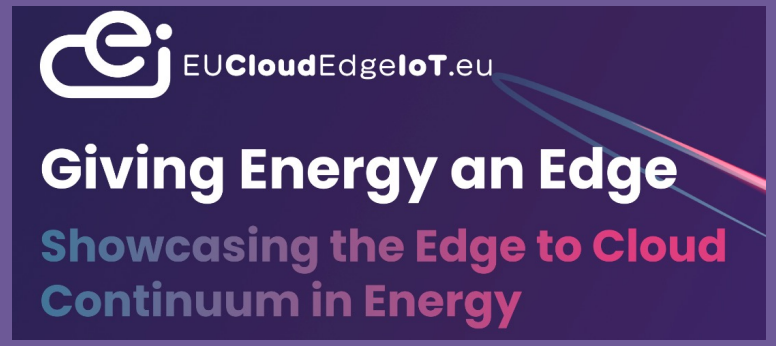
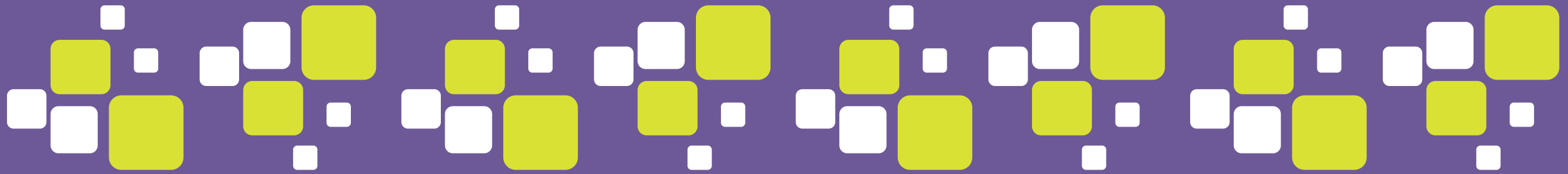


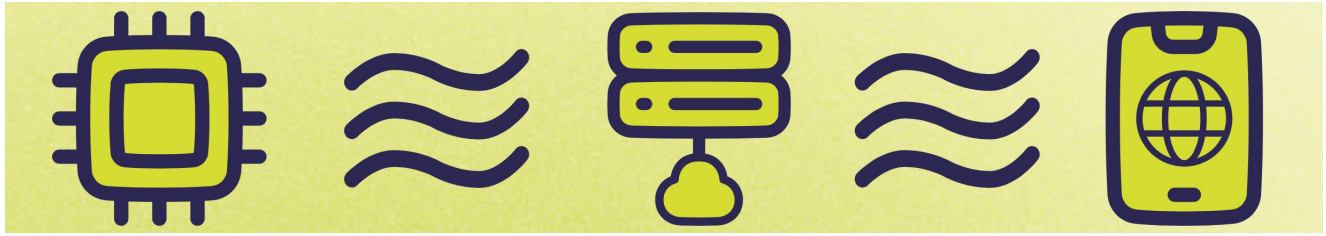
FLUIDOS Intelligent Power Grid Use Case

Elisa Albanese
Ricerca Sistema Energetico S.p.A.
Giving Energy an Edge – Nov 10th, 2023

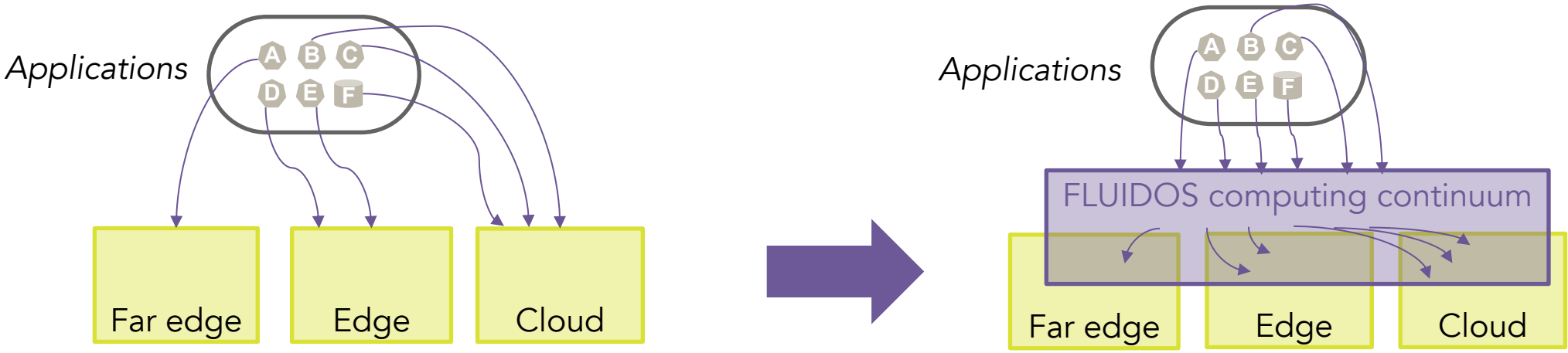


FLUIDOS: A Dynamic and Trustable Computing Continuum

FLUIDOS (Flexible, scaLable, secUre, and decentralIseD Operating System) aims to leverage the enormous, unused processing **capacity at the edge**, scattered across heterogeneous edge devices, servers and on-prem datacenters, and to coherently form a seamless **computing continuum**.



FLUIDOS Continuum

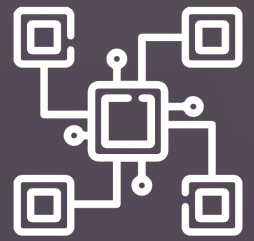


The FLUIDOS computing continuum is **not** simply the capability to deploy services in multiple sites datacenter clusters or devices.

The FLUIDOS computing continuum is a **virtual space** spanning across multiple **technological domains** and **administrative boundaries**

FLUIDOS objectives

Unify edge and cloud computing through decentralized, autonomous resource integration.



Orchestrate hyper-distributed applications in a continuous, automated fashion over multiple devices and domains.

Orchestrate services and applications with energy-efficient AI

Introduce a Zero Trust paradigm aimed at securing access to geographically scattered resources.

Enable the emergence of a multi-stakeholder market of edge services and apps, ensuring European digital autonomy.

Leveraging open-source software

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FLUIDOS

USE CASES

Three Use Cases demonstrate FLUIDOS's value in the real world

Intelligent Power Grid – Energy

Smart Viticulture – Agriculture

Robotics Logistics

Robotnik

terraviewos

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FLUIDOS

Intelligent Power Grid, RSE

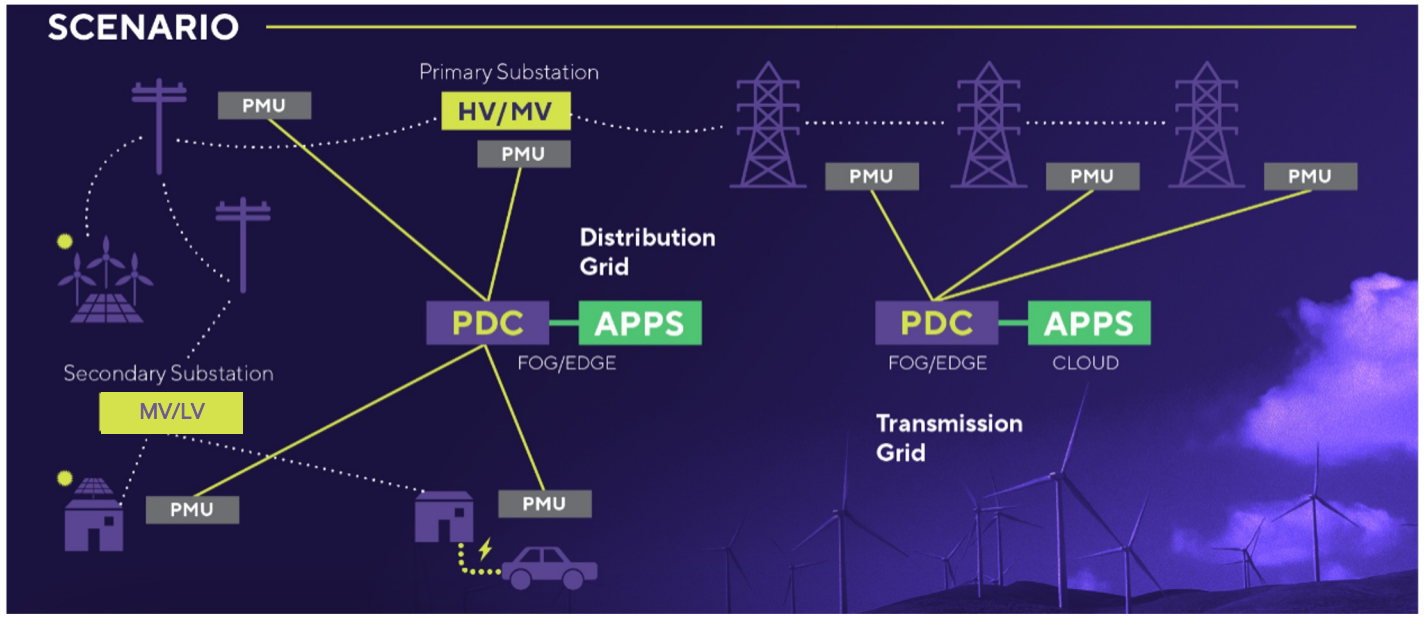
Ricerca sul Sistema Energetico, RSE S.p.A., is an italian publicly owned company dedicated to **applied research** in the **entire energy sector**, serving as a hub connecting policymakers, businesses, and citizens. The activities focus on:

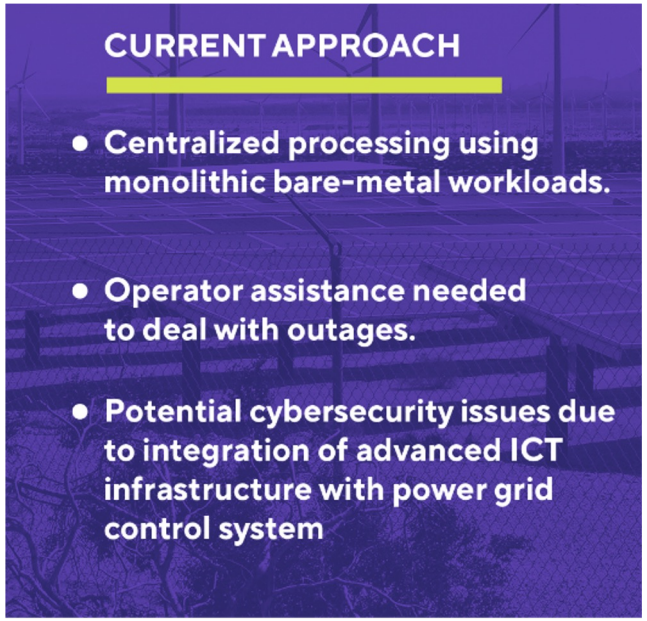
- research and development to support power plants and the interaction between the energy ecosystem and the environment
- electricity market and regulatory frameworks
- efficiency and end-user
- storage and production technologies
- innovative architectures and digitalization for transmission and distribution grids

Intelligent Power Grid

Use Case description

The Intelligent Power Grid use case includes electrical measuring devices called **PMUs** (Phasor Measurement Units), services performing data collection and synchronization called **PDCs** (Phasor Data Concentrators), and **monitoring and control applications**, based on the grid state estimation algorithm.





From transmission to distribution grid

Intelligent Power Grid

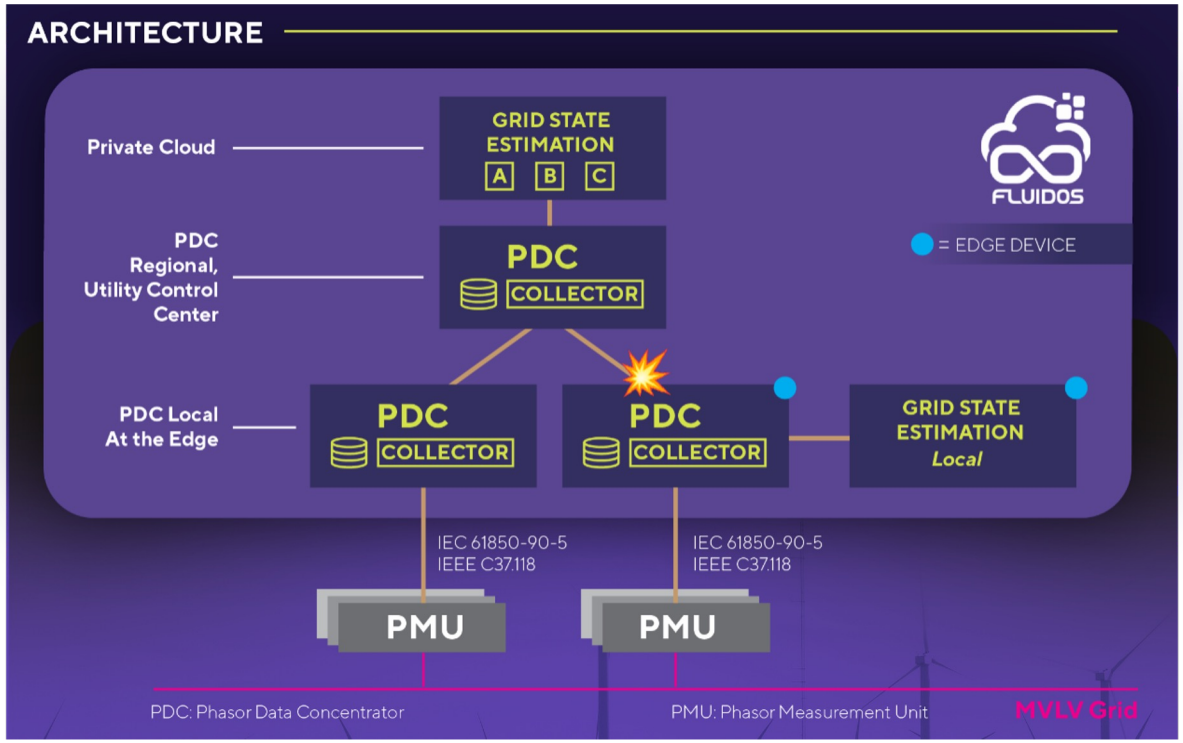
Challanges

The introduction of PMUs into the distribution grid brings about various challenges, including:

- **Scalability**: the distribution grid requires a number of PMU of the order of thousands, this implies the need to manage a **massive amount of distributed devices and their corresponding data flows.**
- **Resilience**: managing **faults** or planned maintenance of the ICT infrastructure should be automated.
- **Latency**: **strict data latency** requirements (of the order of milliseconds) are needed to enable real-time control of the power grid.
- **Cybersecurity**: the power grid must be protected from any malicious **attack**, including the ones targeting monitoring and control services.

Intelligent Power Grid

FLUIDOS approach



- Computing Continuum: FLUIDOS would enable PDCs and analysis applications to continue functioning even if communication with control centers is interrupted by migrating services to an adjacent node in case of fault.

- Orchestration: FLUIDOS can automatically orchestrate PDCs based on the latency between the node and PMUs, thereby improving the power grid state estimate or responding to faults.

- Cybersecurity: FLUIDOS ensures service isolation, logging and anomaly detection capabilities and provides survival capabilities in case a portion of the grid is disconnected from the main network due to a cyber attack.

Intelligent Power Grid

RSE Testing Components

The main activities are held in the LV portion of RSE's Distributed Energy Resources Test Facility (DER-TF).

LV Smart Grid

Non-programmable power generation:

- PV panels
- Wind turbines

Flexible power consumption:

- EV Charging Stations
- Loads charge/discharge
- Smart home

Grid State Estimation

- **5 PMU**

Intelligent Power Grid

RSE Testing Components

PMU	PDC	NETWORK	APPLICATION
Real and virtual PMU National Instruments devices and PMUSim simulators	**Containerized** version of openPDC software, deployed on: • **CLOUD** private openstack • **FOG** StarlingX, Nebbiolo • **EDGE** Raspberry PI	Private ethernet, optical fiber, 5G	Grid State Estimation Algorithm written Python and control applications

Intelligent Power Grid

Scenarios

ICT Outage

Seamless phasor data concentration and grid state computation in presence of multiple **ICT outages.** We emulate ICT outages due to node failure, cyberattacks, and performance degradation.

Simplified ICT maintenance through service offloading in nearby nodes. An upgrade in the phasor data concentration algorithm or a generic security patch is simulated, and we plan to show that these can be done without loss of phasor data and/or interruption of the grid state estimation.

Grid Reconfiguration

The hierarchical structure between **PMUs and PDCs may change in the event of a grid reconfiguration**. Being able to migrate applications across clusters accounting for network metrics can lead to a substantial improvement of latency, allowing the SE algorithm to satisfy the stringent requirements of real-time applications.

Thanks for listening!

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The FLUIDOS project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No 101070473

Questions?

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