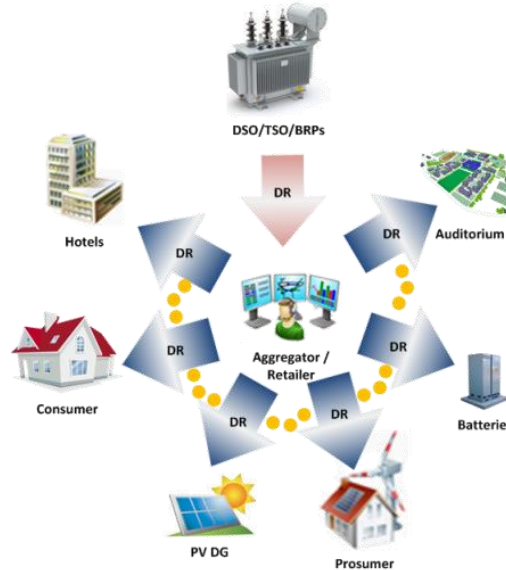
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DELTA Impact

I1 Energy stakeholder interconnection

I2 Stable & Secure Increase of RES penetration

I3 Affect ongoing policy development

I4 Bring greater energy security, sustainability & competitiveness

I5 Provide Access to medium and small prosumers

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DELTA Vision & Concept

## A new energy distribution structure (II)

Objectives

- Relieve Aggregators from resource-intensive tasks: **DELTA Virtual Node**

- Establish an automated, efficient DR management structure: **DELTA DR Management toolkit/ DELTA Fog-enabled Device**

- Simplify and fortify complex energy contractual agreements: **DELTA Blockchain**

- Enrich Aggregator's Portfolio by engaged Small/Medium prosumers: **DELTA Collaboration Platform and Award enabled services**

Key Enablers

Current DR in the GRID

DELTA DR Framework

Key Innovations
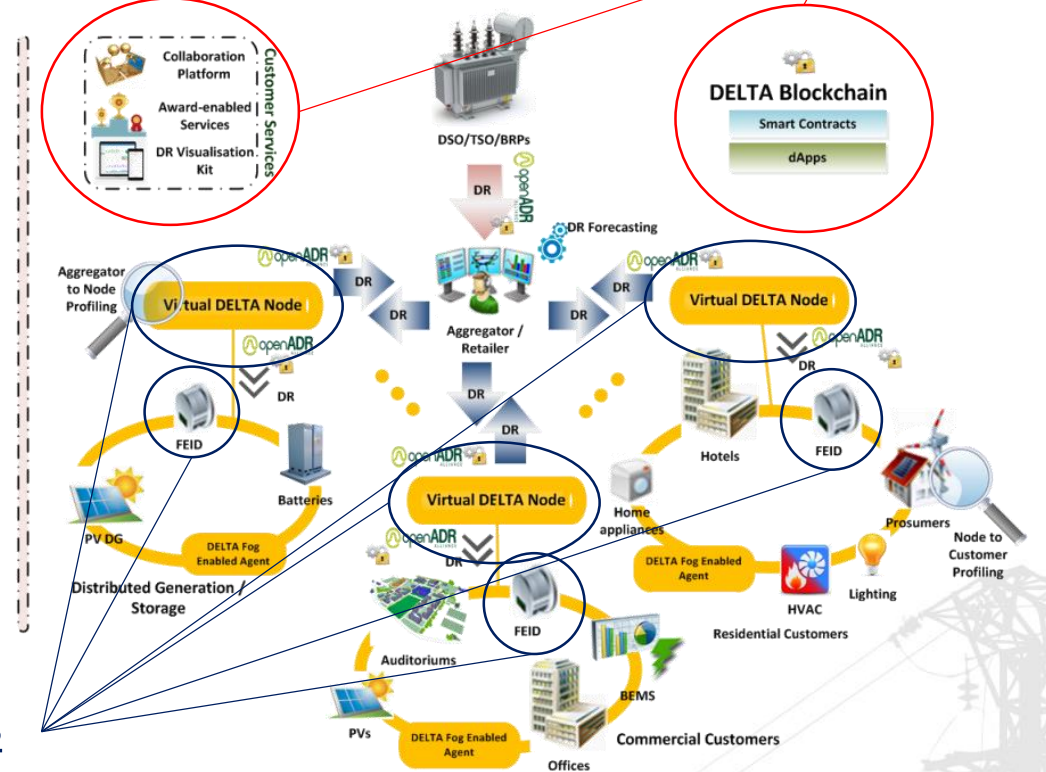
DELTA Customer

- Implementation of a Novel powerful toolkit to empower small end medium customers to participate in DR programs:

  - **Lightweight** edge computing

  - **Hardware Security** (TPM 2.0)

  - Direct **Communication** with multiple Wired and Wireless protocols

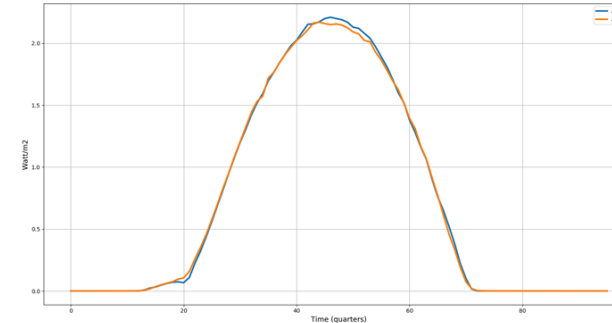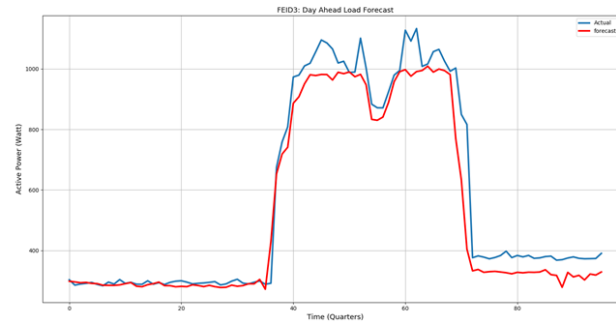 - **Interfaces** for communication with Smart Meters, BMS, EMS

  - openADR compliant
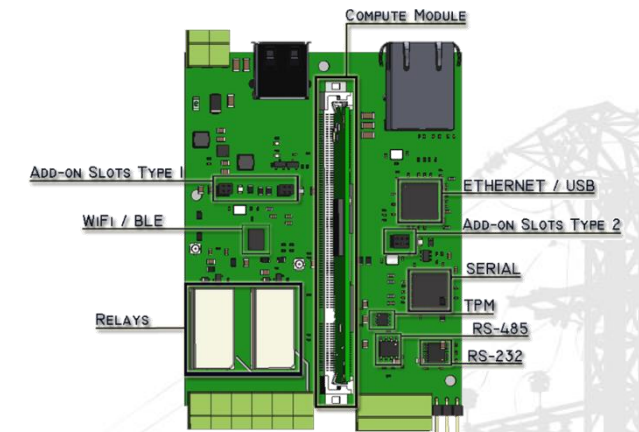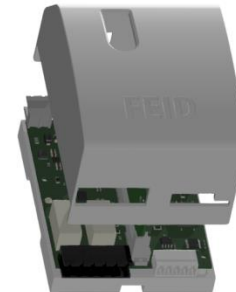
DELTA Customer

- **Adaptive Load and PV forecasting** engines

Algorithm : Extreme Gradient Boosting		Execution Time : 5 seconds
MAPE (%)	SMAPE (%)	RMSE (W)
8.08	4.31	73.66

- **Cutting Edge Flexibility Estimation**
  - Combination of unsupervised (flexibility patterns identification) and supervised (detection) models
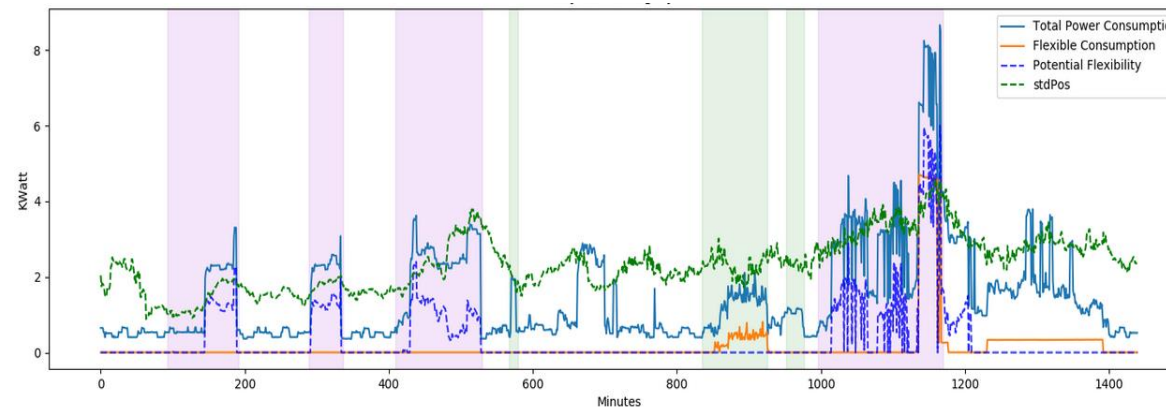
DELTA Virtual Node

Following the Virtual Power Plant (VPP) Principles

- Multi-Agent Design that offers a **highly robust DR management**
  - Internal **Clustering** of customers based on adaptive characteristics
    - Flexibility, Availability, Reliability, ...

  - Cross validation on load/pv forecasting through individual and aggregated results

  - Intelligent **Optimal Dispatch** and **Fail-safe mechanisms** to ensure DR success
    - Introducing **Flexibility** as a **virtual Distributed Energy Resource** for optimization problems

    - Efficient Intra and Inter – DVN communication to **early identify shortcomings** and deliver requested DR **in real-time operation**.

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DELTA Virtual Node

Example of application

- VPP formed of 25 customers

- DR signal:
  - -20kW for the time window 15:00-15:30

- Optimisation Engine
  - C-id007, C-id008, C-id013, C-id014, C-id017, C-id020

- Failure of C-id020 at 15:11
  - safety valve 1 -> Inter

- Failure of C-id017 at 15:20
  - safety valve 2 -> Intra

- **DR Completed successfully**

Scenario 3: OptiDVN + Intra + Inter + Intra
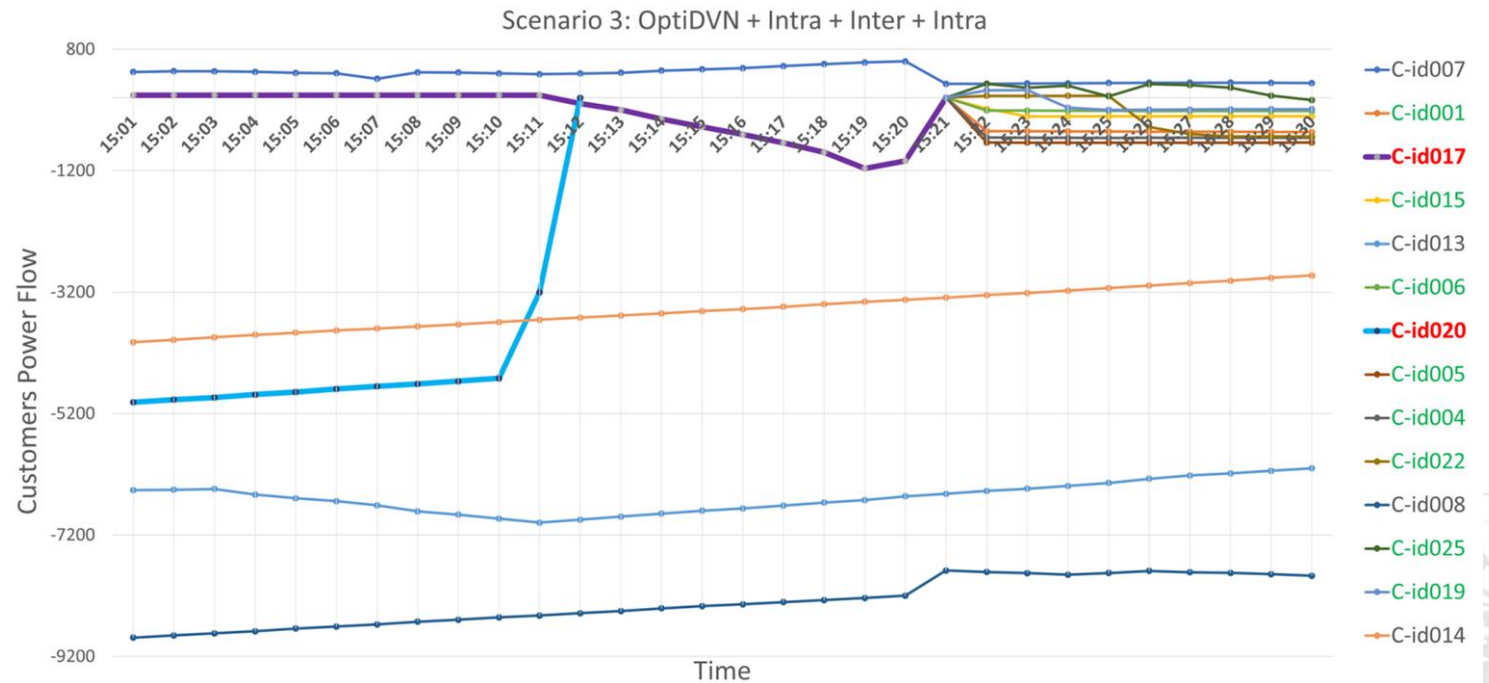
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DELTA Virtual Node

- **Faster execution times** between rule-based and optimisation engines
  - can be considered most pertinent for such MAS-oriented resilient applications, especially when scaling up to hundreds, or even thousands of customers.

- **Significant profit margins** - up to 3 orders of magnitude higher in some cases.

- **More fair** and **balanced** utilisation of customer assets, compared to greedy algorithms.

- Combining customer clustering with the optimization engine **becomes better as the VPPs increases in size** (large customer portfolio).

- The proposed scheme provides a **2-point-tolerant system**, a specification far above the standard in power systems communities (1-point-tolerance).

D E L T A

DELTA Aggregator

- **Efficient**, **automated**, and **dynamic** Aggregation of Small and Medium customers
  - Handling each DVN as a larger customer

- **Intra-day** and **Imbalance** markets' **price forecasting**
  - Improved bidding and potential increase in revenues

- Unobtrusive collaboration with DSOs for ensuring **Grid Stability**

- Dynamic **optimization** based on spatiotemporal characteristics, DVN Reliability and Fairness.

- **Gamification** and **collaboration** (i.e. forum) **services** for enhanced end-user engagement
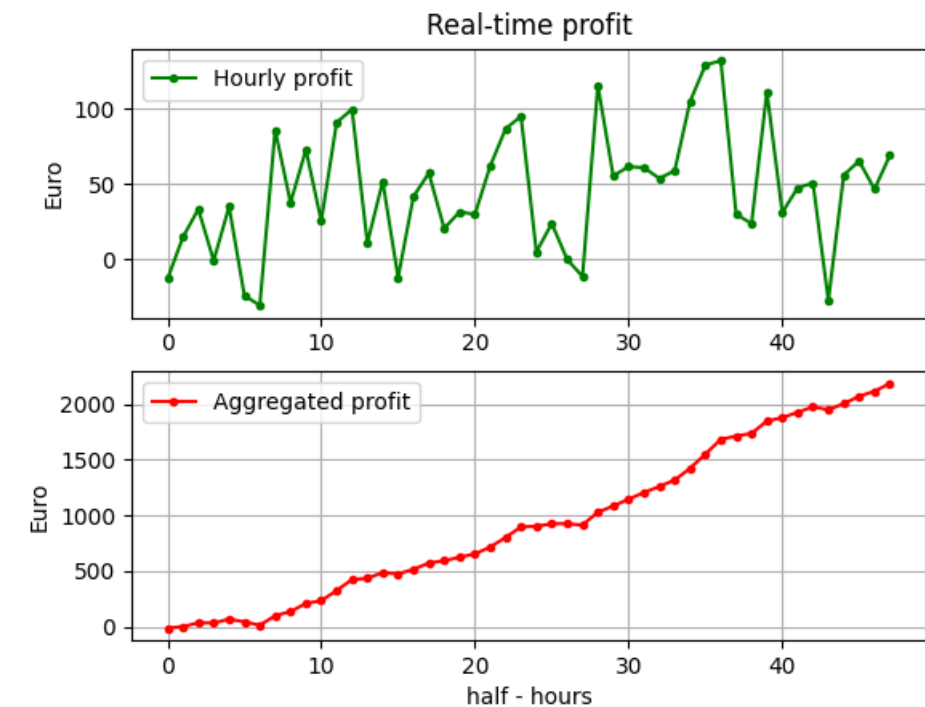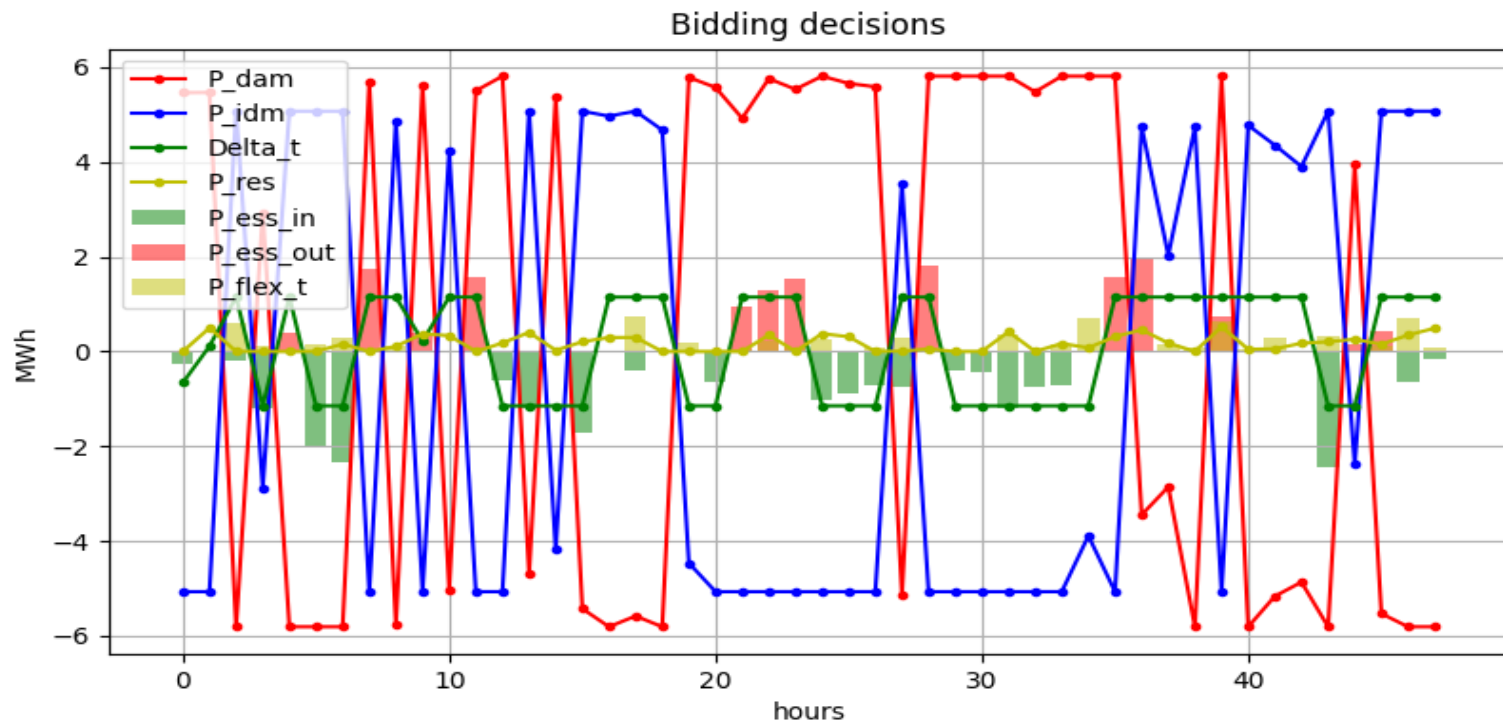 - DR Games, Collaboration Games, Vouchers, etc.

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DELTA Aggregator

Objective is to maximize the expected profit:

$$minimize \; -\sum_{s=1}^{N_s} \rho_s \cdot \left(\sum_{t=1}^{T} \left(\beta_{s,t}^{dam} \cdot P_{s,t}^{dam} + \beta_{s,t}^{idm} \cdot P_{s,t}^{idm} + \lambda_{s,t}^{im} \cdot \Delta_{s,t}^{im}\right)\right)$$

Bidding decisions

Real-time profit

Day-ahead Market   **Intraday Market**   **Imbalance Market**

DELTA Aggregator

Optimization of incentive-based flexibility exploitation

Learning period = 60 days + Evaluation period = 30 days. 90 days = 90 * 48 = 4320 episodes

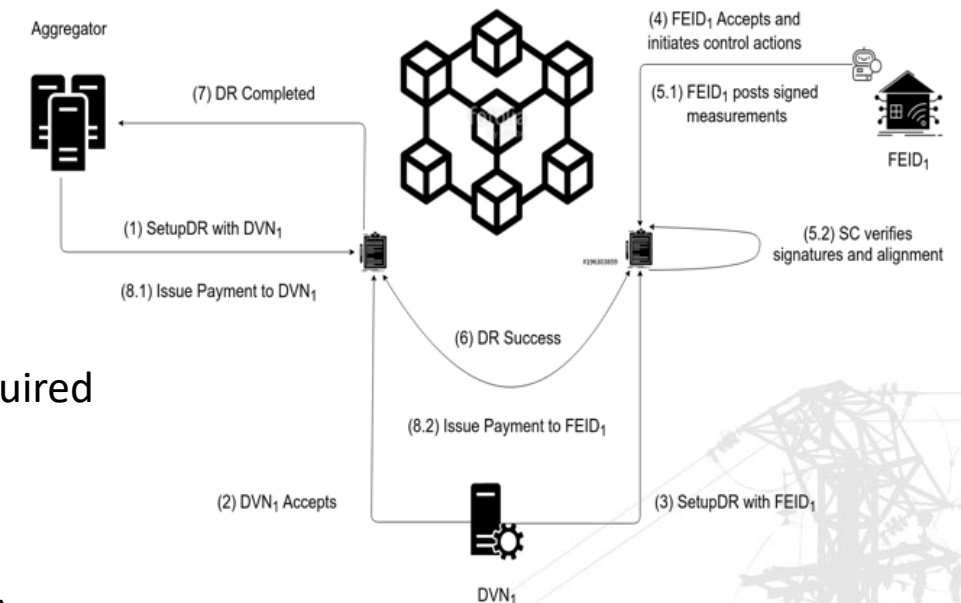

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DELTA Blockchain & Smart Contracts

Verifiable and Automated DR Transactive Framework

- **DELTA's Permissioned Blockchain**
  - HyperLedger Fabric
    - Consortium: Aggregator, large industrial clients, external auditors etc
  - Distinct roles: Aggregator, DVN, FEID etc
  - Fine-grained data access control policies
  - Privacy & anonymity of transacting parties
  - Logging measurements & tracking of energy supply chain

- **OpenADR smart contracts**
  - Automated, digital agents that encode, monitor and enforce arbitrary agreements among stakeholders
    - Computer-to-computer agreements, no human intervention required
  - Monitoring & regulation of energy supply
  - Financial settlement: earnings & penalties
  - Smart contract templates for each particular use case, e.g.:
    - Time-of-Use tariffs (Implicit) and/or Direct Load Control (Explicit)

DELTA Pilot Deployment

UK Pilot – Residential and Commercial Buildings

Cyprus Pilot – University of Cyprus Campus

Pre-pilot lab testing – nZEB Smart Home of CERTH/ITI

Feedback from the experts

Markets & Products Poll

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next-level Demand Response
https://www.delta-h2020.eu/

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Questions?

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