

Interoperable Recommender

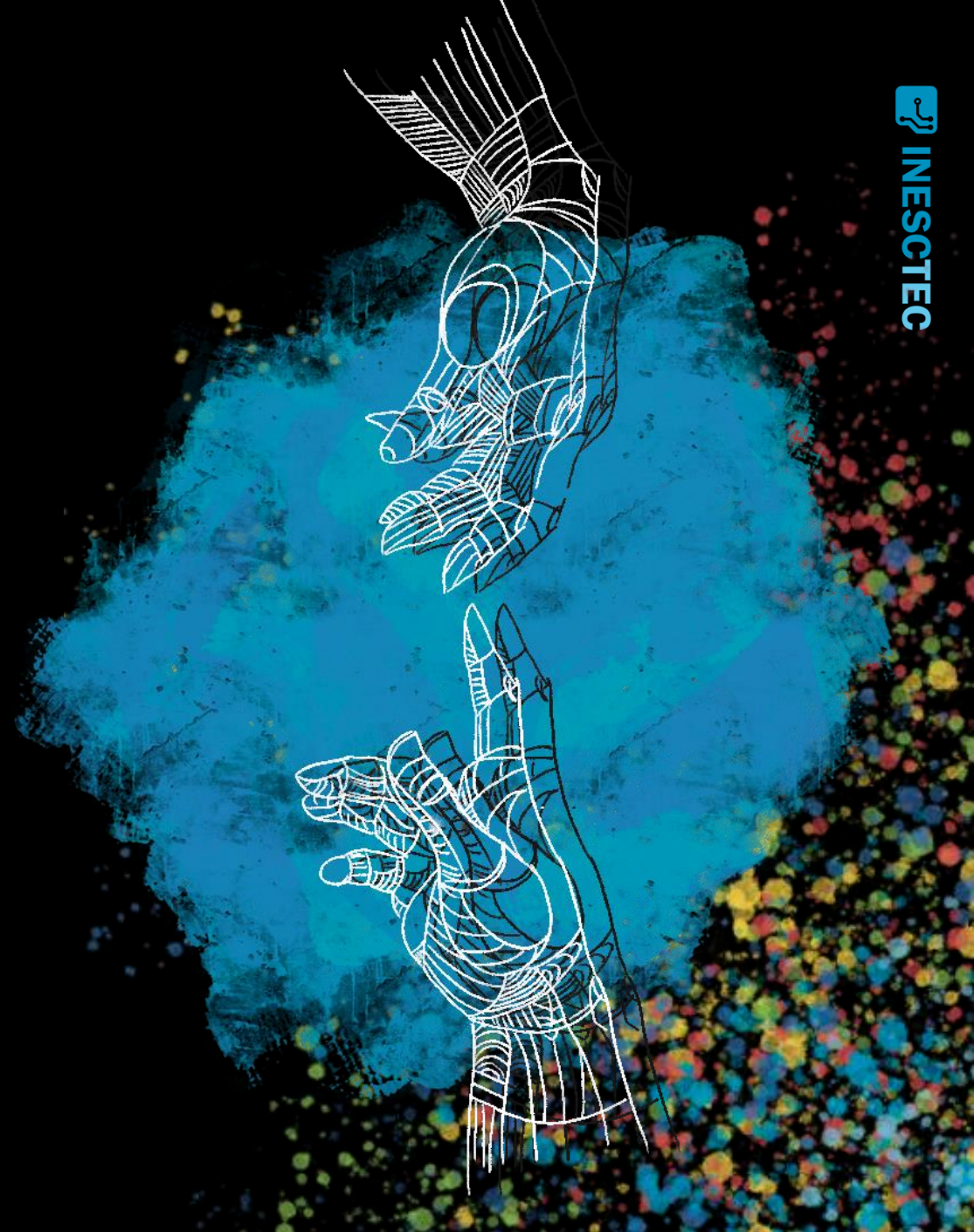
*Enhancing Energy System Resilience
with a Recommendation System
for Voluntary Demand Response*

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INSTITUTE FOR SYSTEMS
AND COMPUTER ENGINEERING,
TECHNOLOGY AND SCIENCE



InterConnect at a glance

- **H2020 Large Scale Pilot (2019-2024)**
 - InterConnect gathers **50+ European entities** to develop and demonstrate advanced solutions for connecting and converging digital homes and buildings with the electricity sector.
- **Cross-domain semantic interoperability based on SAREF over several use-cases**
- **Validation in 7 connected large-scale test-sites:**
 - PT, BE, DE, NL, IT, EL and FR.

SIF

DSOi

IR

Open Calls

- **OC1:**
Interoperable Prototypes
- **OC2:**
Energy Applications

R&D



Consultancy

Associations

DSOs

Retailers



Manufacturers



IoT/ICT Providers

End-user



interconnectproject.eu

Challenges and Roadmap for Energy Resilience in Europe

Challenges: Climate change, geopolitical risks, decarbonization → increased reliance on renewable energy, but with variable supply.

Need: Greater flexibility in energy consumption to help prevent periods of excess demand or energy generation

Sustainability: Aligned with the EU's action plan goals by promoting smarter energy use

CERF-Compliant Energy Applications (EU2020 InterConnect)

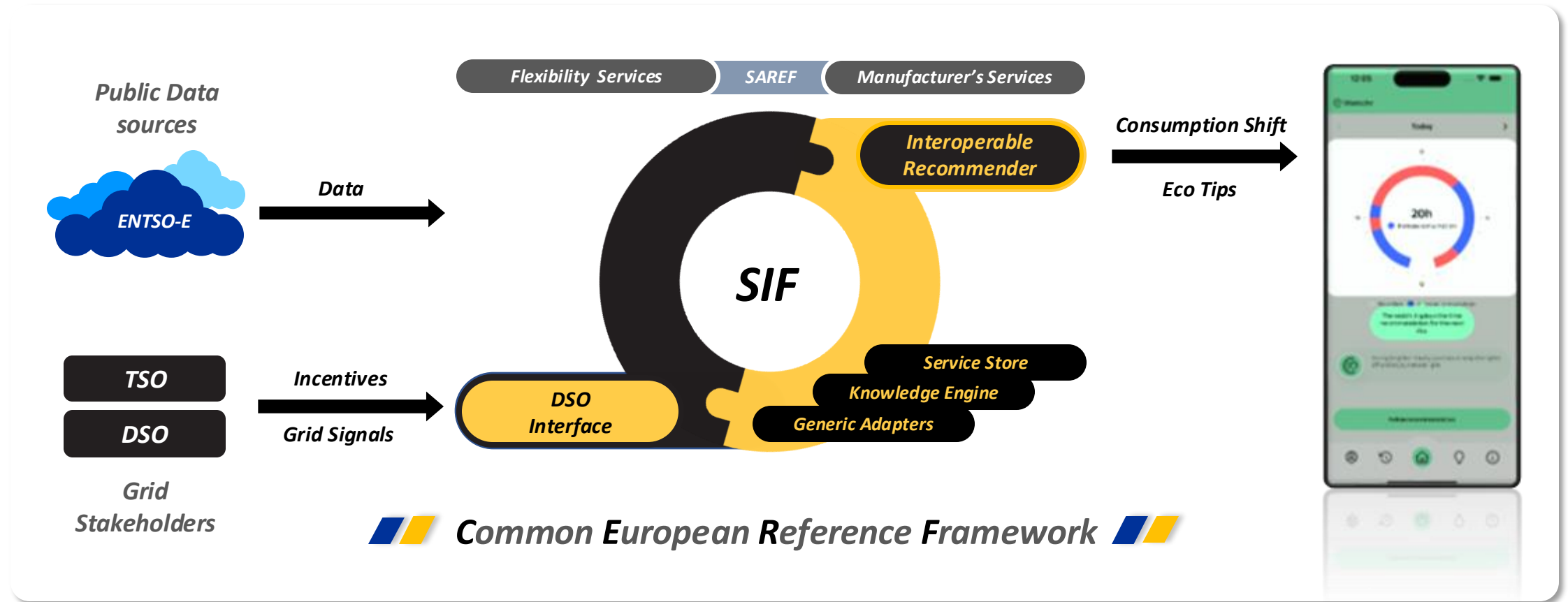
Goal: Demonstrate the adaptability of H2020 InterConnect project to support a new use-case: Energy applications aligned with the *Common European Reference Framework (CERF)*

Method: Use flexibility from the demand side alongside “grid signals” to engage end-users to help improving system resilience

Challenge: implement a credible technical and scientific strategy for end-user participation

W
H
Y

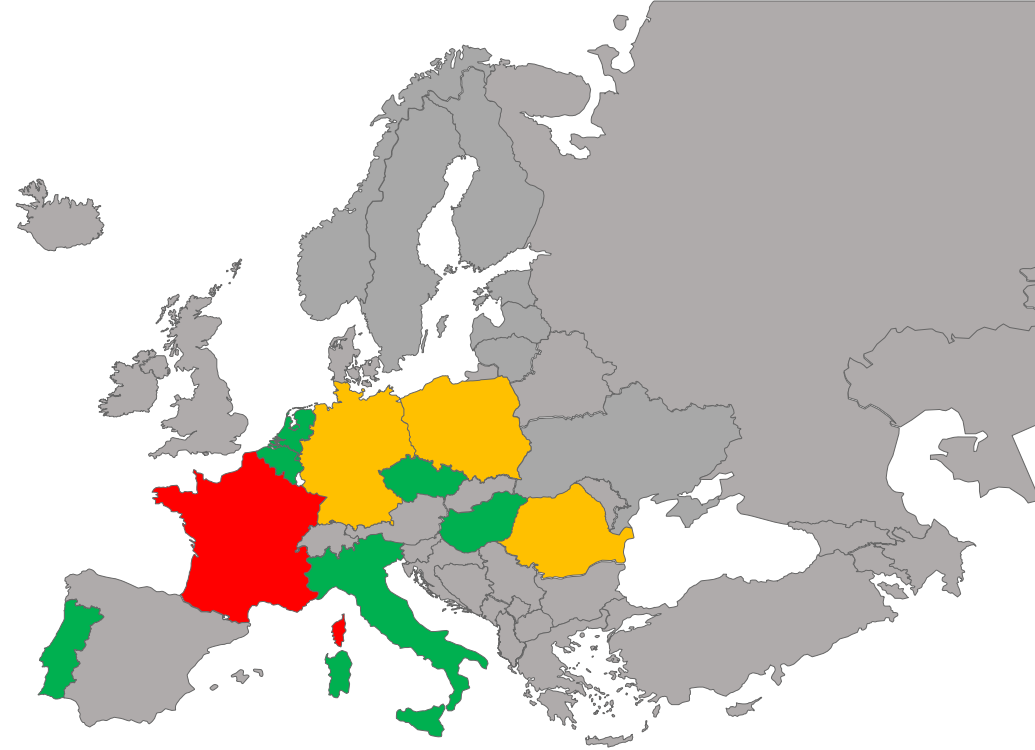
CERF - Enabling an Ecosystem of Stakeholders



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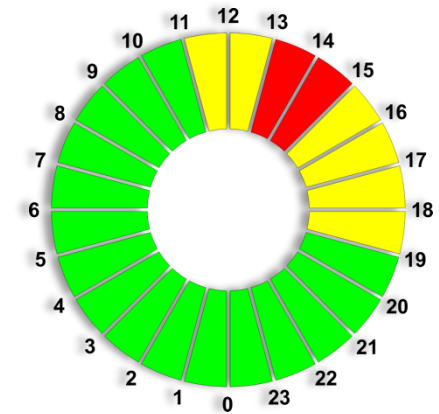
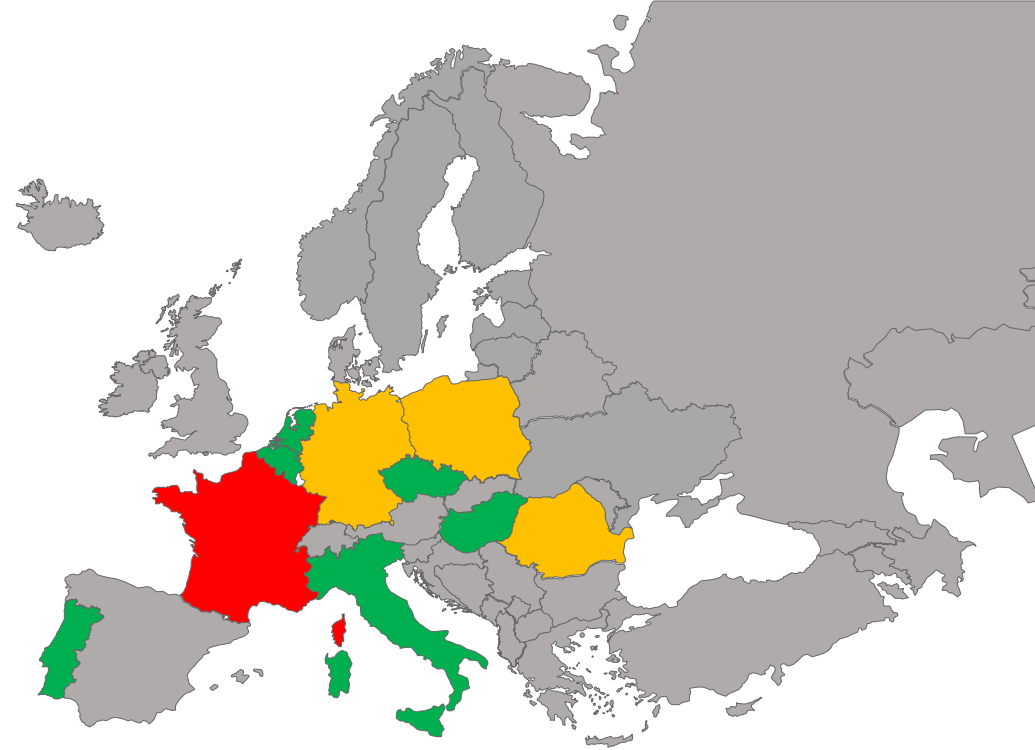
Objectives

- Develop a methodology to assess periods of **expected system vulnerability** in Europe's energy infrastructure
- Promote **country-level actions** (increase/decrease energy consumption) during those periods to enhance resilience
- **Data-driven methodology** to assess vulnerability and compute actions with publicly available data, considering the status of each country and its neighbours/interconnections
- Share this information with other interested parties, through the **EnergyAPP backend**



Interoperable Recommender Methodology

- **System vulnerability? Why?**
 - RES generation **variability** and **forecast uncertainty**
 - Increasing challenges of **day-ahead load forecasting**
- **Risks?**
 - Risk of **energy scarcity** or **renewable energy curtailment**
 - **Unexpected** problems and unavailability of reserve capacity
- **How to proceed?**
 - Calculate the **system margin** per country considering **load and RES forecast uncertainty**
 - Extract **risk attributes** from the system margin to assess the impact of a potential reserve level
 - Define **country-level actions** to mitigate this risk and enhance resilience for **each country and its neighbours** (interconnections)



Hourly recommendations
(per country in the pilot)

Interoperable Recommender Methodology

1. **Data Acquisition:** Collect real-time, publicly accessible system data from ENTSO-E Transparency Platform

2. **Forecasting:** Create RES / Load Probabilistic Forecasts (Quantiles)

3. **Risk Assessment (country specific)*:**

- Calculate system margin
- Develop risk-reserve curves
- Calculate reliability indexes (LOLP, PCRE)
- Find operating reserve requirements (based on *TSO risk threshold*)
- Calculate deterministic rule for reserve (DRR)

5. **Final Recommendations**

- Evaluate if the current DRR meets acceptable risk criteria.
- Simple output. Easy to communicate.

● $R \leq DRR \rightarrow$ Healthy

● $R > DRR \rightarrow$ At Risk

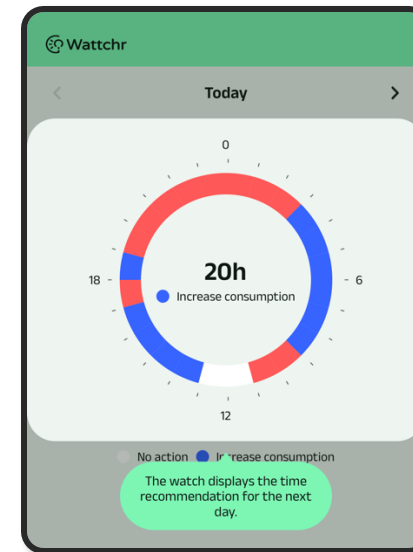
Healthy \rightarrow No recommendation

Upward Risk \rightarrow Decrease Consumption

Downward Risk \rightarrow Increase Consumption

4. **Risk Coordination:**

- Assess if a country's interconnections could help mitigate risk

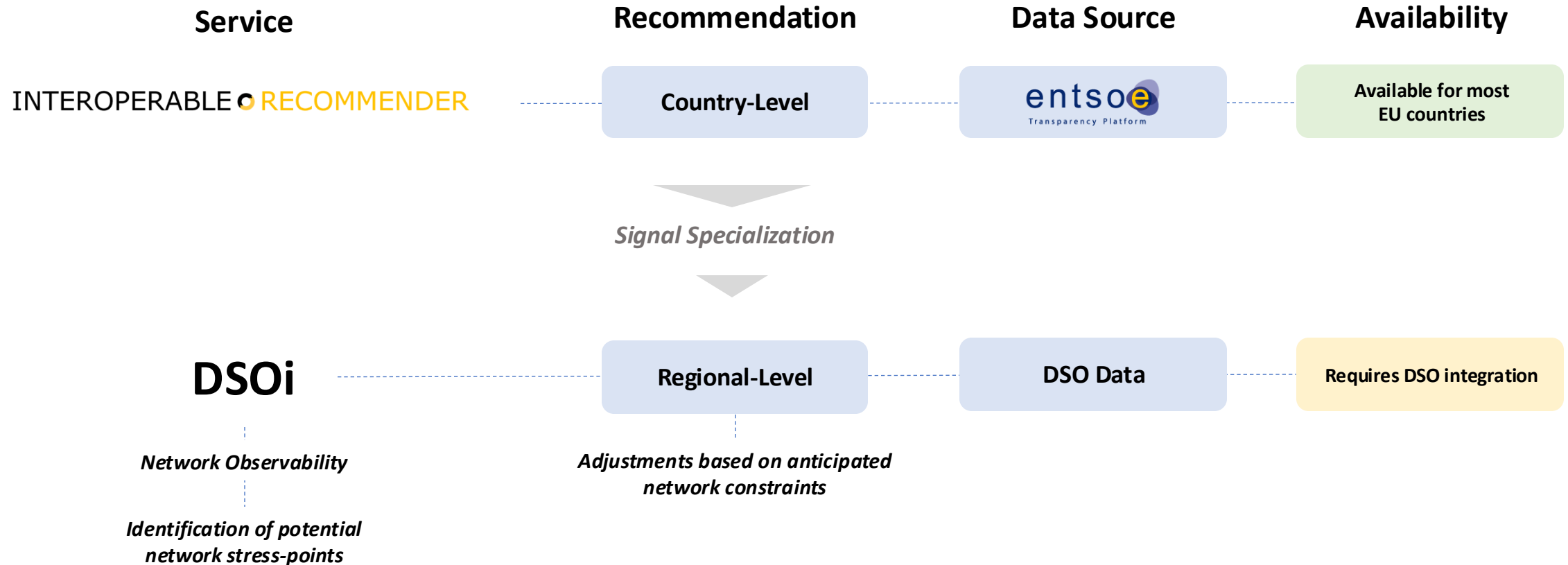


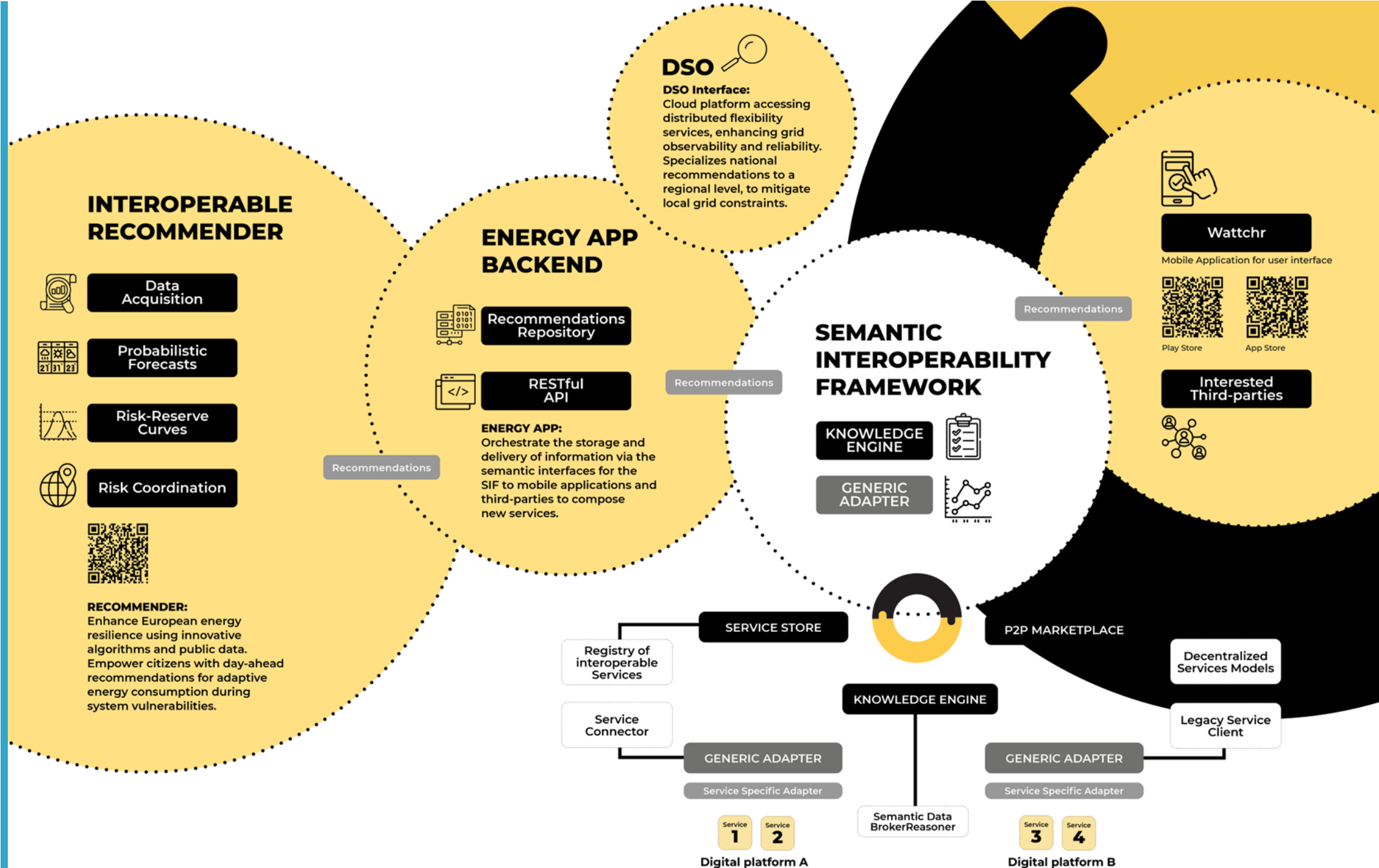
(Wattchr APP)

* Reference: M.A. Matos, R.J. Bessa, "Setting the operating reserve using probabilistic wind power forecasts" IEEE Transactions on Power Systems, vol. 26(2), pp.594-603, May 2011.

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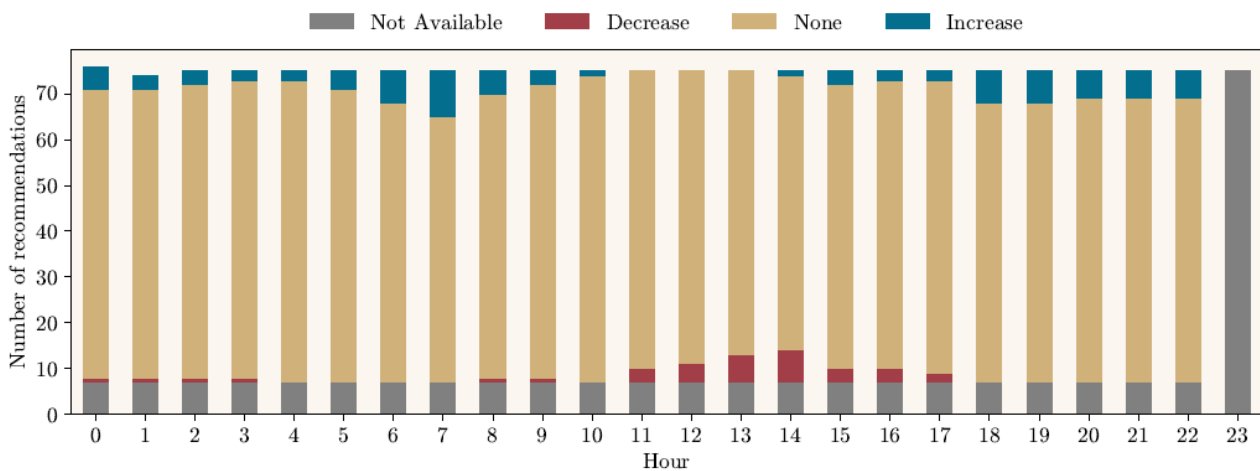
Towards regional recommendations





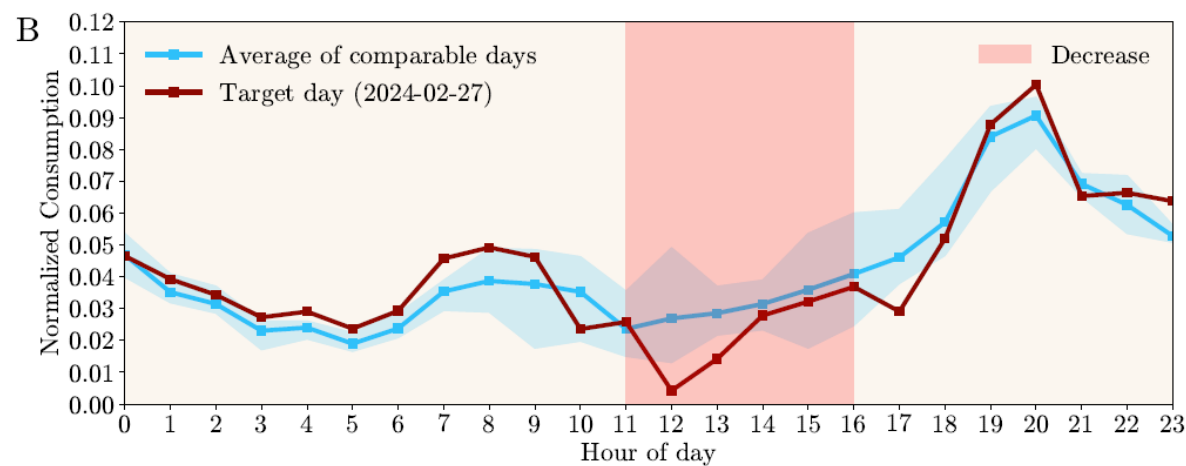
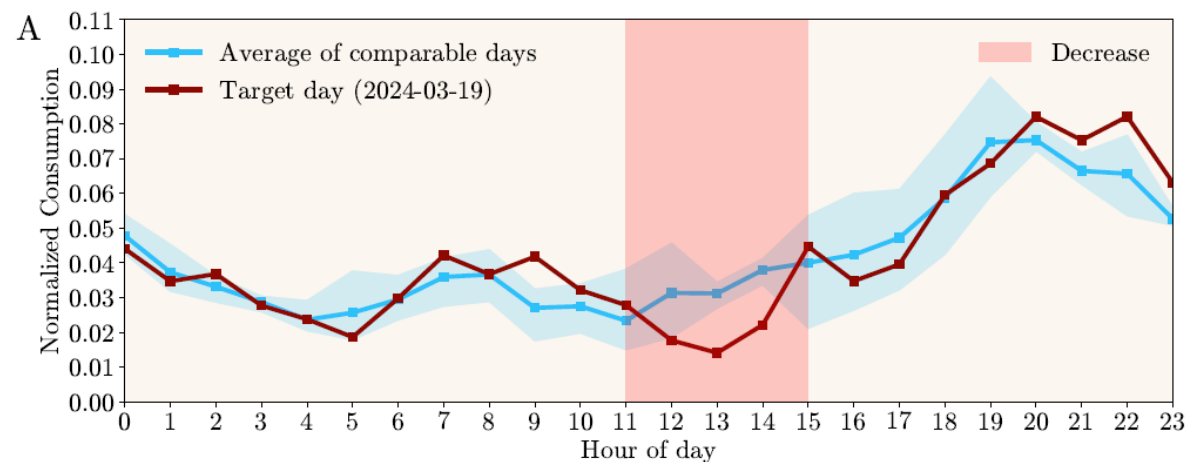
Pilots Key Results

- Service operational during multiple months in **12 countries**
- **400+ consumers involved** in testing
- Preliminary results show **consumer response**:
 - ✓ (PT) 4% consumption decrease during *Decrease* recommendations when analysed against *comparable days*
 - ✓ (PT) 81.6% of collected feedback showed commitment to adopt recommendations (4 to 5 stars)



Histogram of recommended actions for Portugal.

(PT) Residential setting



Portuguese pilot: Comparison between days with recommendations and historically comparable days.

Interoperable Recommender

What's next? Some ideas

Enhance Data and Methodology

- Improve data reliability with backup sources and detailed country-specific models.

Integrate Consumer Feedback

- Use real consumer energy data for feedback loops and personalized recommendations.

Optimize DR Program Efficiency

- Evaluate DR strategies, addressing scalability, infrastructure, and GDPR compliance.

Expand Studies for Long-term Insights

- Extend pilot programs, generalize findings across Europe

Improve coordination with TSO-DSO

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Publications / Source Code

Enhancing the European Power System Resilience with a Recommendation System for Voluntary Demand Response

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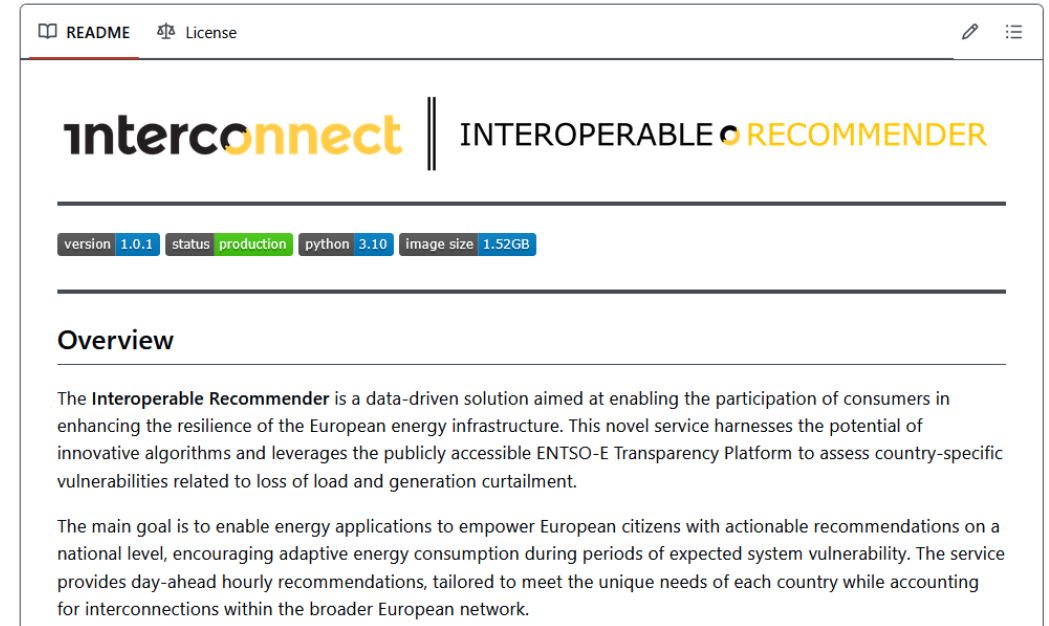
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(under review in iScience)



Interoperable Recommender

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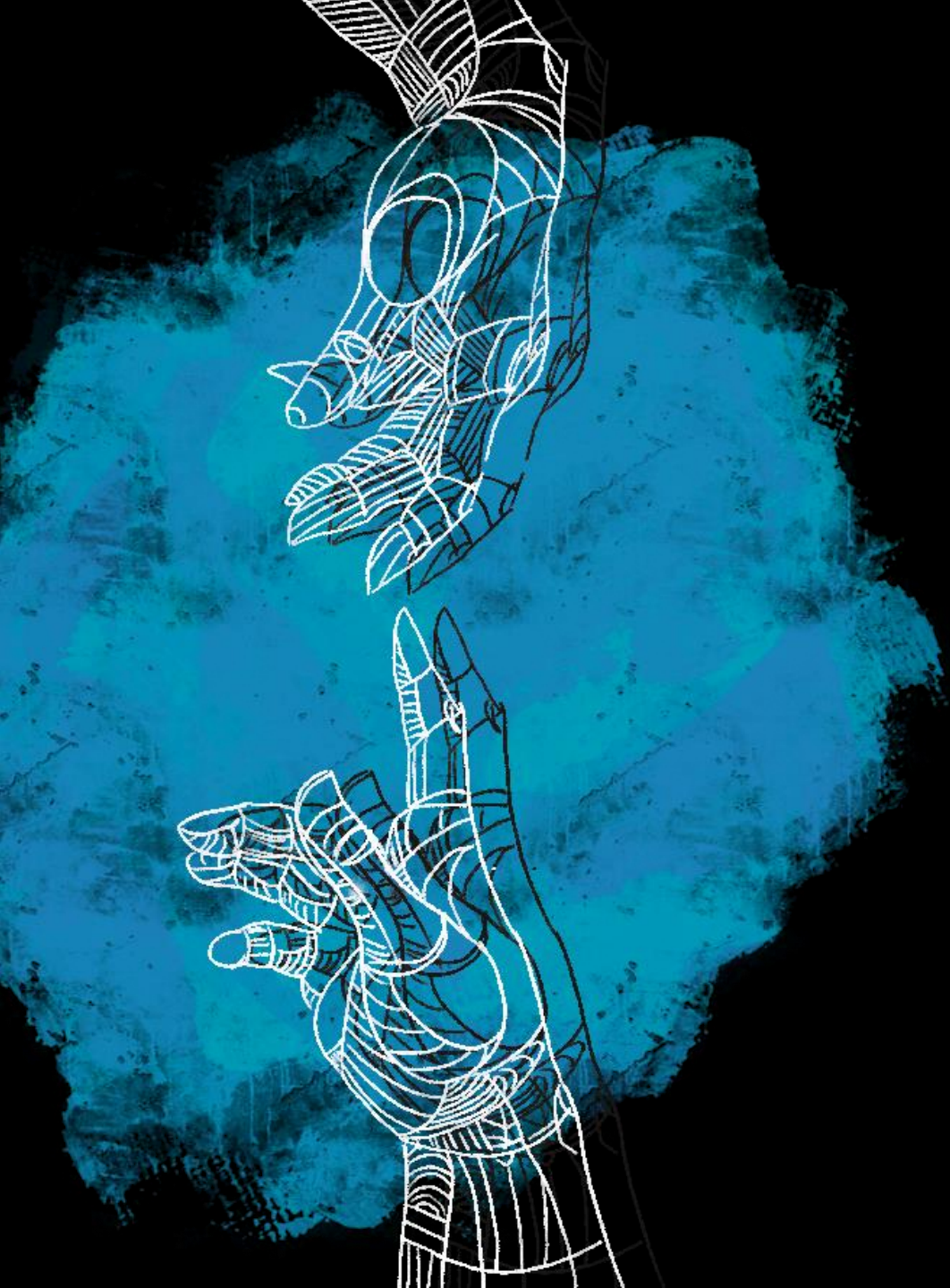
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