CONCERTED ACTION
ENERGY EFFICIENCY
DIRECTIVE

CA EED Workshop on Data Centres and Energy Efficiency

Catalyst

Converting Data Centres in Energy Flexibility Ecosystems

CATALYST Project Overview

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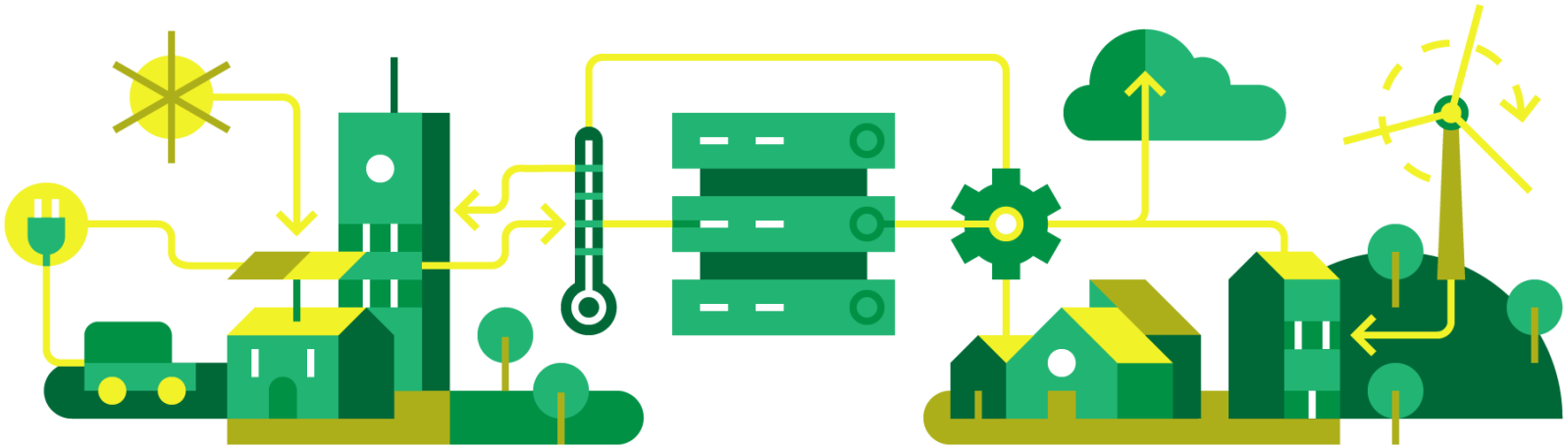
H2020-EE-2017-20
Innovation Action
Grant Agreement no:
768739

Data Centres can and should offer energy flexibility services to their smart grid and district heating networks



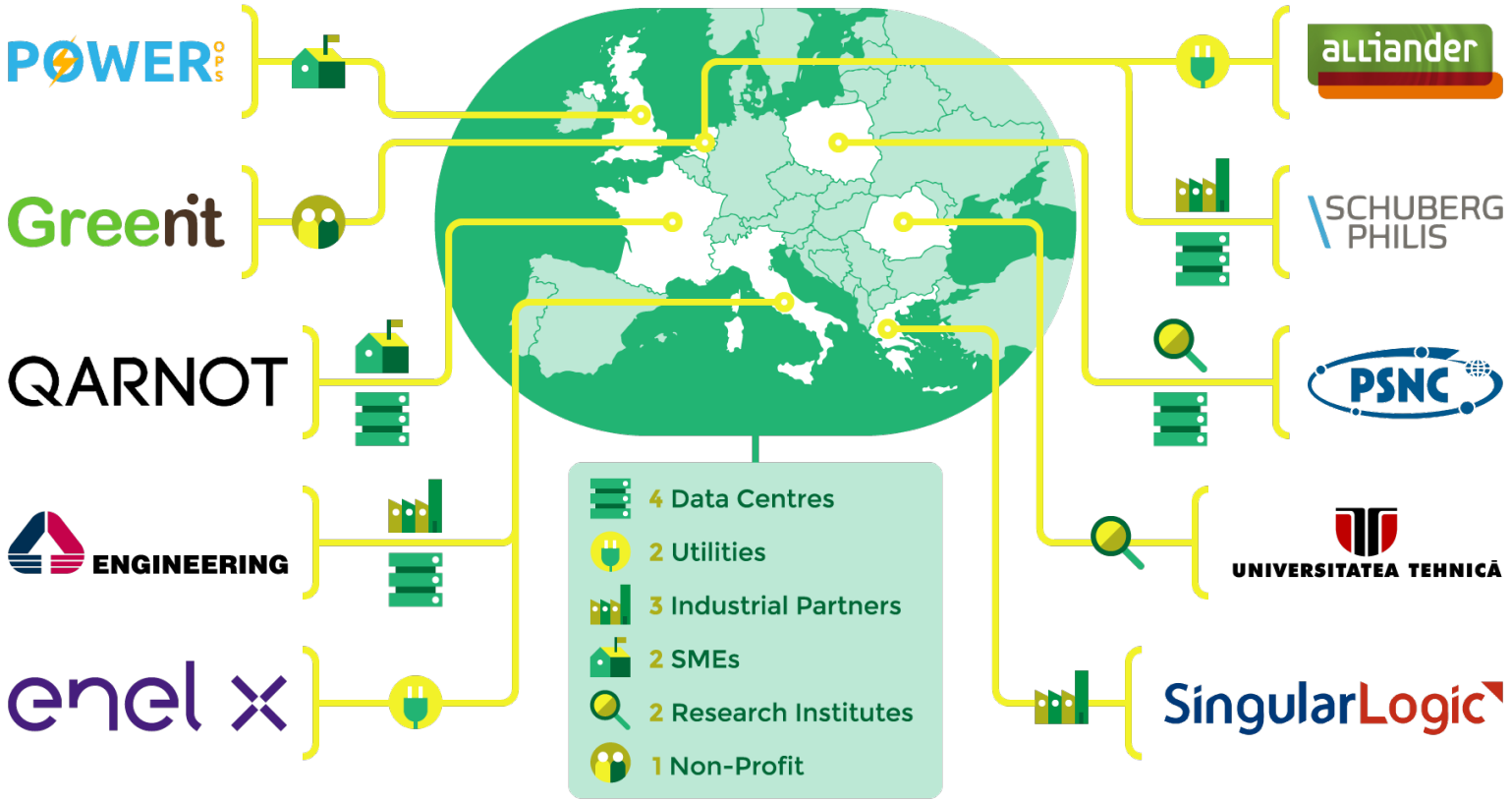
At a glance

Converting Data Centres in Energy Flexibility Ecosystems

H2020-EE-2017-20 Innovation Action

October 2017 – September 2020

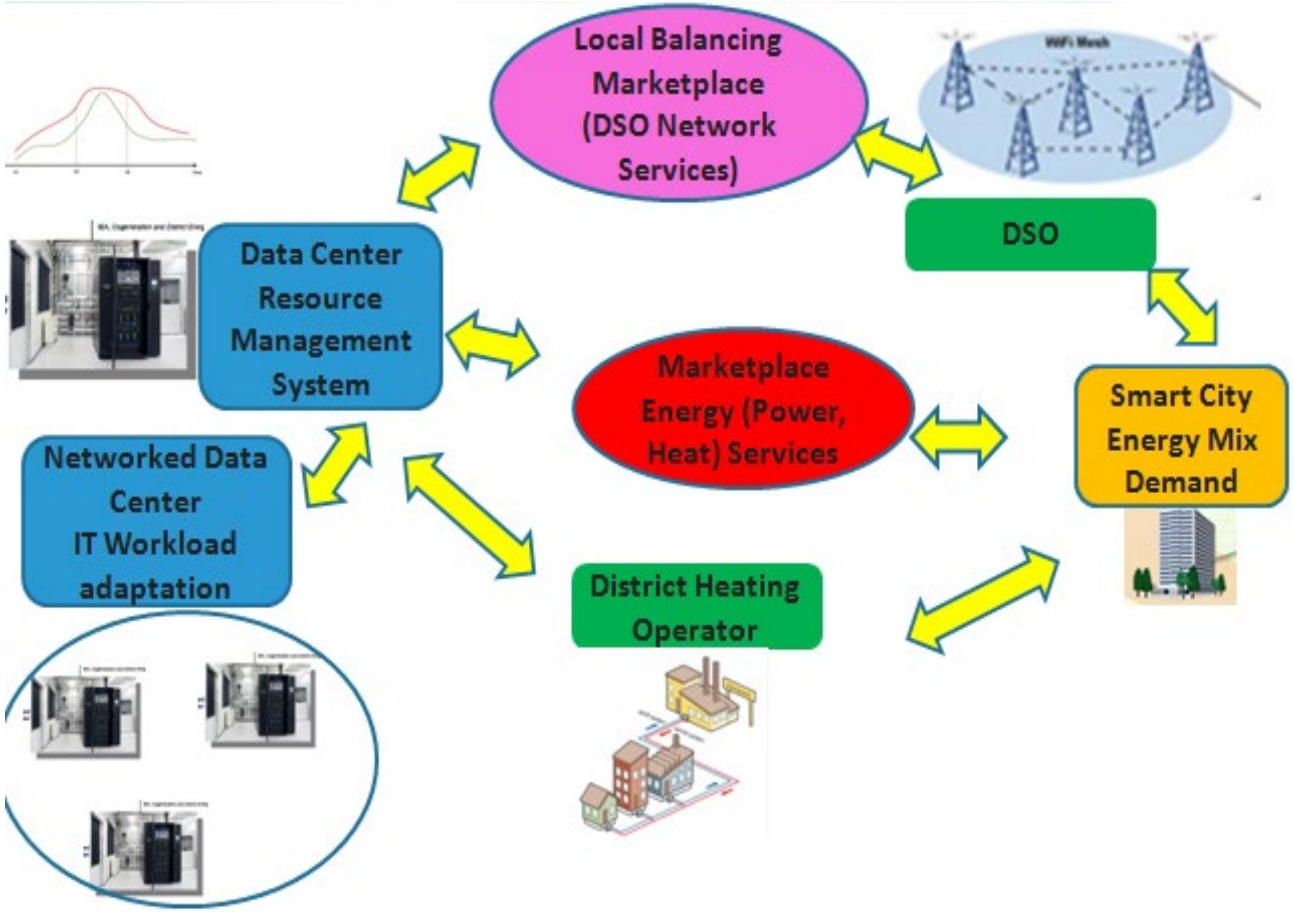
2.982.805 Euro (EU 2.299.103,5 Euro)



The Vision

- The **CATALYST vision** is to turn **data centers** into **multi-carrier hubs**
  - at the ***crossroads of smart electricity grids, district heating networks and IT/Data networks***
  - able to
    - *exploit and manage the **latent flexibility** and hence deliver **system-level multi-carrier flexibility services***
    - *hence gain **multiple revenue streams** from the respective grid operators*
- **Envisaged multiple revenue streams for data centers are the key to speed up waste heat reuse, while facilitating integration of renewable energy and energy efficiency improvements** (such as optimal management of IT workload, novel yet more efficient cooling)

Concept


Local Balancing Marketplace (DSO Network Services)
DSO
Data Center Resource Management System
Marketplace Energy (Power, Heat) Services
Smart City Energy Mix Demand
Networked Data Center IT Workload adaptation
District Heating Operator

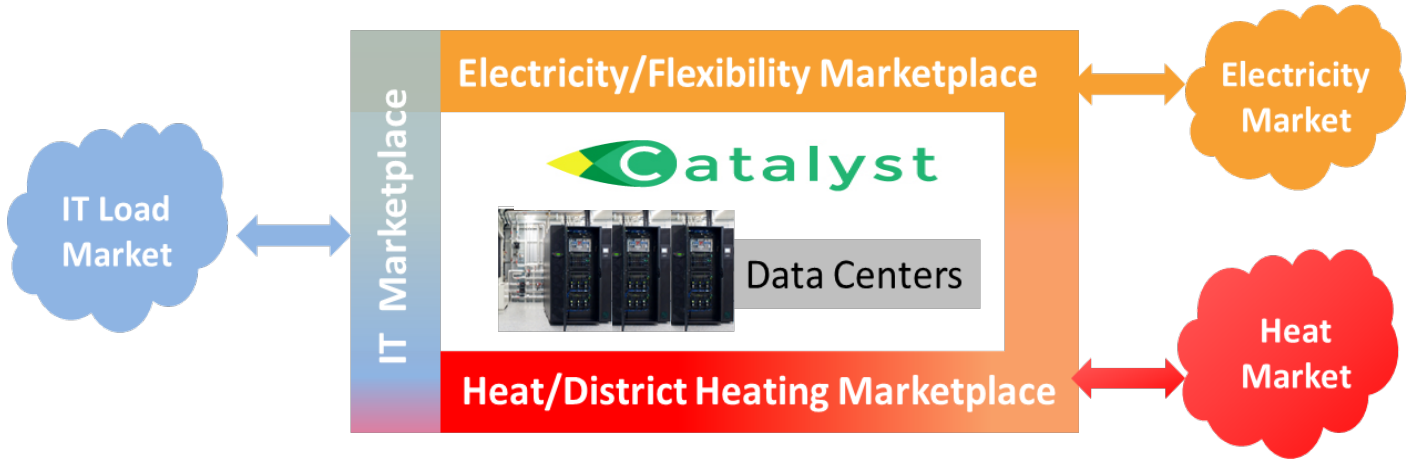
Marketplace as a Service

CATALYST vision introduces a ***"Marketplace as a service" (MaaS) concept,*** instantiated in three emerging and innovative DC revenue streams/markets:

a) the ***Electricity/ Flexibility marketplace*** between DCs and electricity stakeholders (ranging from Smart Grid owners/operators to end-user prosumers with non-grid owned RES/DES) to trade electricity generation, storage, resiliency and flexibility services;

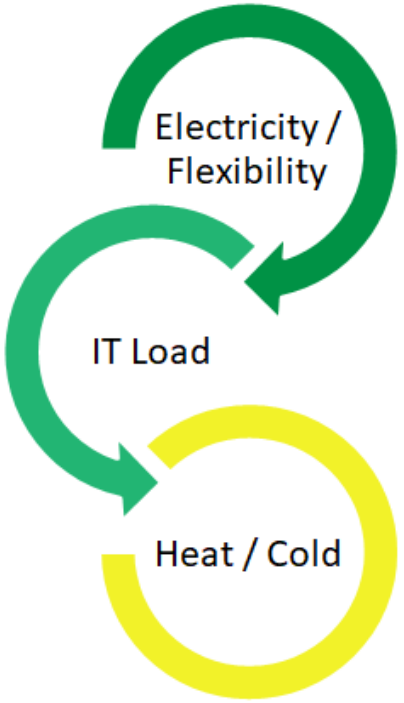
b) the ***District Heating/Cooling marketplace*** between the DC and DHC operators/heat suppliers to trade heat and cooling;

c) the **IT load marketplace** (e.g. IaaS, PaaS), which is now automated and extended with secure and traceable micro-contracts between DCs, to cover not only Cloud performance and elasticity but also support energy efficiency, cooling cost reduction and regional Smart Grid stability (Follow-the-energy-approach).



Marketplace as a Service

Scenarios are built up from the **premise** that ***electricity (incl. flexibility), heat and IT load*** are nothing but **commodities** that data centres can **transfer, exchange and trade** in their corresponding emerging markets either individually or combined to achieve **synergies** whenever applicable.



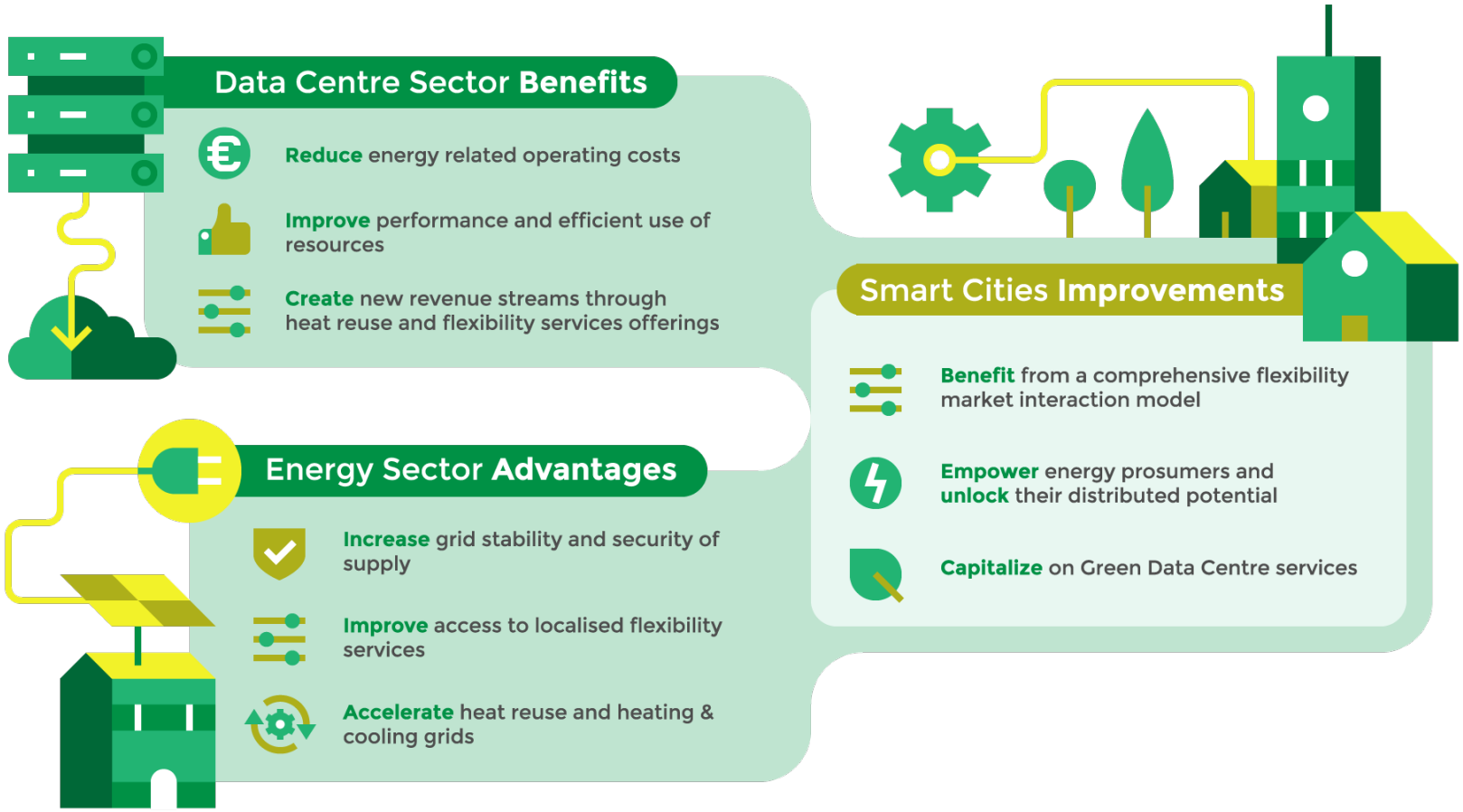
Objectives

CATALYST has adapted, scaled up, deployed and validated **an innovative, adaptable and flexible technological and business framework by leveraging on FP7 GEYSER and DOLFIN TRL 4/5 results, aimed at providing DCs with a set of TRL 6/7 enabling solutions and tools, which:**

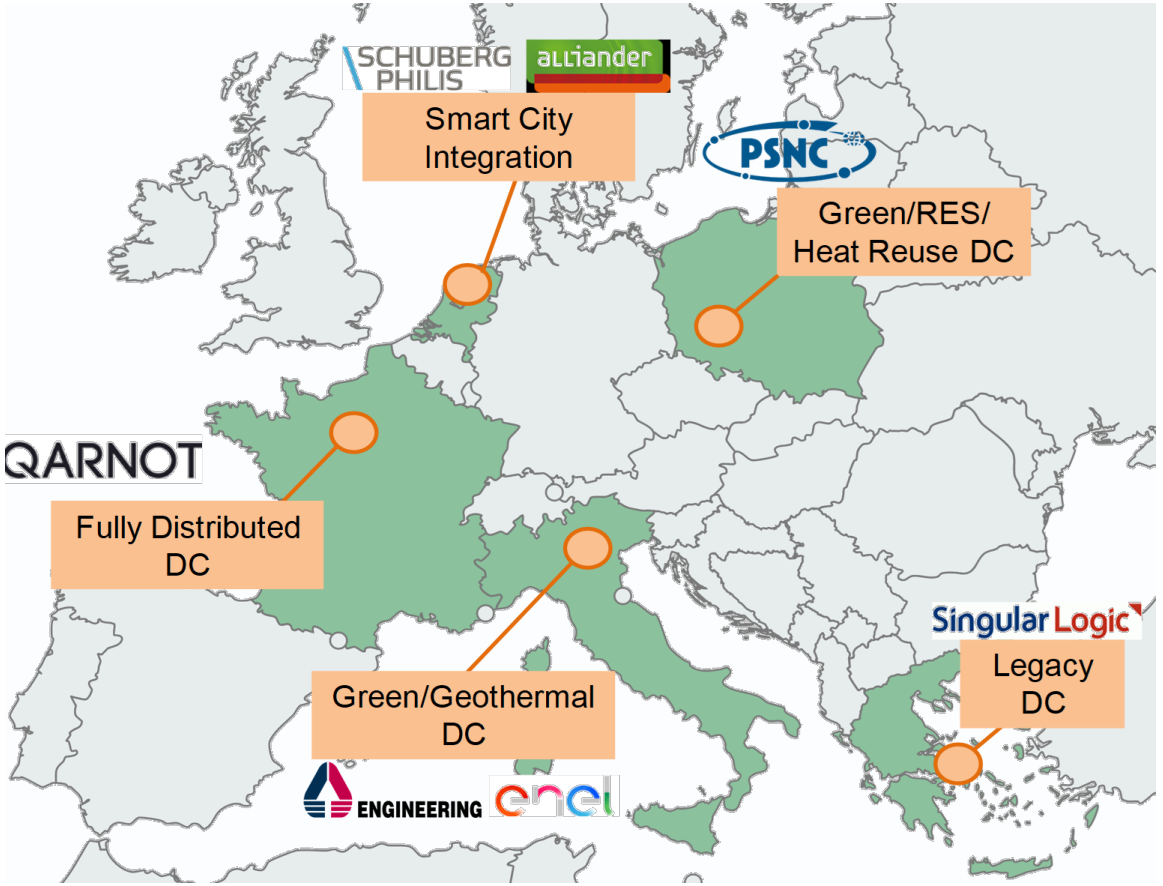
- utilize and trade the **wasted DC heat** to lower the overall system-level energy distribution footprint, reduce DC energy costs and even create a new DC income source over longer times;
- assess **resiliency of energy supply and flexibility**, against adverse climatic events or abnormal demand, trading off DC assets energy generation/consumption against local/distributed RES, energy storage and efficiency
- deliver **energy flexibility services** to the surrounding energy (power and heat) grids ecosystems
- exploit migration of **traceable ICT-load** between federated DCs, matching the IT load demands with time-varying on-site RES surplus availability or where heat generation in needed (**follow the energy approach)**

The CATALYST framework is conceived to be **adaptable to a broad variety of DCs categories,** ranging from different **DCs types** (co-location, enterprise, HPC DCs), to different **geographical location**, to different **architectures** (large centralized versus fully decentralized micro-DCs) and energy efficiency orientation.

Value Proposition

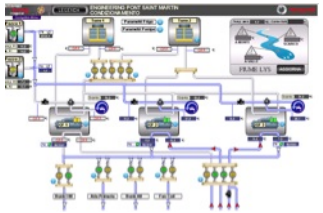


CATALYST Pilots



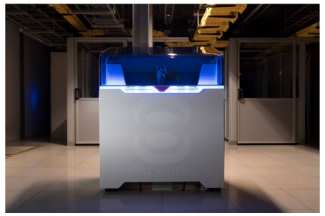
Validation

Core features of CATALYST that have been validated



- **Type**: Colocation
- **Trials**: Thermal inertia of cooling
- **Resources**: PSM production DC owned by ENG
- **Scenarios: 1, 2, 4**

- **Type**: HPC
- **Trials**: Heat re-use, use of PV onsite, power capping, IT load migration
- **Resources**: Liquid cooled HPC DC, micro DC with PV system integrated
- **Scenarios: 1, 2, 3, 5**



- **Type**: Colocation
- **Trials**: IT load migration, thermal inertia of cooling, use of UPS and/or generators
- **Resources**: Production DC, Asperitas immersive cooling system
- **Scenarios: 1, 2, 3, 7**

- **Type**: Distributed
- **Trials**: Direct heat re-use, IT load migration
- **Resources**: Subset of nodes in residential buildings and offices, production site in a warehouse
- **Scenarios: 1, 3, 6**

Validation

Core features of CATALYST that have been validated

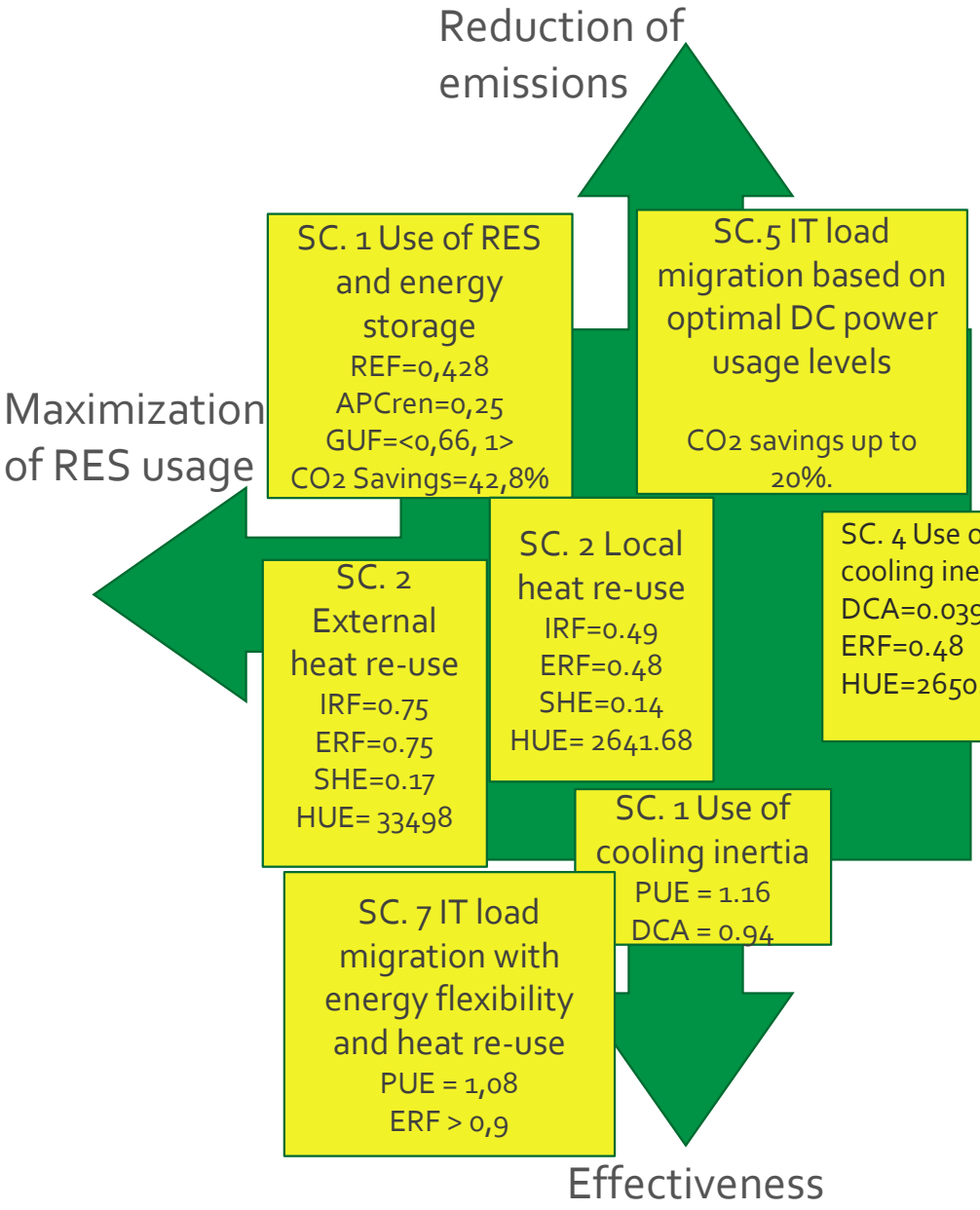
- **Free air and water cooling (geothermal)** (ENG PSM) and **passive water cooling** connecting to the drinking water grid (SBP, Netherlands, in collaboration with ALD);
- **Waste heat regeneration** (via heat pumps) and **reuse** in smart thermal low temperature DH Networks (SBP and PSNC) and space heating/cooling of co-location DC offices in favourable seasons (PSM co-location center in alpine climate area, Italy, PSNC and SBP);
- **Smart waste heat reuse** in pre-heating diesel engines in UPS systems (SBP, Netherlands);
- **RES** (PV panels) and **DES** (batteries) **integration** (PSNC);
- **Heat demand-driven IT workload balancing** in a fully distributed DC (QRN, France);
- **Energy flexibility services** via backup generation, battery storage/UPS and flexible workload adaptation of IT workload (PSNC and SBP);
- **IT load balancing**, targeting lowering of energy consumption and cooling needs, between legacy/commercial DCs belonging to different administrative domains (e.g., SiLO) and green DCs (ENG PSM or PSNC);

Assessment and Replication Guidelines

Suitability of specific CATALYST scenarios to data center types

Scenarios		Data center type				
Sc.	Trial type	Collocation	Enterprise	Cloud	HPC	Distributed
1	Delay-tolerant workload shifting	-	+	+	+	+
	Use of cooling inertia	+	+	+	+	
	Use of RES and energy storage	+	+	+	+	+
	Use of diesel generators	+	+	+	+	
2	Local heat re-use	+	+	+	+	+
	Heat re-use at external entities	+	+	+	+	
3	IT load migration	-	+	+	-	+
4	Dynamic usage of the cooling system and shifting of delay tolerant workload	-	+	+	-	+
5	IT load migration based on optimal DC power usage levels	-	+	+	-	+
6	IT load migration + heat re-use	-	+	+	-	+
7	IT load migration with energy flexibility and heat re-use	-	+	+	-	-

Assessment and Replication Guidelines



- Benefits to data centers
  - Improvement of KPIs

- Benefits to data centers
  - Additional revenues
  - Maximizing RES usage
  - Reducing CO_2 footprint
  - Improving efficiency

Addressing challenges and mitigating potential risks

Assessment and Replication Guidelines

Constraints in access to DC infrastructure data and BMS	Connector implementation, e.g. OPC server Limited access to selected necessary information and actions
Limited possibility of IT load shift; problems in identification of delay-tolerant load	Separation of clusters/systems Alternative use of power capping techniques
Low data center temperature and high temperature demands in DH and buildings	Use of DLC or immersive cooling systems (allowing higher temp.) Calculation of optimal settings Direct re-use of heat in local low temp network and excess heat passed to DH in warmer seasons
Resistance of data center managers to perform actions such as switching off cooling	Partial switching off, e.g., single units Controlling temperature, e.g., by changing coolant flow

Conclusions

- Extensive tests of project approaches and CATALYST framework
  - On real infrastructure or data
  - Including validation of important tools such as Intra DC Energy Optimiser, DCMC, Marketplace, prediction tools and others
- In the final report 16 trials have been presented
  - 7 executed on real physical systems,
  - 6 simulated,
  - 1 combined both real experiments and simulations, and
  - 2 desk studies.
- Evaluation of results and a set of guidelines defined
- Promising results and validation of energy flexibility management and multi-flavour marketplace concept for data centers
  - Including waste heat re-use
- The main challenges
  - Data centres' aversion to risk and availability priority vs energy usage reduction and sustainability
  - Locality of heat market

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