GLOBAL PST CONSORTIUM

G-PST Webinar Series

Benefits of open source software: a power system operator perspective

+

RTE

Boris Dolley

Director, Open Source Program Office, RTE

In other industries, open source software has been a proven approach for providing **transparent** and **auditable shared building blocks** that organizations can freely adapt to their requirements – however, the electricity sector has been somewhat slower to adopt this model.

What are the **benefits to system operators** of collective investments in common software infrastructure, and how can **open tools and interfaces** help accelerate the deployment of innovation and by extension the energy transition?

AGENDA

RTE – Who are we?

The (global) shift to **O**pen-**S**ource **S**oftware for RTE (energy)

- why
- when
- how
- what for
- what
- where
- with whom

Q & A

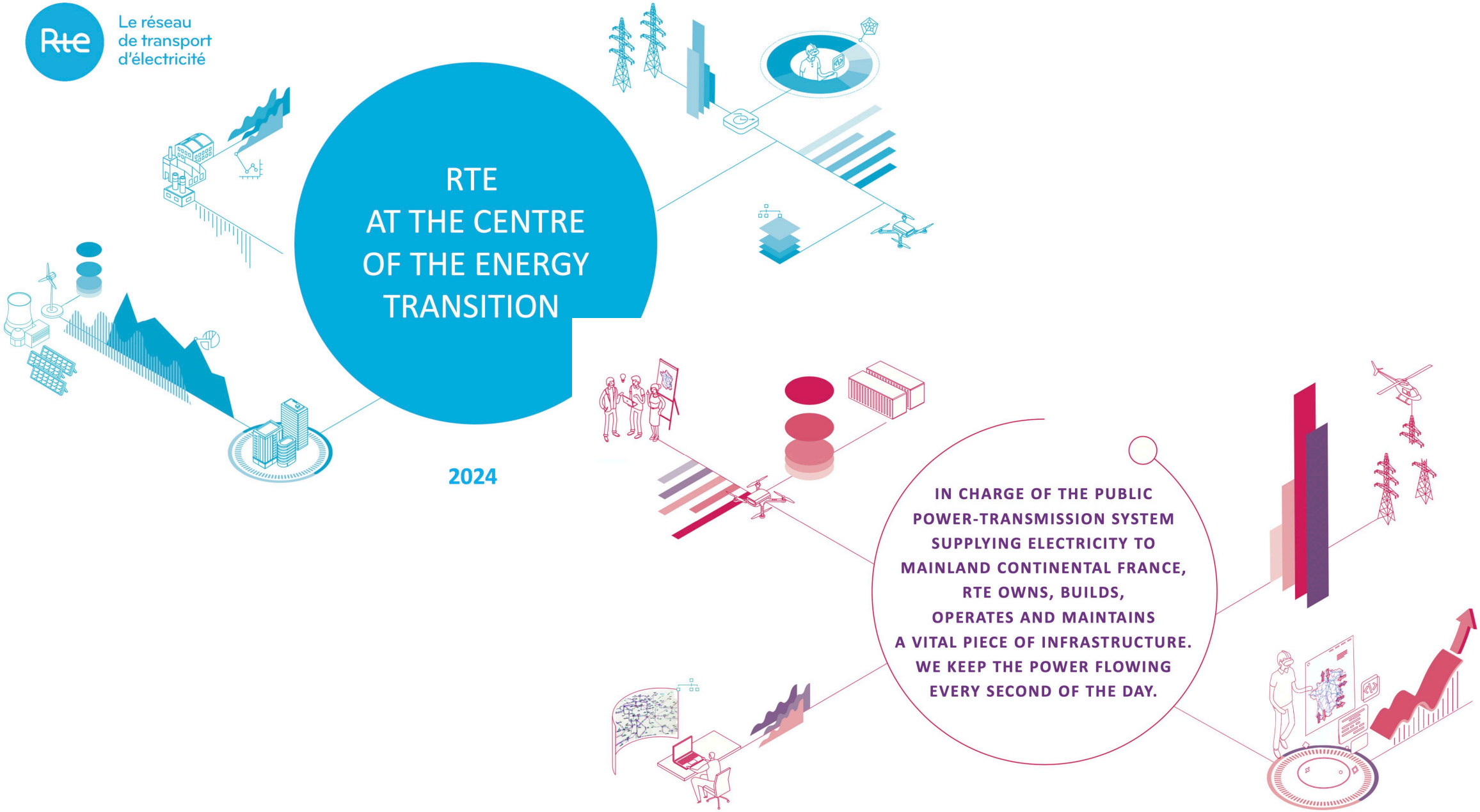
Follow-up

Key Takeaways

Le réseau
de transport
d'électricité

RTE
AT THE CENTRE OF THE ENERGY TRANSITION

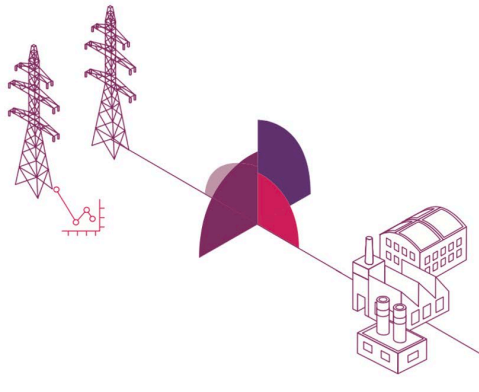
2024



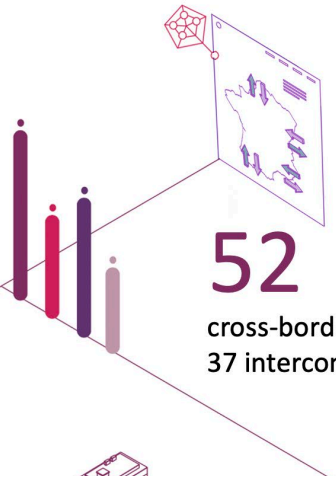
IN CHARGE OF THE PUBLIC POWER-TRANSMISSION SYSTEM SUPPLYING ELECTRICITY TO MAINLAND CONTINENTAL FRANCE, RTE OWNS, BUILDS, OPERATES AND MAINTAINS A VITAL PIECE OF INFRASTRUCTURE. WE KEEP THE POWER FLOWING EVERY SECOND OF THE DAY.

RTE

RTE in key figures...



AMONG
Europe's
leading



52
cross-border links
37 interconnections

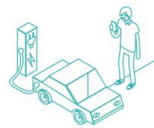
RTE in key figures...

>115,817 km
of power lines
and 2 900 substations currently in operation
from 63 kV up to 400 kV

€ 6,131 M
in annual sales
417 M of annual results

AMONG
Europe's
leading
TRANSMISSION SYSTEM OPERATORS IN TERMS OF GRID SIZE AND INVESTMENT

9,586
employees including
470 apprentices

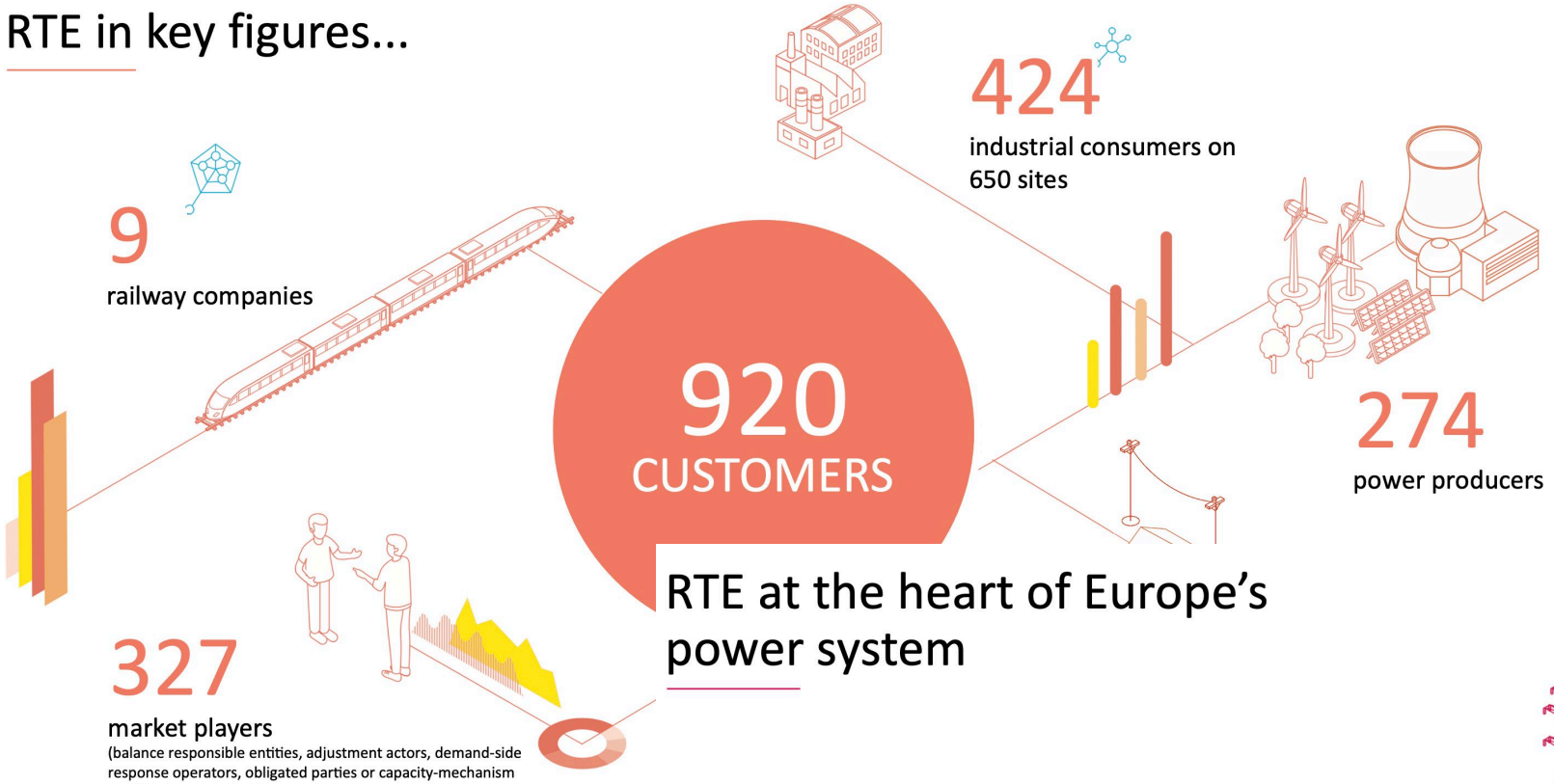


€ 2,077 M
of capital expenditure, +10 % growth expected in 2024, €4Bn in 2028 (submarine interconnection projects, offshore connections to the grid ...)

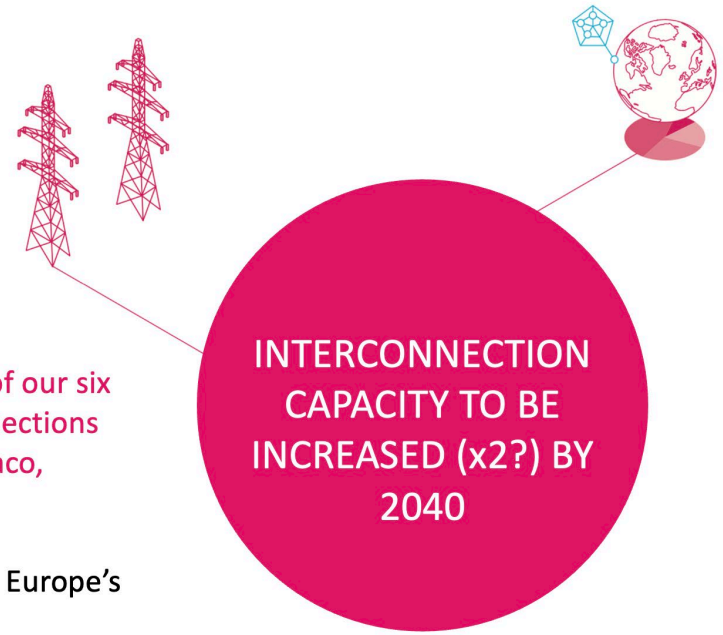
€ 40 M
annually committed to R&D
175 M for ICT

RTE

RTE in key figures...



RTE at the heart of Europe's power system



Our mandate extends beyond the borders of France.

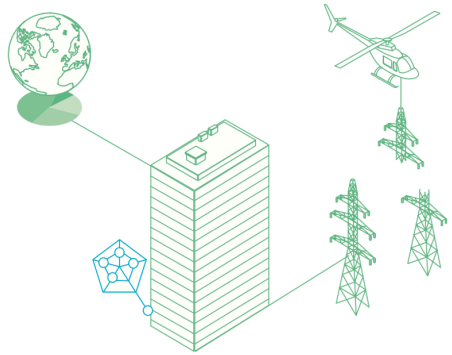
Every day, electricity is imported and exported across each of our six electricity "borders", via 37 cross-border "market" interconnections and 15 dedicated cross-border customer connections (Monaco, Andorra, Jersey …).

Our central position makes us a key player when it comes to Europe's energy policy in 3 main objectives:

- Building the European internal electricity market
- Maintaining security of electricity supply
- Fighting against and adapting to climate change

RTE

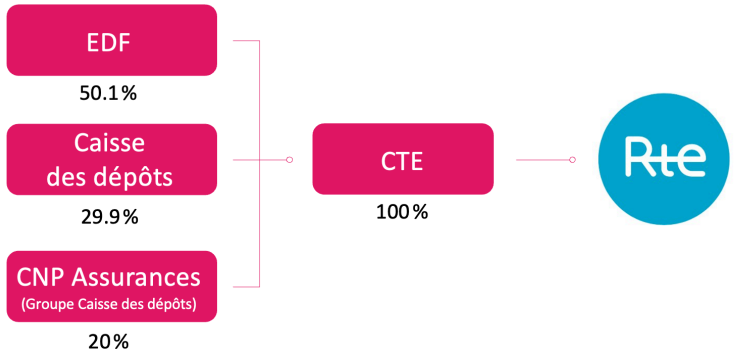
RTE: a national regulated monopoly

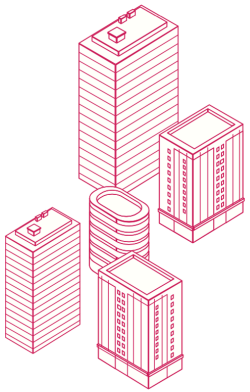


RTE is the sole operator of the electricity system and the high and extra-high voltage network in mainland France.

- Consequence: RTE operates in accordance with the rules of conduct of a **regulated monopoly**.
- Most of RTE's resources come from the **transmission tariff (TURPE)** charged to grid users. The tariff is set by the French Energy Regulatory Commission (CRE).
- **RTE is responsible** for the balance, performance and security of the French electricity transmission grid and power system.
- RTE is required to provide the same standard of service to all grid users.

Shareholders: 100 % of shares held by the holding *Co-entreprise de Transport d'Électricité (CTE)*



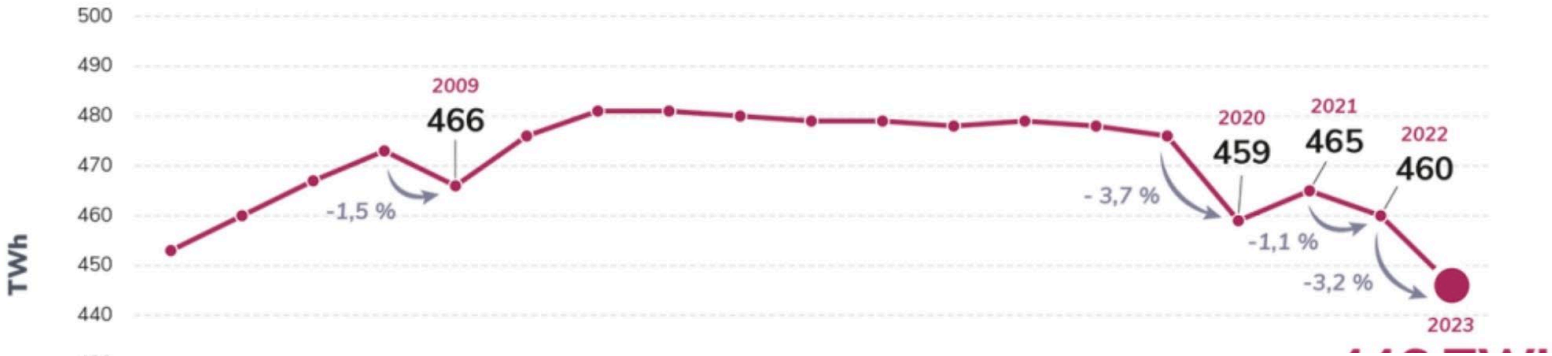


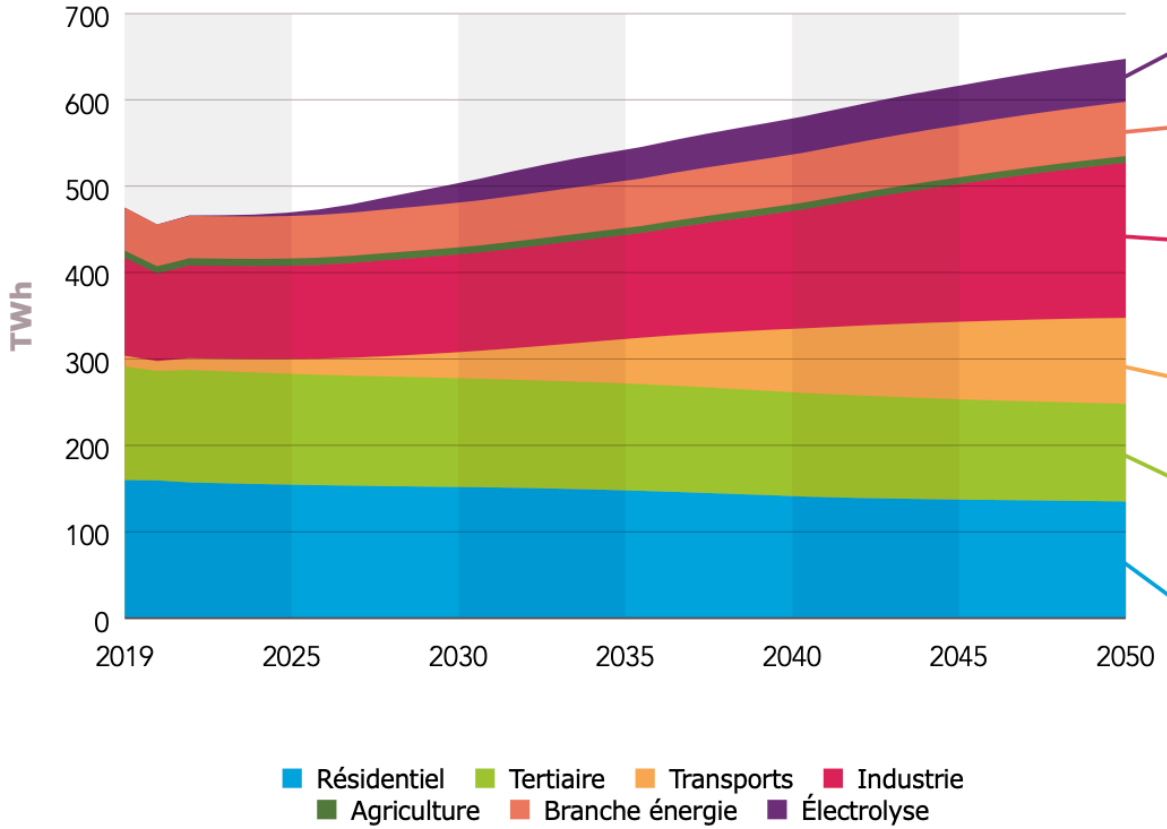
Compatible with a

Public Money
Public Code

approach

RTE





Hydrogène (0 → 50 TWh) :
produit par électrolyse, pour les besoins industriels et le transport lourd

Énergie et pertes (50 → 60 TWh) :
légère croissance des pertes qui suit la demande d'électricité

Industrie (115 → 180 TWh) :
croissance de la production (valeur ajoutée +40% d'ici 2050) et électrification importante des procédés

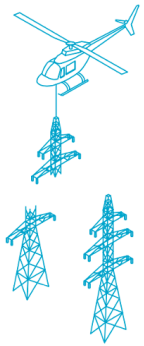
Transports (15 → 100 TWh) :
fin des ventes des véhicules thermiques en 2040 : en 2050, 94% des véhicules légers et 21% de camions sont électriques

Tertiaire (130 → 110 TWh) :
croissance de la consommation des data centers (~x3), plus que compensée par l'amélioration de l'efficacité énergétique dans d'autres usages

Résidentiel (160 → 135 TWh) :
le développement du chauffage électrique (70% des logements comparé à 40% aujourd'hui) est compensé par l'effet baissier des rénovations et l'amélioration de l'efficacité des équipements

RTE

4 subsidiaries delivering our expertise and assets



RTE INTERNATIONAL

Delivers our expertise while at the same time promoting and selling our power-transmission know-how to international customers.

ARTERIA

Provides the spare capacity on the 25 500 km of optical
installed on RTE's power
well as electricity pylo
accommodate mobile
antennae.

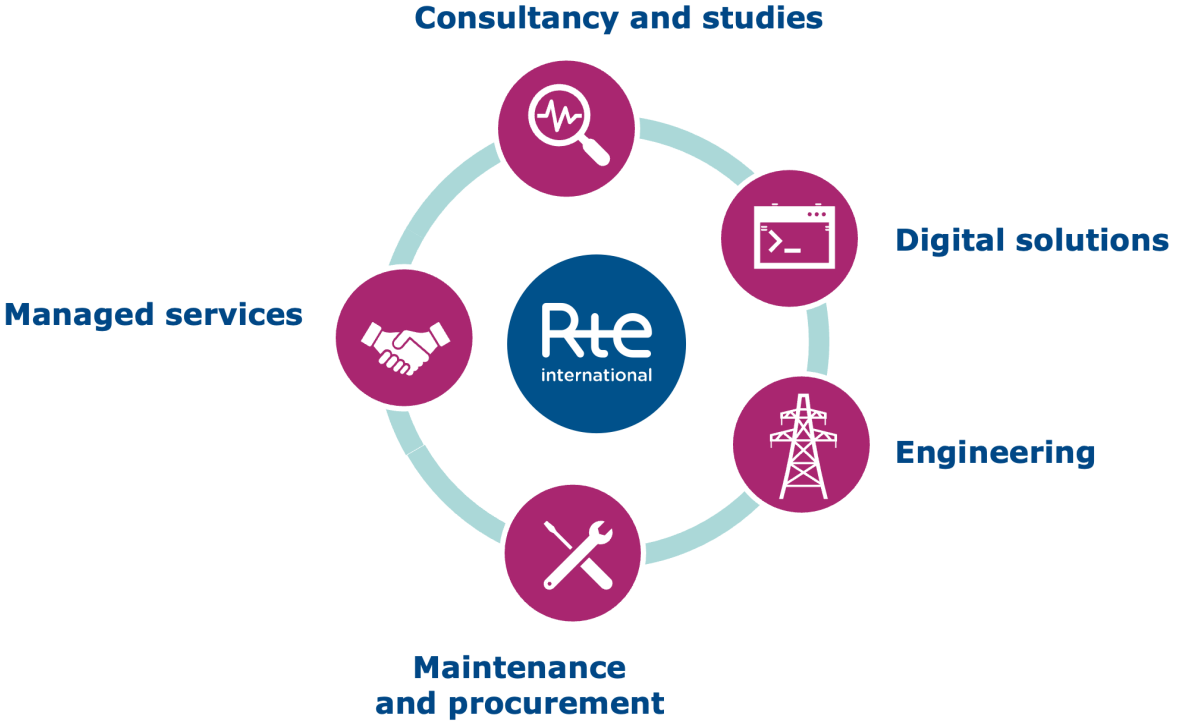
AIRTELIS

Promotes and sells

CIRTEUS

Develops and sells

RTE INTERNATIONAL – PROMOTE THE FRENCH TSO'S EXPERTISE

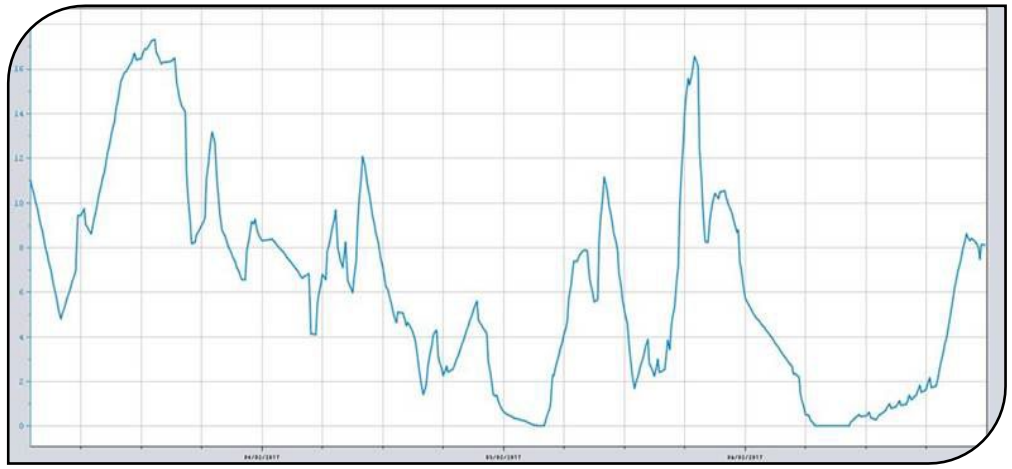


RTE

OSS/WHY – globaly

Energy Transition drives change in power transmission and distribution grids

- Distributed renewable energy sources, demand response, electric mobility, smart services to the grids from a growing number of third-parties



Software as an essential **enabler** to achieve this transformation

- Solutions to monitor, control, optimize, understand, and transact in a future power system of systems of growing complexity

OSS/WHY – Concretly

Pain points **FROM** Control rooms Operators

R&D + ICT **speed** for innovation then production

Interoperability (w/ SDOs)
Modularity of digital services and code
Upgradability (technical debt is managed)
Cost-efficiency (customization & scalability)
Recruitment and Talent Retention
Reputation and Branding
Speed of innovation
Faster **Time-to-Market**
Ecosystem Influence
Compliance and Security
Quality improvements
Avoiding **Vendor Lock-in**
Tackle European separation Layers

TO Substations technologies

OSS/WHY – concretely

A vendor ecosystem to maintain in the long run

Make

Buy

Make Together (even w/ competitors)
- stop building new
- stop the never ending birth – death in a 5 years cycle per application
- start never ending projects / services

OSS/WHEN – The story

- 2002 (downstream)
  - ⇒ Boris DOLLEY: first Linux kernel-based solution in production (load-shedding system)
  - ⇒ Then IT 4 IT product began to be adopted on-prem.

- 2007
  - ⇒ Gabriel BAREUX asked to his Manager (R&D dpt): “what about upstreaming this software?”
    - ⇒ Nope!

- 2017
  - ⇒ LinkedIn message from Shuli GOODMAN (a message in a buttle)
    - ⇒ Phone Call w/ Shuli Goodman + Gabriel BAREUX (R&D Director) + Lucian BALEA (R&D deputy)
      - ⇒ Shuli came to France at Network Together (RTE vendors meeting)

- 2018
  - ⇒ One year of cooperation with Shuli on building THE Energy Foundation for OSS = LFEnergy
  - ⇒ Study Tour at the LF HQ in SF for few RTE OSS Fellows
  - ⇒ Antares-Simulator goes OSS (upstream) on GitHub (not in LFE but in //)

- 2019
  - ⇒ Creation of Linux Foundation for Energy (LFE => lfenergy.org)
    - ⇒ 2 then 3 members (Linux Foundation + RTE then Alliander (DSO))
    - ⇒ ~ 2 projects

- 2024
  - ⇒ LFE board = RTE (TSO) + GAFAM + RTE + Alliander (DSO) + Shell
    - ⇒ ~ 70 members
    - ⇒ ~ 30 projects
      - ⇒ Evolving each weeks

OSS Reflex: how **other** industries are leveraging open-source collaborations

OSS/HOW

Telecom, End User driven Innovation & Billions in Savings

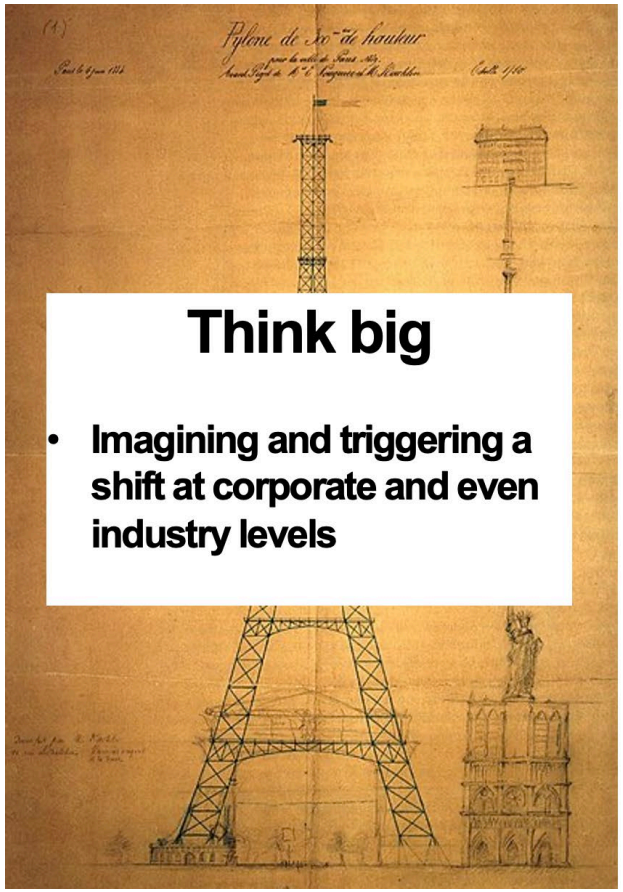
Major Problem	How LF Innovated	Results - 2018
• How to create a standard management and orchestration platform for global operators • How to automate network management preparing for 5G • How to create NFV and SDN reference architecture	• 2016 the Linux Foundation brokered a merger of AT&T's eComp platform and China Mobiles Open-O efforts to create the Open Network Automation Platform	• AT&T will save $1.6B through dis-aggregation • Within one year ONAP was joined by telecommunications providers representing 70% of the worlds telecom subscribers – roughly 3.5 billion people. • $576M of shared development by a community of over 2,500 developers.

THE LINUX FOUNDATION

OSS/HOW

Inspired by other industries, we decided to build an Open-Source capacity aiming at…

- an acceleration by **reusing** what exists and **sharing efforts** (wf & $), allowing to build faster and cheaper software,
- improved **modularity**, **interoperability** and shorter **release time cycles**,
- cutting-edge technological and **business model innovation**,
- access, through **collaboration**, to wider and more diverse skills and to a diversity of viewpoints,
- **reduced vendor lock-in or customer-specific approaches that impede velocity and cost-efficiency.**



Release early, fast, often and improve forever

OSS/WHAT FOR

Global industry strategy and community building

Imagining and triggering a shift at corporate and even industry levels following the path of other industries (applying proven best practices and avoiding reinventing the wheel)

LF ENERGY

STRATEGIC MEMBER

Providing a 21st century plan of action to decarbonization through open source, open frameworks, reference architectures, and a support ecosystem of complementary projects.

https://lfenergy.org/software-defined-vertical-industries-transformation-through-open-source-2024/
June, 2024

OSS/WHAT FOR – Create value

Value demonstrations in RTE:

- Cost-efficiency (customization & scalability)
- Recruitment and Talent Retention
  - Internal and External collaborators
- Reputation and Branding
  - Feedback after recruiting
- Speed of innovation / Faster Time-to-Market
  - From 3 years to 3 months (PoC SafeTy)
  - From 1 year to 2 weeks (OpFab)!

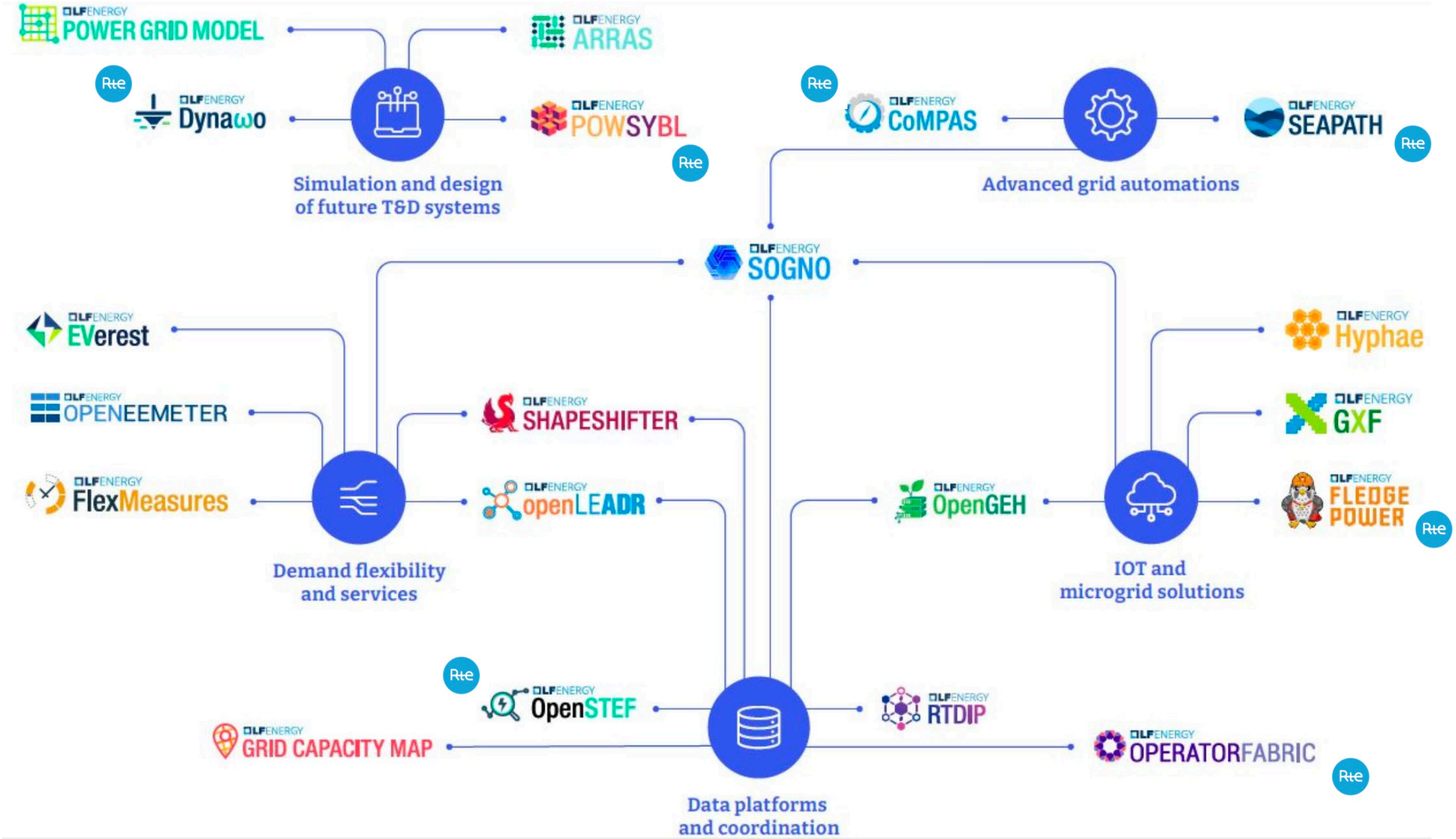
A huge 12-digits market is emerging
On DSAS

An acceleration of how our substations will be reconfigurable from the control-room

Foundation is game changing:

- Ecosystem Influence (**SeaPath** / Compas / FledgePower)
- Compliance and Security (OpenSSF silver badges for the most critical projects)
- Quality improvements (All 7 projects from RTE Vs 200 inhouse)
- Avoiding Vendor Lock-in (for substations hard+soft, for grid planning, forcasting, asset management, …)

OSS/WHAT


LF ENERGY POWER GRID MODEL
LF ENERGY ARRAS
Rte
LF ENERGY Dynaωo
LF ENERGY POWSYBL
Rte
Simulation and design of future T&D systems
Rte
LF ENERGY CoMPAS
LF ENERGY SEAPATH
Rte
Advanced grid automations
LF ENERGY SOGNO
LF ENERGY EVerest
LF ENERGY OPENEEMETER
LF ENERGY SHAPESHIFTER
LF ENERGY FlexMeasures
LF ENERGY openLEADR
Demand flexibility and services
LF ENERGY OpenGEH
LF ENERGY Hyphae
LF ENERGY GXF
LF ENERGY FLEDGE POWER
Rte
IOT and microgrid solutions
Rte
LF ENERGY OpenSTEF
LF ENERGY GRID CAPACITY MAP
LF ENERGY RTDIP
LF ENERGY OPERATORFABRIC
Rte
Data platforms and coordination

OSS/WHAT

CoMPAS Configuration Module for Power Industry Automation Systems: Configuring control center systems for substations / IEC 61850 standard

Dynawo is a suite of tools for studying the stability of the Electrical System in the face of increasingly complex physical and digital dynamics (penetration of renewable energy sources, HVDC, automation systems, etc.).

FledgePOWER is a multi-protocol translation gateway project for electrical systems: addressing the problem of heterogeneity of the numerous protocols used in digital control systems by overcoming the technological lock-in of proprietary solutions

OpenSTEF is a Python package used for short-term forecasting in the energy sector (renewable energy production, consumption). Machine learning modules for developing forecasts (AI)

OperatorFabric is software for centralizing events and coordinating real-time interactions between stakeholders. At RTE, it is used in operation centers to prefigure COSE and within CORS-N

PowSyBl is a library for data import/export, electric grid calculations, or visualization (Single Line Diagrams). PSB spans areas from real-time to network development, including the integration of the Dynawo suite. For RTE, PSB brings together a community of developers and projects: NAZA, Plasma, Titien, GridSuite, Castor, Imagrid

OSS/WHAT

LF ENERGY SEAPATH

SEAPATH, Software Enabled Automation Platform and Artifacts (THerein), aims at developing a “reference design” and “industrial grade” open source real-time platform that can run virtualized automation and protection applications (for the power grid industry in the first place and potentially beyond). This platform is intended to host multi-provider applications.

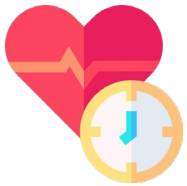
GridSuite

Import and explore data, setup groups of equipment to be used in many different studies. Study networks: visualize, search and navigate electrical data or simulation results. Explore effects of modifications on simulation results, compare network states.

antares simulator

Forecasting the optimal energy mix in each considered areas playing with many parameters:

- Studying forward-looking visions of the energy sector
- Analyzing the costs and benefits of a new interconnection or production project
- Evaluating the risks to supply security or costs
- Measuring the impact of an energy policy on the production mix



ReLife is Python library for asset management based on reliability theory and lifetime data analysis

- Survival analysis: non-parametric estimator (Kaplan-Meier), parametric estimator (Maximum Likelihood)
- Reliability theory: optimal age of replacement for time-based maintenance policy
- Renewal theory: expected number of events, expected total costs or expected number of replacements for run-to-failures or age replacement policies.

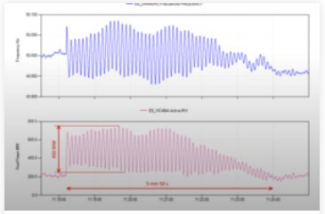
OSS/WHAT

CRESYM

→ LFENERGY

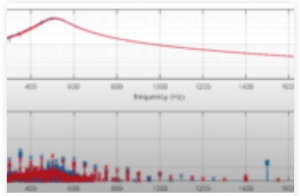
COLib

COLib (https://colib.net) is the library of opensource, verified energy network component models and test cases



WOLF-I

WOLF-I stands for Wide-area Oscillations of Low Frequency with presence of IBRs (Inverter-Based Resources). Wide-area



Harmony

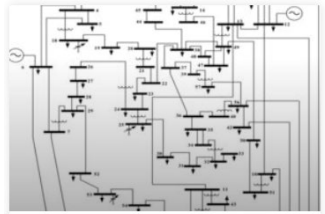
Harmony is a toolkit for easy harmonic analyses of (local EMT), to assess multi-terminal HVDC power systems, TSO-DSO interface, controller interoperability and HVDC protection

Inter-oPEn

Complementary to other related research (interOPERA, HVDC-wise, etc.), Inter-oPEn investigates how openness ("whiteboxes" especially) can unlock interoperability issues of power electronic (PE) devices in power

Restoration

Restoration aims at exploring the advantages and disadvantages of power-electronics interfaced components during network restoration procedures, and to outline recommendations for BESS-based restoration plans.

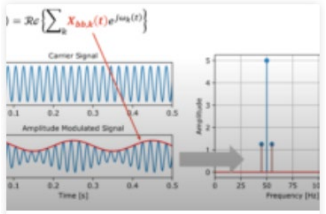


Optgrid

Optimisation of the grid configuration (topology) for the power grid operation to ensure an acceptable level of electricity supply reliability.

LaRISA – Large Res Integration Stability Analysis

The Slovenian network will experience in the next 10 years a high growth of electricity demand, decreasing inertia due to an high level of RES penetration (40% in energy coverage), and an increasing level of cross border exchanges. Stability issues must be tackled in network planning exercise.



BiGER Explore

BiGER shall bridge the gap between EMT and RMS modelling, for stability studies and daily operation of fast, active components-dominated power systems

MUESSLI

MUESSLI aims at "smart-linking" simulation tools to perform cross-sector, actually scalable, simulations and enable the optimal development and operation of an holistic "energy system" (power, heat, transportation, etc.) with electricity and hydrogen as main carriers.

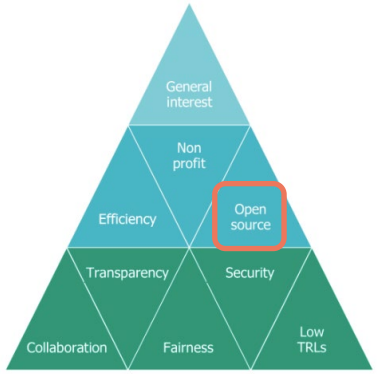
DiSST

DiSST expands the SOGNO platform to help distribution companies meet their 3D goals (digitalisation, decarbonation, decentralisation).

TwinEU

TwinEU is the digital twin of the European power system. The project is sponsored by the Horizon Europe program under grant agreement n° 101136119.

100 % OSS



OSS/WHERE – Upstream

OSS/WITH WHOM – sure / potential

National

centralelille
METEO FRANCE
Toujours un temps d'avance
cea
CentraleSupélec
utc
ANDRA
L2EP
ARMINES
LAAS CNRS
ines
INSTITUT NATIONAL DE L'ENERGIE SOLAIRE
CENTRALE NANTES
FRANCE ENERGIES MARINES
EPFL
Grenoble INP
anrt
ASSOCIATION NATIONALE RECHERCHE TECHNOLOGIE
SystemX
G2Elab
Ceebios
Dauphine | PSL
école normale supérieure paris-saclay
université PARIS-SACLAY
SuperGrid Institute
Shaping power transmission
le cnam
SciencesPo ÉCOLE URBAINE

European

Commission européenne
berlin
SINTEF
RWTH AACHEN UNIVERSITY
TU Delft
Fraunhofer
DTU
entsoe
EPFL
KTH VETENSKAP OCH KONST
ETH zürich
UNIVERSITY OF OXFORD
EUI FLORENCE SCHOOL OF REGULATION
KATHOLIEKE UNIVERSITEIT LEUVEN
LINKÖPINGS UNIVERSITET
OpenModelica
INESCTEC ASSOCIATE LABORATORY PORTUGAL
University of Cyprus
Imperial College London
RSE Ricerca Sistema Energetico
UNIVERSIDAD PONTIFICIA ICAI ICADE COMILLAS MADRID
ULg UNIVERSITÉ de Liège
MANCHESTER 1824 The University of Manchester
alliander
UNIVERSITÉ DE GENÈVE
University of Ljubljana
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

International

PSERC
Lawrence Livermore National Laboratory
POLYTECHNIQUE MONTRÉAL
UNIVERSITÉ D'INGÉNIERIE
Stanford University
Georgia Tech
UNIVERSITÉ DE SHERBROOKE
WASHINGTON STATE UNIVERSITY
IOWA STATE UNIVERSITY SCIENCE AND TECHNOLOGY
LF ENERGY
MOHAMMED VI POLYTECHNIC UNIVERSITY

Young shoots

Dynamica
rovenso
COSMOTECH
Dowel innovation
GRUPO AIA
DYNAMICA
Artelys OPTIMIZATION SOLUTIONS
BLACKLIGHT ANALYTICS
SMART WIRES
T&D europe
Softlab

Large companies

SNCF
europacable Try life without us
GRTgaz
Schneider Electric
Prysmian
SIEMENS
Ingeteam
orange
CSTB le futur en construction
ENIM Air Space
ENEDIS L'ELECTRICITE EN RESEAU
CCR

Q&A

Follow-up

At least **contact the community you're interested in** (slack, mailing-list: should be easy to find!)

Contact me

- boris.dolley@rte-france.com
- **LinkedIn (PM):** https://www.linkedin.com/in/boris-dolley-rte/

Key Takeaways

You tell me :-)

MORE AND MORE DETAILS

The role of Open Source Foundations

Since the power of the open source collaborations lies in the strengths of the underlying technical communities, foundations basically aim at fostering the growth of communities:

- Providing a neutral level playing field, based on a proven and trustable governance framework,
- Educating and coaching projects on appropriate operational practices, including the setup of appropriate processes to manage compliance and security risks,
- Ensuring cross-pollination on best practices, helping onboarding,
- Providing visibility through marketing and outreach

Cultural transformation

From a "control and forbid" mindset to a "motivate and enable" culture

(unlock control to unleash innovation: open as possible, close as necessary

- Learn to work openly with the community / bring internal discussions to the community
- Release soon, release often
- Trust in technical communities
- Acknowledge that sharing brings value (diffusion of information can create unexpected opportunities, diversity of viewpoints mitigates the risk of doing wrong)

CRESYM: collaborative R&D works to deliver opensource energy system simulation tools

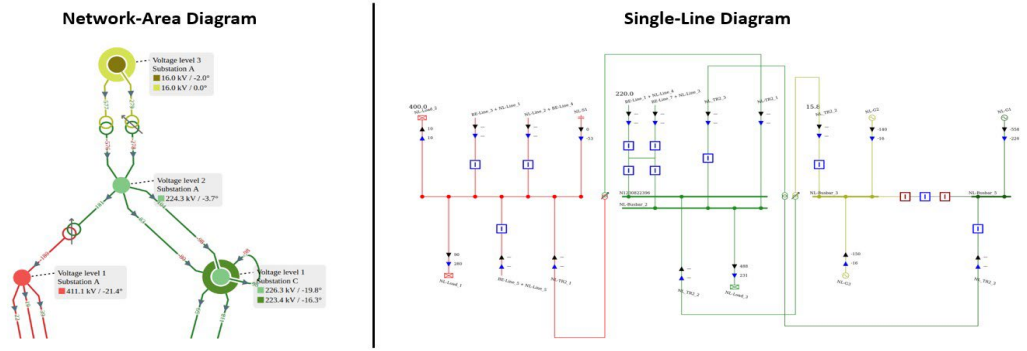
- Non-profit association
- Gathering industrial & academic research organisations
  - Collaborations on low-TRL R&D issues of general interest
  - Open source dissemination of works

Building the next generation of power system tools

Improving the flexibility, scalability and upgradability of power system simulation and study tools

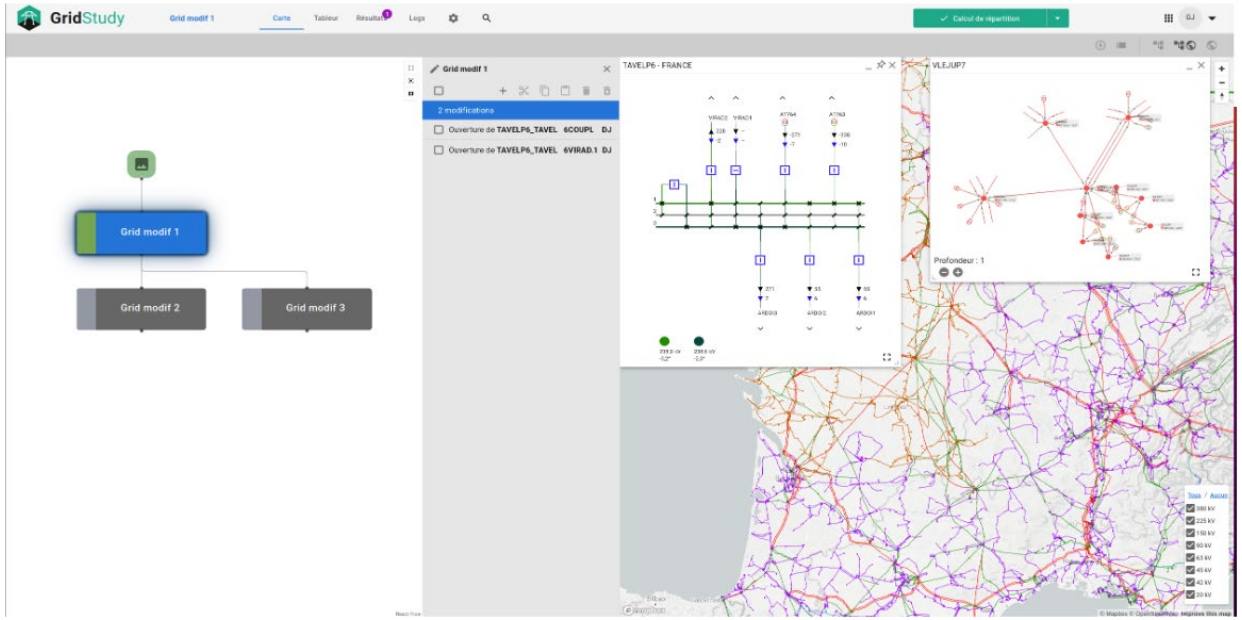
LF ENERGY POWSYBL

- A set of modular software components for building grid simulation and study tools: grid modelling, exchange formats, grid simulation, visualization, etc.



- GridSuite: RTE's industrial application built on top of PowSyBl and used for all power grid studies"

GridSuite



PowSyBl overview

- Supported formats: CGMES, UCTE, XIIDM, JIIDM, PSSE, IEEE-CDF, Matpower, PowerFactory, AMPL.
- Internal grid model called IIDM, fully extendable for specific needs. In addition to classical network equipments, it supports merging, subnetworks, validation level (EQ or SSH), network reduction, modelling of automaton systems, etc.
- APIs to run loadflows, security analyses with remedial actions, sensitivity analyses with contingencies, time domain simulations, optimal power flows, short circuit analyses, remedial action optimizers, etc.
- Network diagrams: single-line diagrams and network-area diagrams
- etc.

- Documentation: https://www.powsybl.org/index.html

Webinar: Electrical Grid Modelling and Simulation Through PowSyBl - A Hands-On Approach

June 3, 11am US Eastern / 17:00 Central European Time

Register for free!

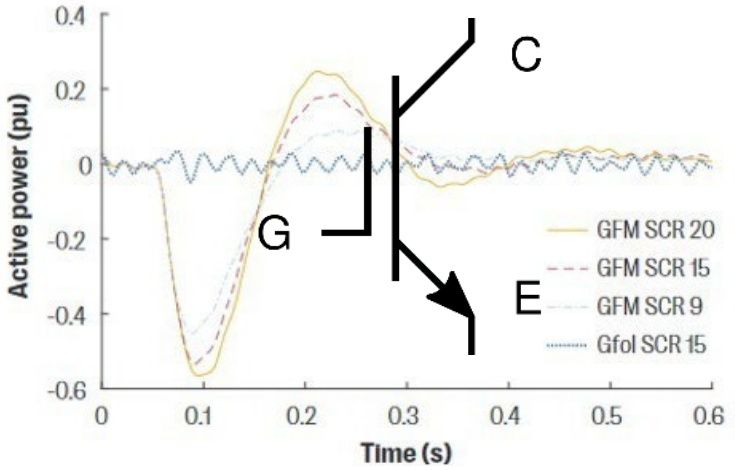
https://community.linuxfoundation.org/events/details/lfhq-lf-energy-presents-electrical-grid-modelling-and-simulation-through-powsybl-a-hands-on-approach

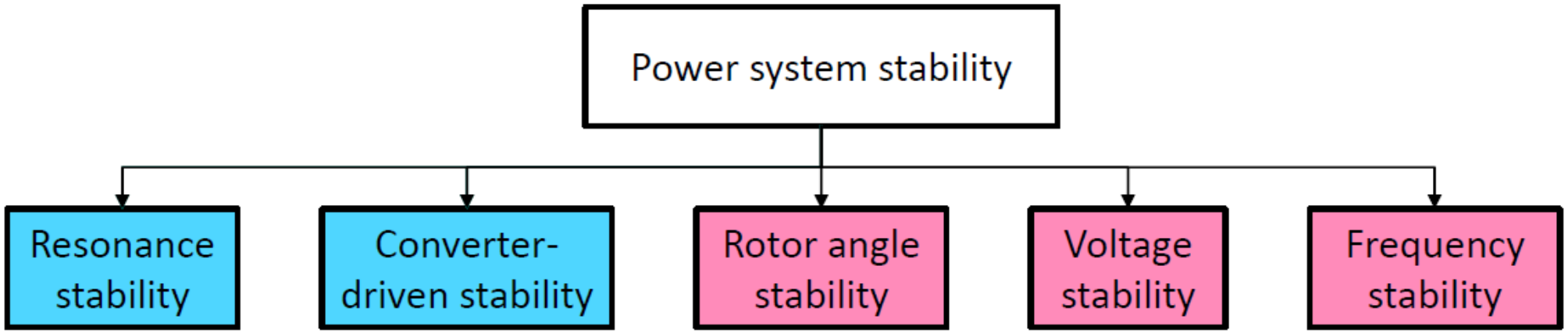
Rte Le réseau de transport d'électricité

LF ENERGY POWSYBL

The need for a new suite of simulation tools triggered by the deep evolution of power system dynamics

- Growing share of power electronics
  - either distributed (rooftop solar panels, EV, heat pumps, etc.)
  - or centralised (offshore wind farms, electrolysers, etc.)





Ongoing development of a new suite of simulation engines:

Simulation tools	DynaFlow Steady-state	DynaWaltz Long-term stability	DynaSwing Transient stability	DySym Short circuit calculation	DynaWave Fast dynamics calculation (quasi EMT)
Modelling	Simplified models	Phasor models	Phasor models	Simplified three-phase models	"Quasi-EMT" models
Numerical resolution	Simplified solver	Simplified solver	Specific DAE solver	Specific DAE solver	Specific DAE solver

Integrated in operational power system study platforms (powsybl) and demonstrated in operational context

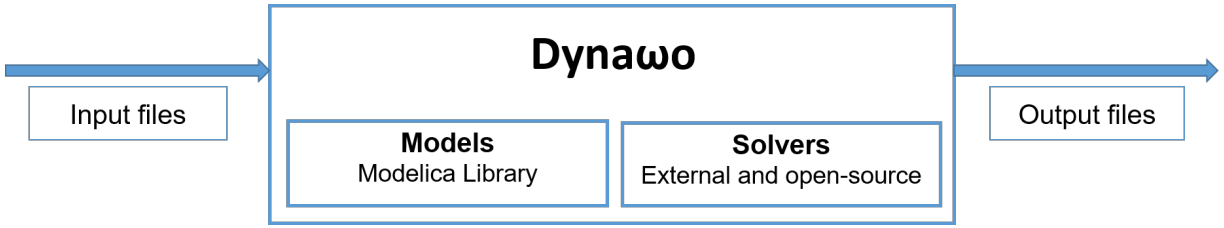
Used in production since 2022

Final validation underway

2025-2028 Roadmap

The Dynaωo approach

- Core principles:
  - Use of a high-level modeling language (Modelica)
  - Strict separation between the modeling and solving parts
  - Open source

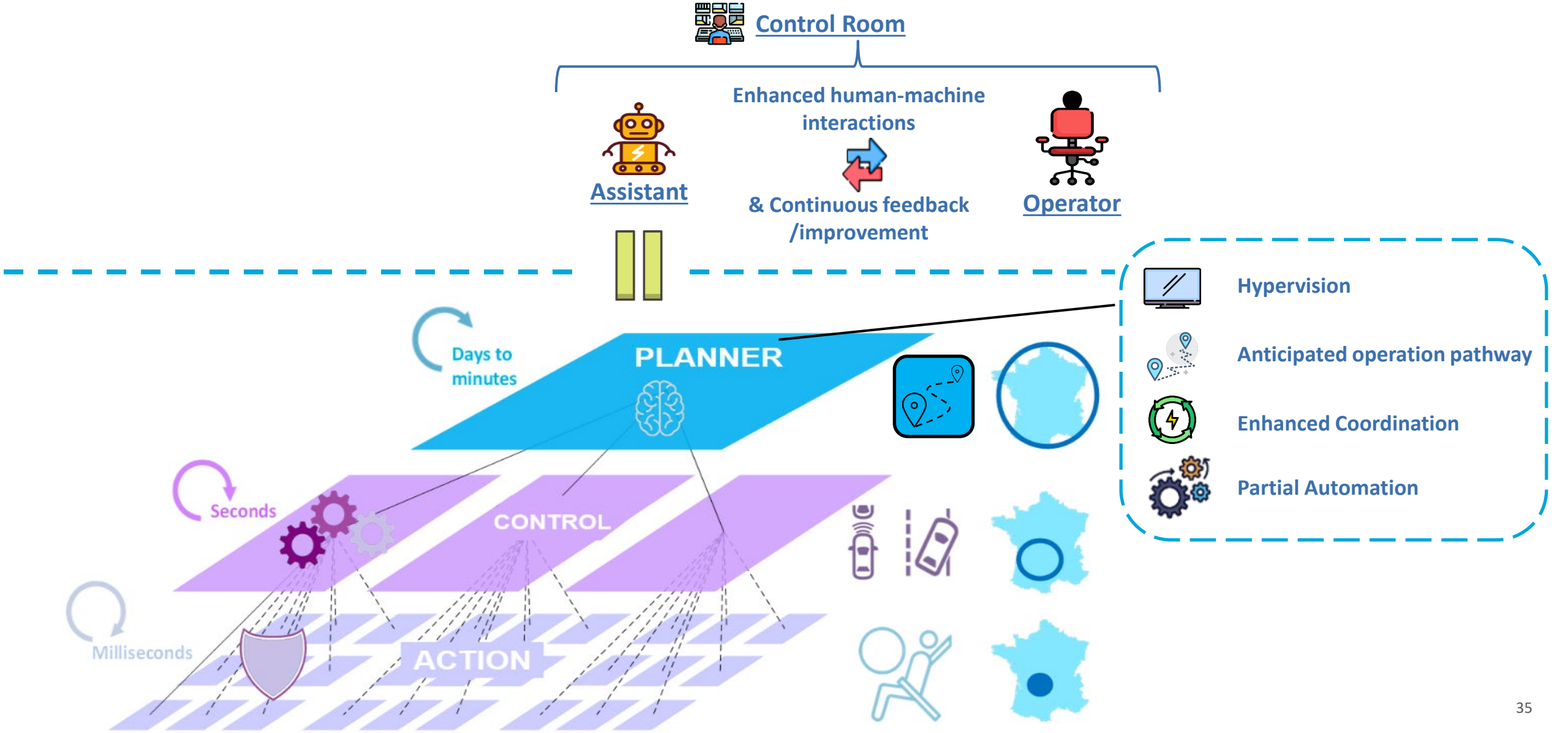


➔ Flexibility and transparency

- Enables collaborative studies by sharing data, modeling and solving choices

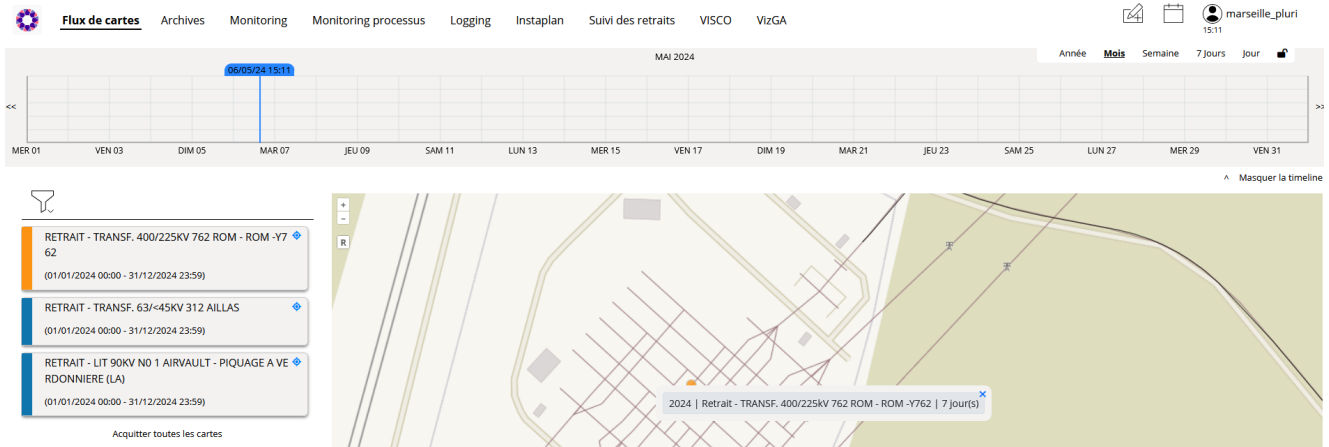
- Documentation: https://dynawo.github.io/

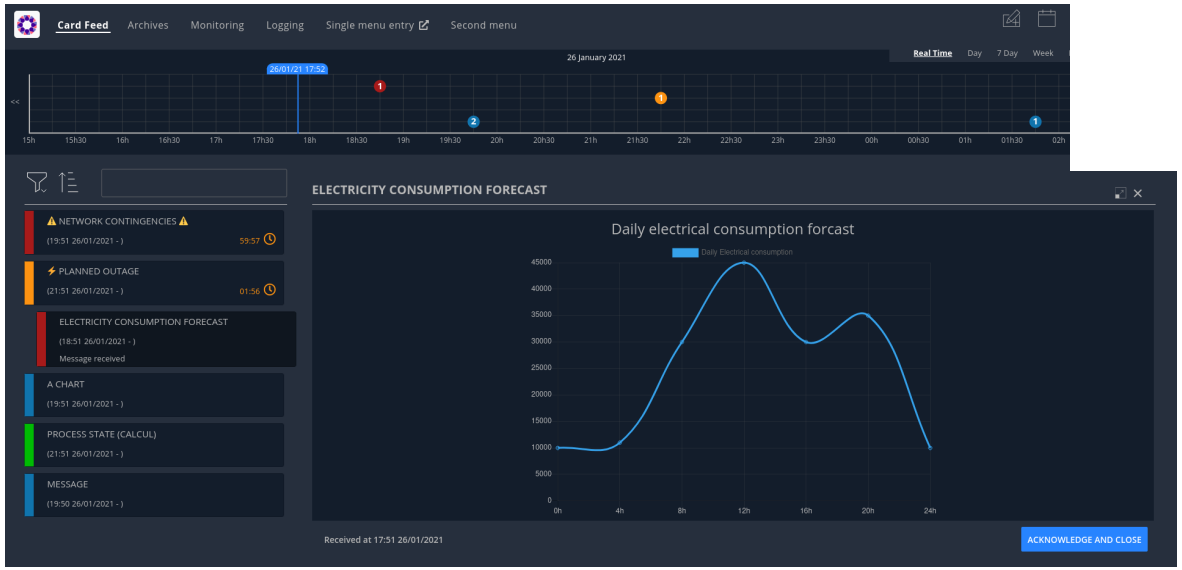
Rethinking the operational control of the grid from the control room down to protection and automation systems at the edge

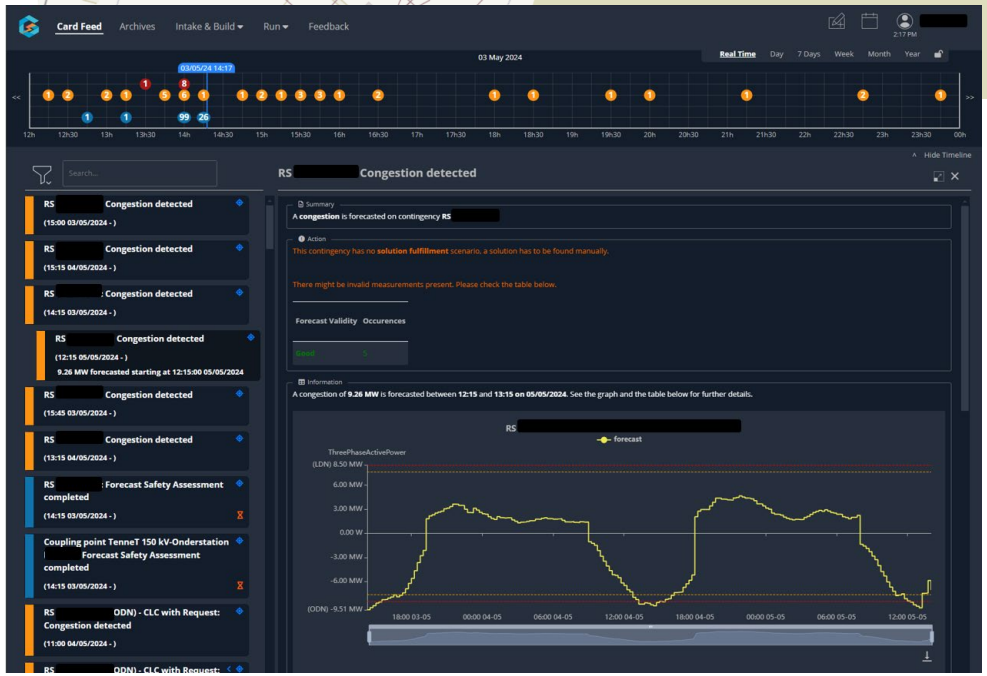


Hypervision: centralizing events and coordinating real-time interactions between operators

LF ENERGY
OPERATORFABRIC







OperatorFabric overview

- Centralization of real time business events in a single platform to avoid having multiple screens/software:
  - event notifications named “cards” with filtering features (severity, date, process…)
  - event dispatching rules on a per user basis (based on groups, organizational entities, processes…)
  - event-sending endpoints for business applications
  - a mechanism of templating to customize events rendering (using HTML5)
  - a view of events on a timeline and agenda view
  - storage of all the events (archive feature)
  - notifications via sounds
  - possibilities to integrate screens form other applications

- Facilitate interactions between operational control centers:
  - Share information in real time, as pre-formatted cards that can be sent either manually by operators or automatically by external solutions
  - Introduce pre-formatted question/response exchanges between control centers. This can be used to implement operational processes (with the notion of “last time to respond”)
  - Share events in calendar (also allowing repeating events)

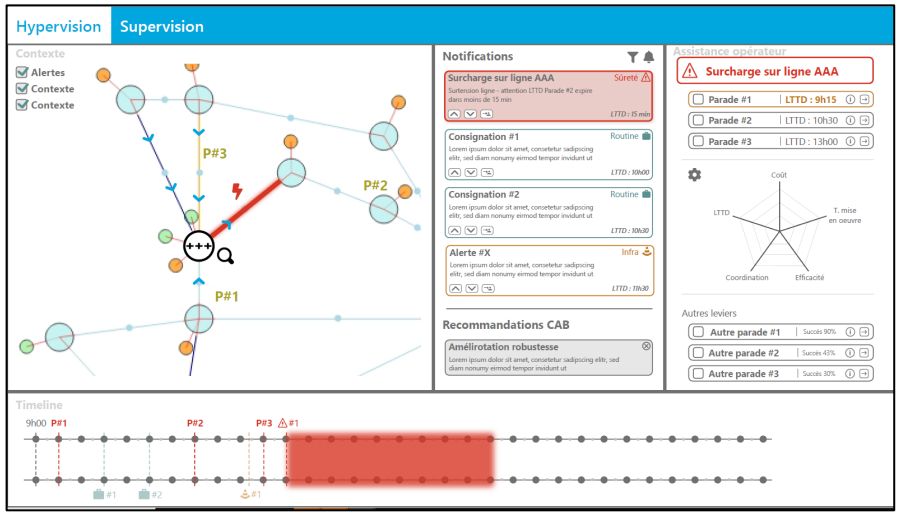
- Documentation: https://opfab.github.io/

Smart assistants for Grid Operations

ASSISTANT FOR GRID OPERATIONS

- ***Decision making assistant*** *to help* ***the operator define operation strategy.*** *Machine* ***learns from the human behaviors*** *(CAB project)*
- ***Hypervision concept*** *embodied by the* ***OperatorFabric opensource platform*** *(application for* ***grid operations use cases)***
- *Interaction tool to present* ***operation trajectory in anticipation*** *&* ***facilitate handover*** *between operators (Storylines project)*

Maturity level: TRL 2 to 5 (Explo - Mock up) **Partners:** Industrial, TSO

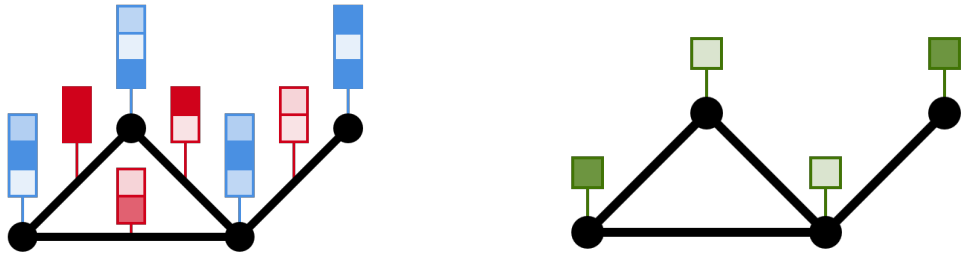


CAB (Cockpit and Bidirectional Assistant) interface

VOLTAGE CONTROL

- *Fast* ***Deep Learning*** *algorithms using* ***Graph Neural Networks*** *for* ***tertiary voltage control*** *and that remain relevant to* ***topological variations*** *(Idefix project)*
- ***Network clustering*** *by voltage level*

Maturity level: TRL 3 to 7 (Explo - Demo) **Partners:** University



- Production & consumption
- Line characteristics

Voltage set points

Deep Learning for Tertiary Voltage Control

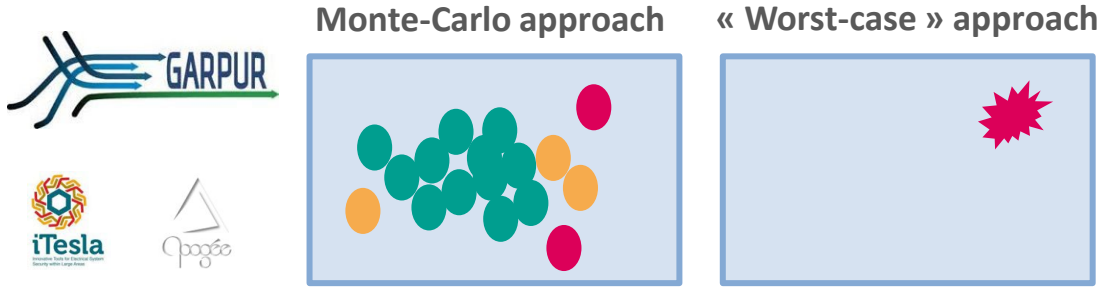
**TRL = Technology Readyness Level*

Smart assistants for Grid Operations

SECURITY ASSESSMENT

- ***New security assessment*** *under* ***uncertainties*** *using* ***robust optimization approach***
- ***National security assessment*** *followed by deeper* ***local security analysis*** *considering local specificities*

Maturity level: TRL 3 to 7 (Mock up - Demo) **Partners:** University, research institutes

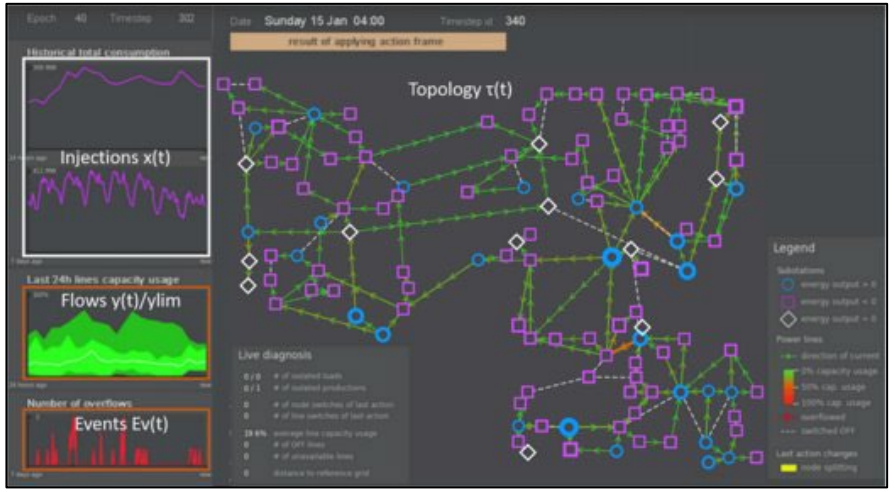


Worst Case approach vs Monte Carlo approach

AI

- ***Prototype of an AI assistant*** *for remedial action proposals (Paris Region AI Challenge)*
- ***EU project AI4Realnet:*** *Development of an* ***AI modules and frameworks*** *for industrial sectors involving physical networks (electricity, trains, aircraft)*
- ***Ontologies for contextualizing operational situations****: capitalization on decisions, digitalization, etc. (SMD project)*

Maturity level: TRL 3 to 5 (Mock up - Explo) **Partners:** Industry, University



Interface of the prototype developed by "La Javaness"

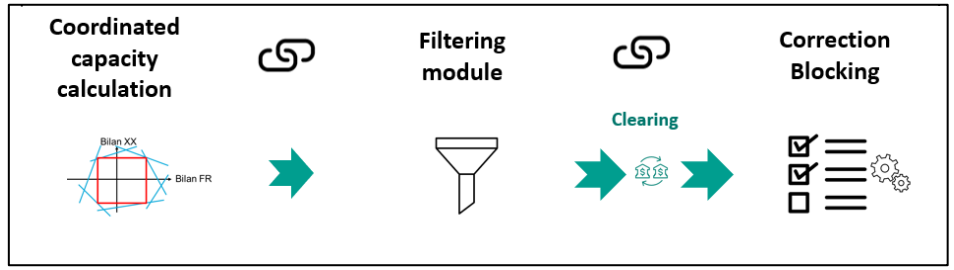
**TRL = Technology Readyness Level*

Smart assistants for Electricity Balancing

COORDINATION BTW. ELECTRICITY BALANCING AND GRID CONGESTION MANAGEMENT - FLEXIBILITIES

- ***Different modes of coordination between balancing and congestion management*** *will be explored with a specific focus on* ***new flexibilities*** *(storage, EV, aggregators, distributed generation, etc.)*
- ***Bid filtering*** *for* ***congestion management*** *in European balancing markets with* ***reinforcement learning approach***

Maturity level: TRL 2 to 6 (Exploration – Mock up) **Partners:** University

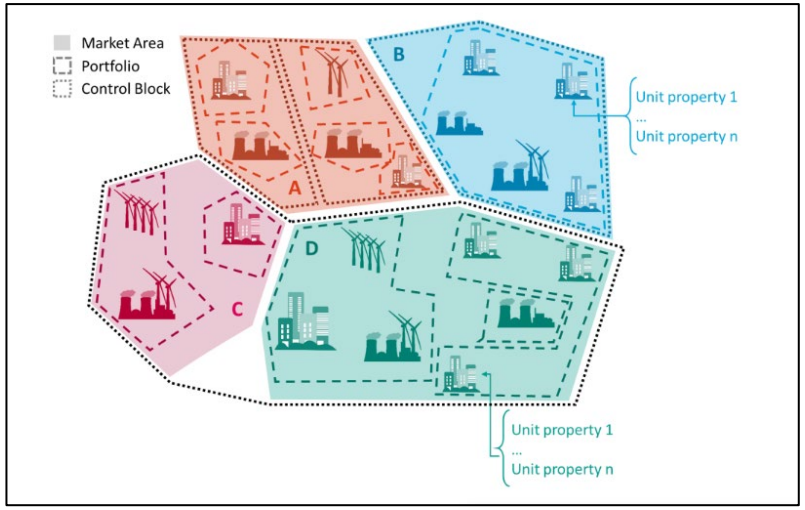


Process to coordinate electricity balancing and grid congestion management

MODELING FROM D-1 TO REAL TIME & ACTOR STRATEGIES

- ***Agent-based modeling*** *of balancing platforms, simulation of balancing in* ***prospective scenarios*** *and* ***simulation*** *of a range of* ***actors' strategies*** *(ATLAS project)*
- *Impact of* ***RES uncertainties*** *or* ***technical constraints*** *on* ***balancing***

Maturity level: TRL 3 to 6 (Mock up – Demonstration) **Partners:** University



Simulation of balancing operations, considering the behaviour of stakeholders

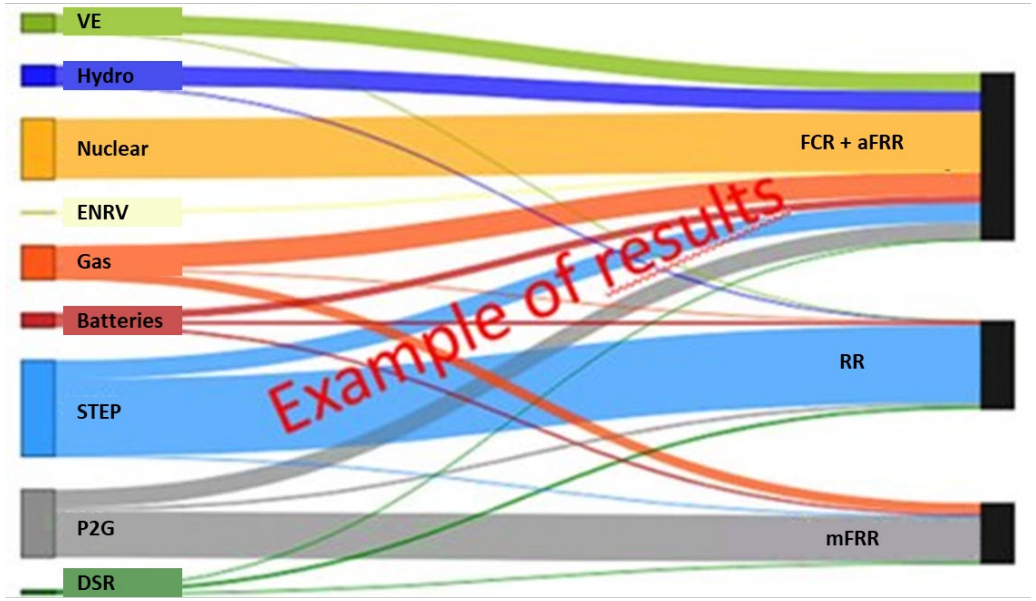
R&D AMBITIONS 2024-2028

Smart assistants for Electricity Balancing

RESERVES SIZING

- *Reserves **sizing and contracting** studies*
- *New **risk criterion**: **Analysis of the historical effective risk level**, continuation of tests with a **probabilistic unit commitment***
- *Impact of **forecast errors** on the need for reserves*

Maturity level: TRL 3 to 6 (Mock up – Demo) **Partners:** University, TSO



Which suppliers of reserves in the future?

ASSISTANT FOR BALANCING

- ***Balancing decision support tool** for operators: current operation and possible future developments*
- ***Hypervision concept** embodied by the **OperatorFabric opensource platform** (application for **balancing use cases**)*

Maturity level: TRL 3 to 6 (Mock up – Demo) **Partners:** University, industrial, research institutes

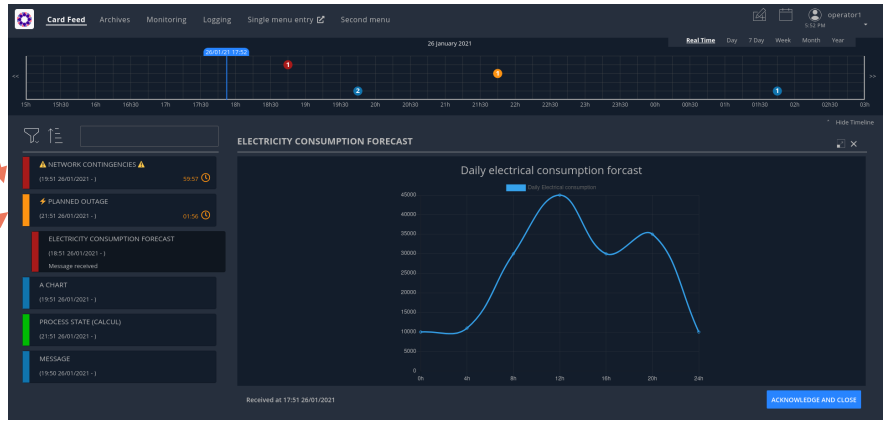
TOPASE

MAUI

...

LiFo

LFENERGY OPERATORFABRIC



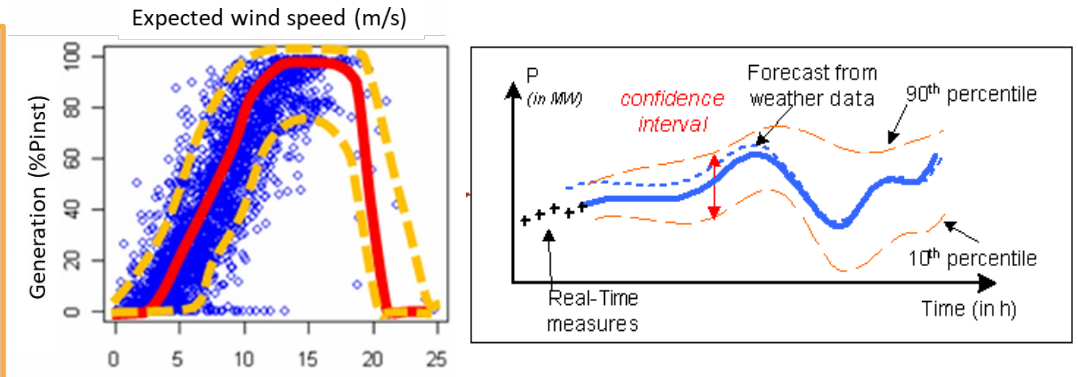
From Supervision to Hypervision

Short term forecasts

WIND FORECASTS

- ***New meteorological products*** *used (including* ***wind gusts****) and integration of* ***new influencing factors***
- ***New approaches according to the forecasting horizon*** *(spatio-temporal model: forecasts based on measurements of surrounding parks) and the* ***geographical area concerned*** *(STA project)*
- *Forecasts considering* ***renewable limitations and market effects (negative spot prices)***

Maturity level: TRL 4 to 8 (Mock up – Implementation) **Partners:** NA

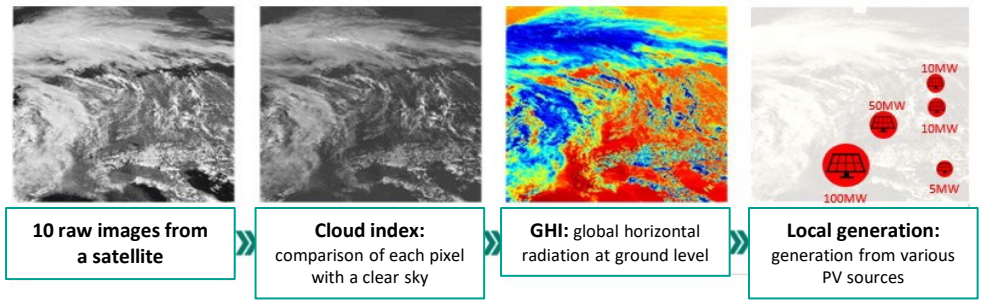


RTE's wind power short term forecast model

PV FORECASTS

- ***Estimate local PV generation*** *by processing* ***satellite imagery*** *(5x5km every 15 minutes) using* ***machine learning*** *algorithms or more theoretical models (MEMPHIS project)*
- ***Extrapolate cloud mass displacements*** *from satellite imagery or* ***use of deep learning*** *to model non-linear cloud displacements (CMV project)*

Maturity level: TRL 5 to 9 (Mock up – Implementation) **Partners:** Research Institutes



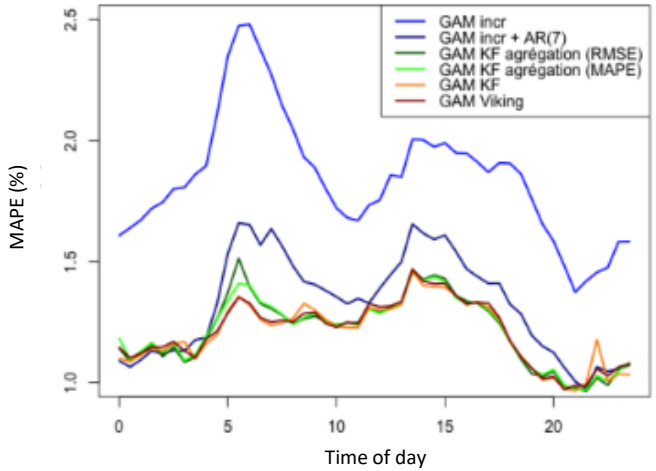
Satellite image processing to estimate PV generation in real time

Short term forecasts

LOAD FORECASTS

- ***Adapting forecasting models*** *to* ***recent structural load*** *(sanitary crisis, sobriety, market prices...)*
- ***New net load forecast*** *to overcome* ***poor local observability***

Maturity level: TRL 2 to 5 (Exploration – Mock up) **Partners:** Private Company



Comparison of performances between different load forecasts models in 2021

TOOLS

Opensource platform *to* ***package all our forecasting models*** *with* ***automatic machine learning pipelines*** *(training, prediction, deployment, monitoring, archiving) (OpenSTEF project)*

Maturity level: TRL 6 to 8 (Demo – Implementation) **Partners:** DSO

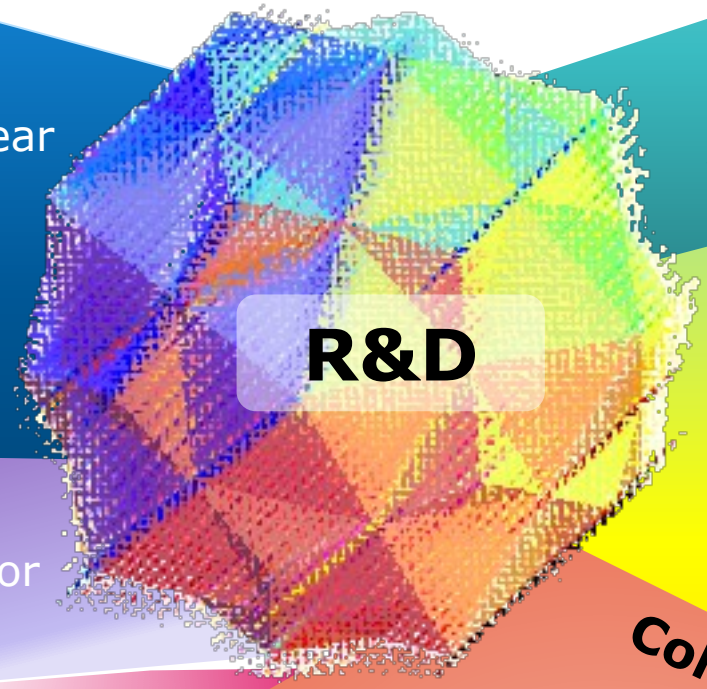
Interface of the forecasting opensource platform

Overview of RTE's R&D

Overview of RTE's Research & Development

Research & Development

- Budget (incentive regulation) ≈ 40M€/year
- Around 130 in-house staff
- ≈ 18 ongoing PhD theses



Publications

~ 40 publications/year

Expertise

- **10 🧍 within the R&D Department**
- Expertise support to day-to-day activities
- Adequacy and prospective studies, grid stability, etc.

Public funding

- 6 ongoing projects with funding from EU or FR programs
- 6 new consortium proposals submitted in 2023

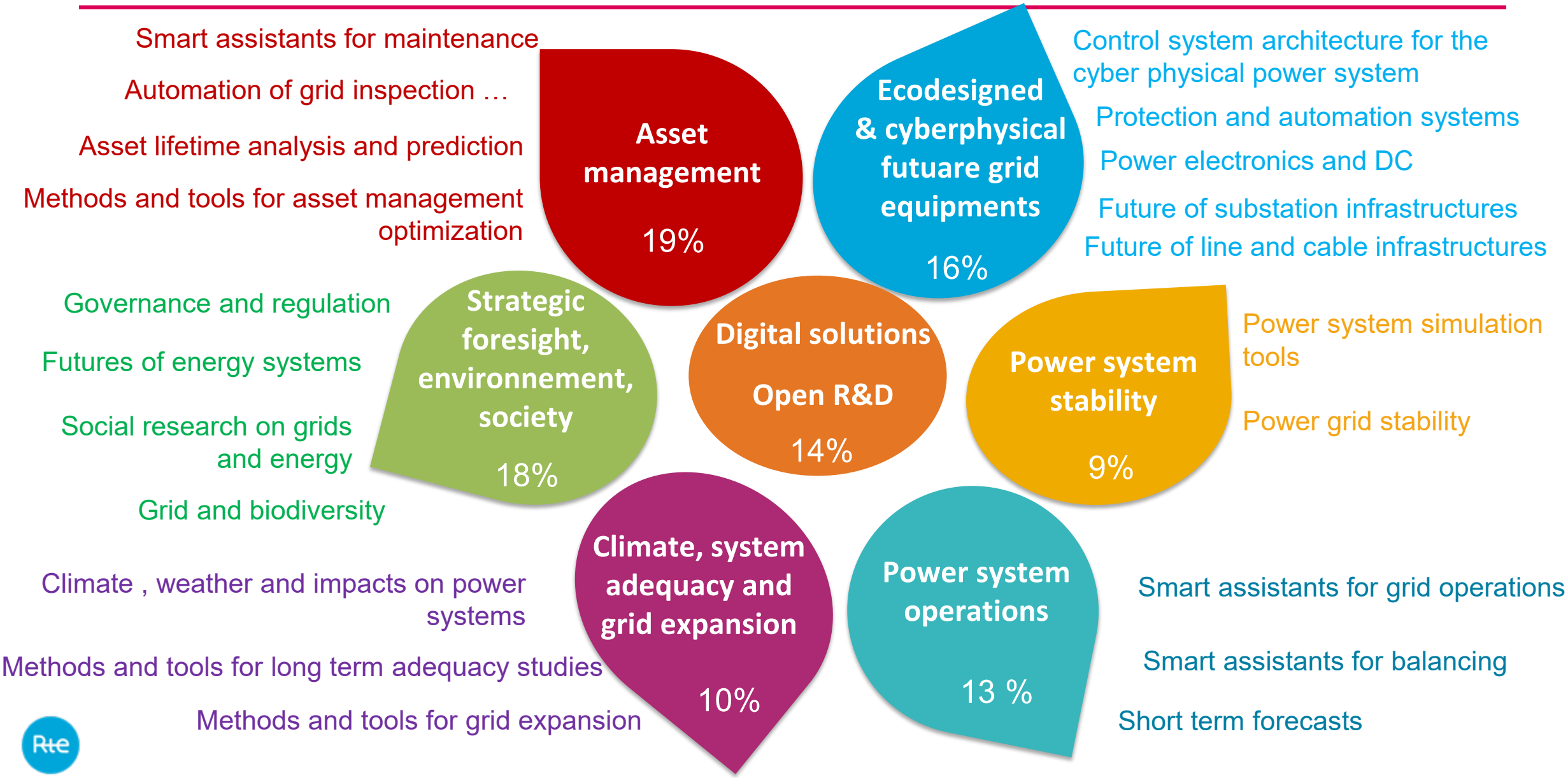
Collaborations

- **More than a hundred partnerships**
- **Universities, TSOs, Industry**
- **All over the world**

Standardization

- **Standardization Program lead**
- 50 experts involved across 40 working groups

8 R&D Programs and 23 Clusters



Nurturing a broad ecosystem of R&D partners throughout the world

National

centralelille
METEO FRANCE
cea
CentraleSupélec
utc
ANDRA
L2EP
ARMINES
LAAS CNRS
ines
INSTITUT NATIONAL DE L'ENERGIE SOLAIRE
CENTRALE NANTES
FRANCE ENERGIES MARINES
EPFL
Grenoble INP
anrt
ASSOCIATION NATIONALE RECHERCHE TECHNOLOGIE
SystemX
G2Elab
Ceebios
Dauphine | PSL
SuperGrid Institute
le cnam
école normale supérieure paris-saclay
université PARIS-SACLAY
SciencesPo ÉCOLE URBAINE

European

Commission européenne
SINTEF
entsoe
EPFL
DTU
UNIVERSITY OF OXFORD
EUI FLORENCE SCHOOL OF REGULATION
OpenModelica
INESCTEC
Imperial College London
RSE
MANCHESTER 1824
The University of Manchester
alliander
RWTH AACHEN UNIVERSITY
TU Delft
Fraunhofer
KTH VETENSKAP OCH KONST
ETH zürich
KATHOLIEKE UNIVERSITEIT LEUVEN
University of Cyprus
UNIVERSIDAD PONTIFICIA COMILLAS
ULg UNIVERSITÉ de Liège
UNIVERSITÉ DE GENÈVE
University of Ljubljana
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

International

PSERC
Lawrence Livermore National Laboratory
POLYTECHNIQUE MONTRÉAL
UNIVERSITÉ D'INGÉNIERIE
Stanford University
Georgia Tech
UNIVERSITÉ DE SHERBROOKE
WASHINGTON STATE UNIVERSITY
IOWA STATE UNIVERSITY SCIENCE AND TECHNOLOGY
LF ENERGY
MOHAMMED VI POLYTECHNIC UNIVERSITY

Young shoots

Dynamica
rovenso
COSMOTECH
Dowel innovation
GRUPO AIA
DYNAMICA
Artelys OPTIMIZATION SOLUTIONS
BLACKLIGHT ANALYTICS
SMART WIRES
T&D europe
Softlab
Rte

Large companies

SNCF
europacable Try life without us
GRTgaz
Schneider Electric
GE
SIEMENS
Prysmian
Ingeteam
orange
CSTB le futur en construction
ENIM Air Space
ENEDIS L'ELECTRICITE EN RESEAU
CCR

Embracing an open collaboration model aiming at :

- An acceleration by reusing what exists and sharing efforts, allowing to build faster and cheaper solutions,
- Improved modularity, interoperability, evolutivity and shorter release time cycles,
- Cutting-edge technological and business model innovation,
- Access, through collaboration, to wider and more diverse skills and to a diversity of viewpoints,
- Reduced vendor lock-in or customer-specific approaches that impede velocity and cost-efficiency.

LF ENERGY
STRATEGIC MEMBER

CRESYM

The OSPO

The OSPO

Learning from more advanced industries: a successful open source strategy requires a structured organization, i.e. an Open Source Program Office

An OSPO has been set up at RTE since 2019 with the following missions:

- Understand open source (compliance, governance, business models) and educate internally
- Promote an open source ambition, monitor objectives and milestones
- Promote adaptations of internal business processes (development practices, procurement) in accordance with the open source strategy
- Disseminate best practices, implement learning loops, support projects to go open source
- Coordinate the interaction with external stakeholders, contribute to community building
- Manage the specific compliance and trust challenges of open source

The OSPO

Structured in a lean way

- 1 full time Open Source Program Officer (access to C-level management is a key enabler)
- A network of (part-time) contributors disseminated in the existing organization: 2 enterprise architects, 1 dev team manager, community/tech leads of open source projects, lawyer

Rationale:

- Limited resources
- Disseminate open source practices withing the regular software activities

Material on OSS at RTE

WHAT IS OSS?

Free/Libre Software are software distributed with a license offering:

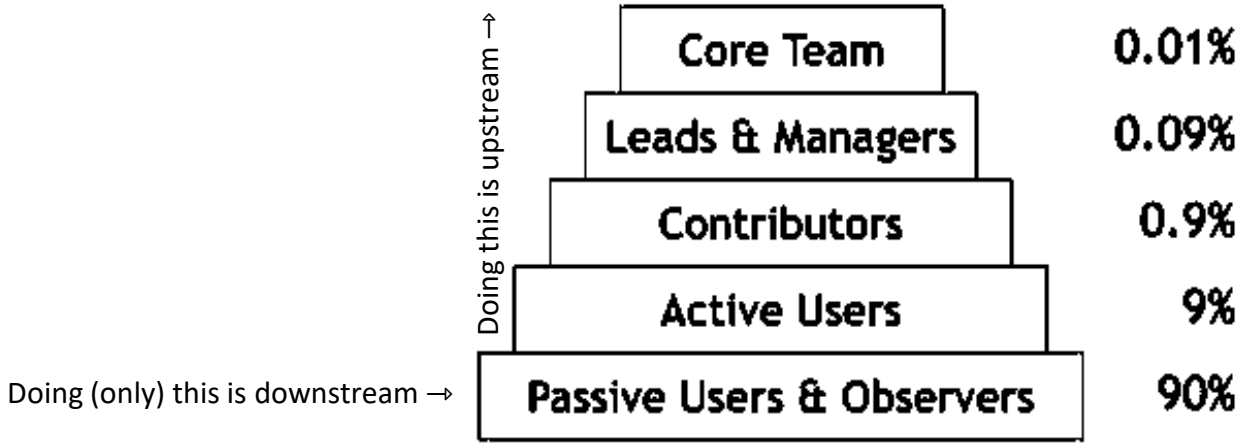
Freedom 0: The **freedom to run the program** as you wish, for any purpose.

Freedom 1: The **freedom to study** how the program works, and **change** it so it does your computing as you wish
Access to the source code is a precondition for this.

Freedom 2: The freedom to **redistribute** copies so you can help others.

Freedom 3: The freedom **to distribute copies of your modified versions** to others.
By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.

- What is OSS?
  - open vs libre/free
  - downstream
  - upstream



Open-Source Software (aka OSS) are software distributed with a license offering:

Free Redistribution

Source Code

Derived Works

Integrity of The Author's Source Code

No Discrimination Against Persons or Groups

No Discrimination Against Fields of Endeavor

Distribution of License

License Must Not Be Specific to a Product

License Must Not Restrict Other Software

License Must Be Technology-Neutral

SOMMAIRE

Upstream and Downstream

IFRI : 80% à 96% lines of code in an closed-source software is based on open source.

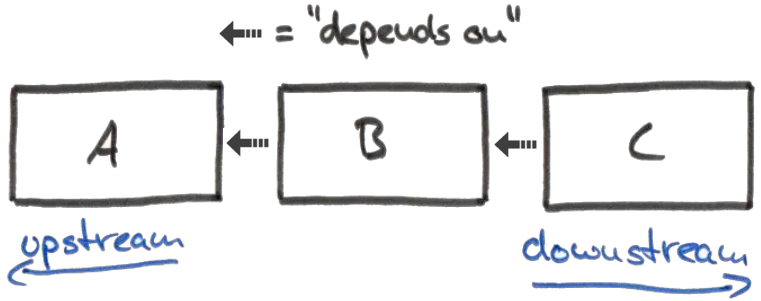
1) Upstream is a dependency relation link
   « *C depends on B and A* »

2) If project C contributes to project B (or A)
   - « *Its contribution goes Upstream* ».

As a projet A, having good* upstream contributions from B or C is a direct benefit for project A.

- « *Open source is the art of making together* »

When you are used to buy proprietary software, you either prefer to make or buy. There's an other way => make together.



*good is about managing your community and your digital asset (roadmap, contribution rules, modularity, …)

VALUE (1/2)

- A (little) discussion about value:
  - where is it?
  - what is it?

1) The kitchen use case (material world)

1.a) Where is the value?

- Let's rank where is the value (big to low)

1.b) What is the final value?

- A need to keep something secret?

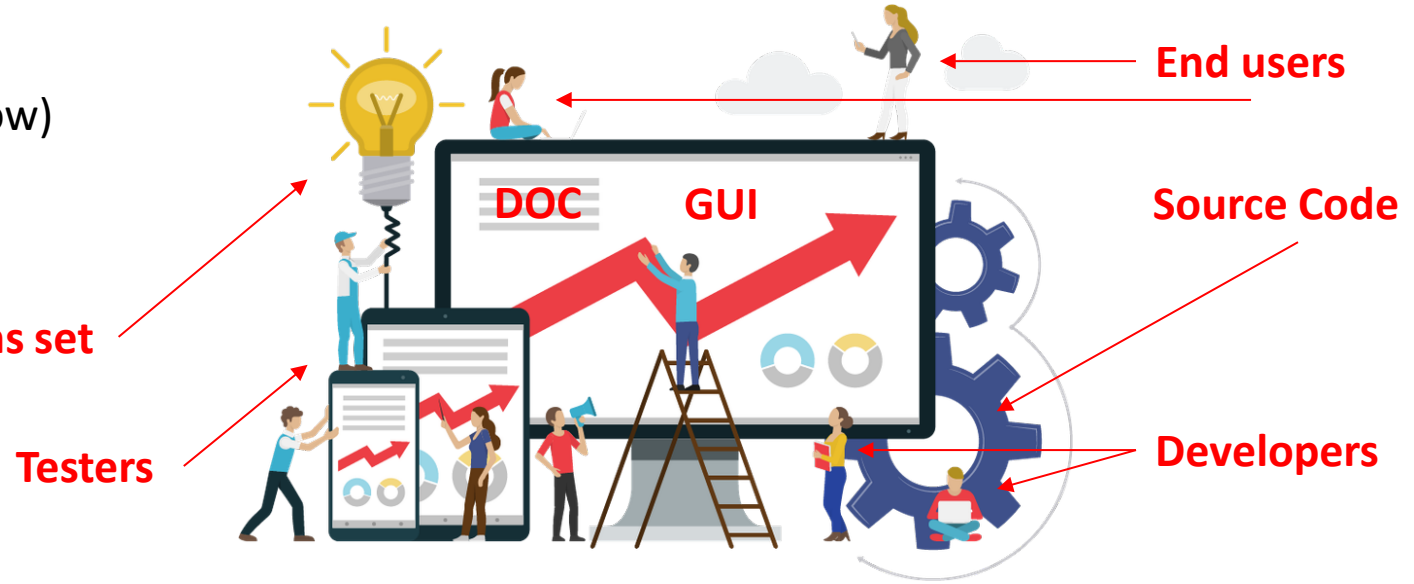
2) The software use case (immaterial world)

2.a) Where is the value?

- Let's rank where is the value (big to low)

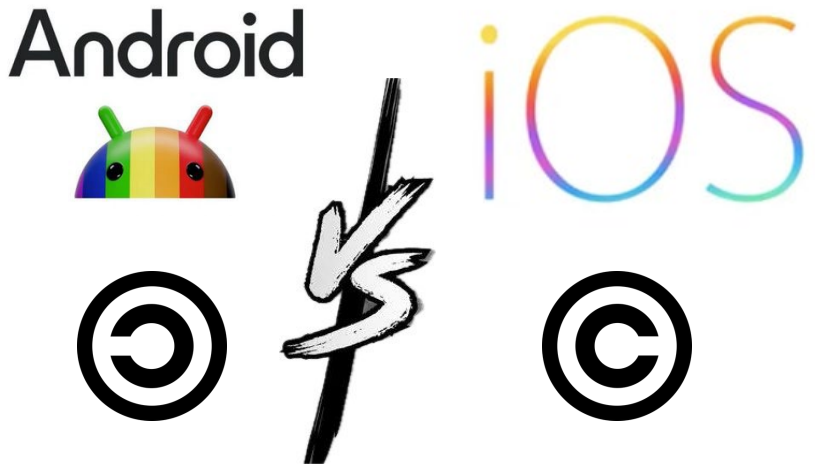
2.b) What is the final value?

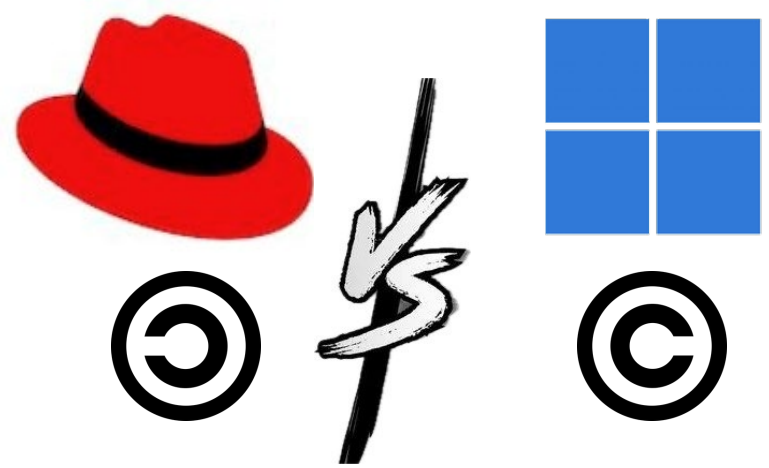
- A need to keep something secret?



VALUE (2/2)

- A (little) discussion about value:
  - where is it?
  - what is it?





CONCLUSIONS THINKING ABOUT OPEN-SOURCE SOFTWARE:

- we need to **forget** all we believed concerning **the software value**
- we need to **focus on the pain points doing software** > and what Open Source brings to help
- we need to shift our minds from “value is in the secret of source code” to “**code is not THE (biggest / only) value**”