SmartSheetPile
Smart, sustainable and resilient solution for health monitoring of structures made of Steel Sheet Piles

SUSTAINABLE PLACES 2024

ArcelorMittal

Sustainable Places 2024

09/2024

Abir GALLALA
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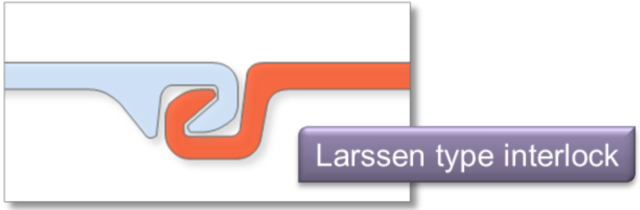
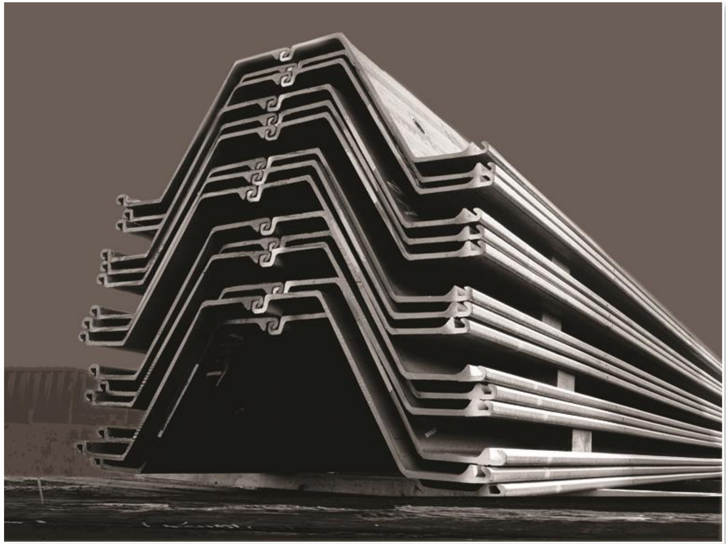
ArcelorMittal Sheet Piling

Steel Sheet Piles

- Hot rolled ‘corrugated’ sheets
- With interlocks



- Form a quite impervious continuous (retaining) wall



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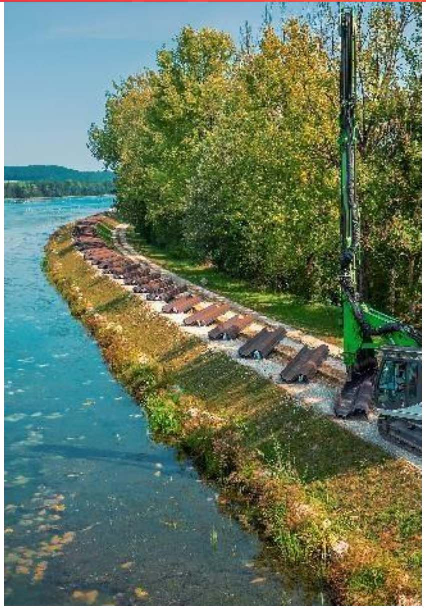
Main application domains

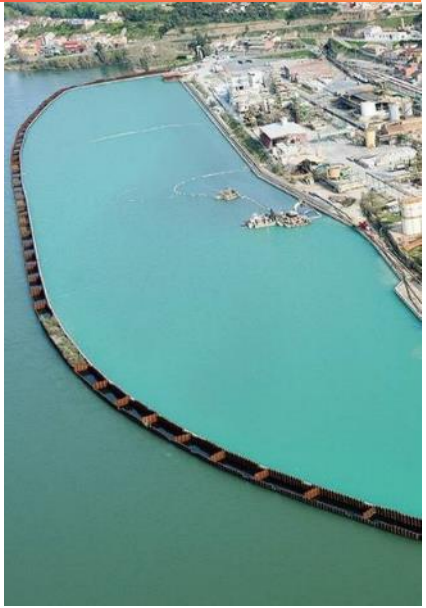
Mobility Infrastructure Solutions

Water Transport Solutions

Hazard Protection Solutions

Environmental Protection Solutions





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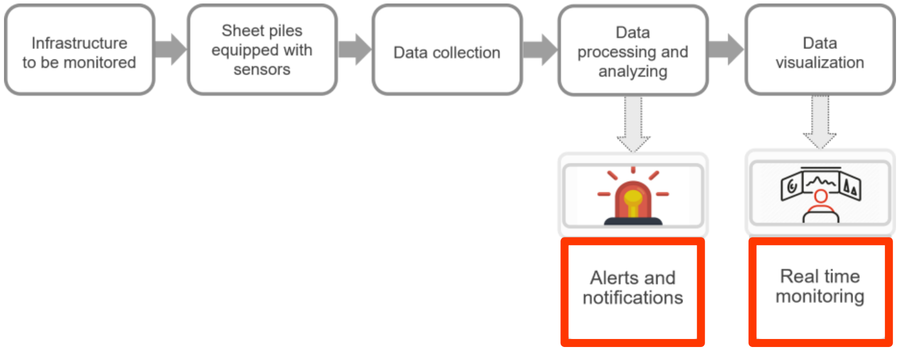
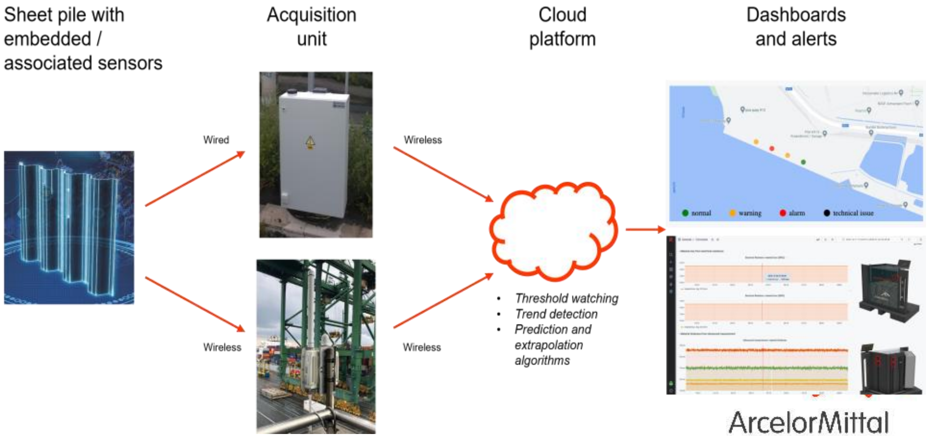
SmartSheetPile
Structural Health Monitoring system

SmartSheetPile

SHM: monitor, detect and forecast/predict/prevent damage based on current and future conditions.

- What is the current condition?
- Is there any damage?
- Where?
- When?
- How much?
- How much it will be?
- What is the future performance of the structure?
- How much longer can the structure be safely used?





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SmartSheetPile added values

Secure the structure :

- Prevent irreparable damage
- Detect accidental and weather-induced damage
- Early warning of potential catastrophic collapse

Achieve preventive/predictive maintenance :

- Know when and where maintenance is needed
- Remove the need for costly inspections and unscheduled repair works

Minimize unavailability :

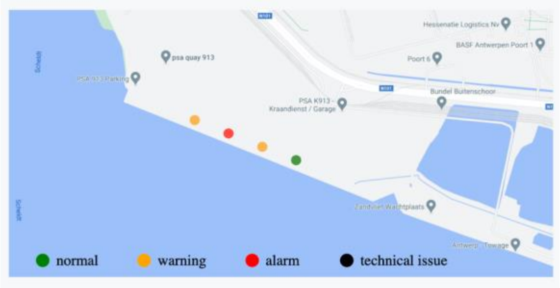
- Avoid unexpected shutdowns (closures)
- Save costs and limit inconvenience to users

Take on the digital transformation :

- Integrate collected data in the digital twin of the structure
- Have a multi-dimensional overview of the structure's performance and interaction with the surroundings
- Effective asset management

Reveal hidden capacities and detect weak spots :

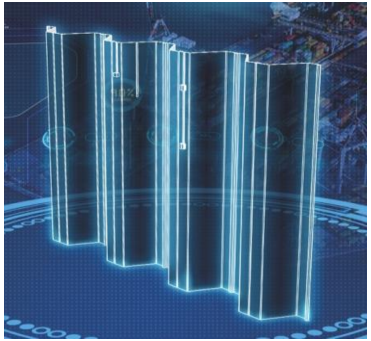
- The data collected gives accurate information on structural health
- Usage of structure can be optimized to benefit from its full potential
- Improve project returns
- Lifetime extension



SmartSheetPile System architecture

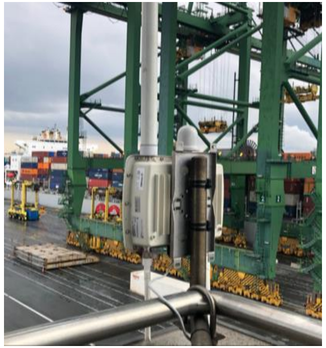
Hardware

Sheet pile with embedded / associated sensors



Wired

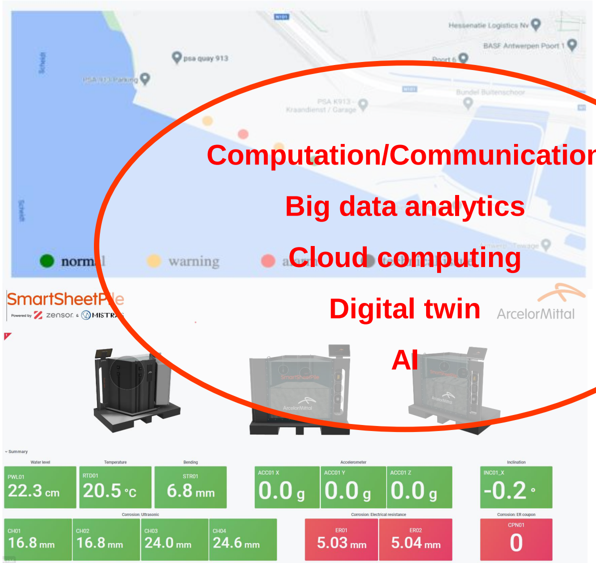
Acquisition unit



Wireless

Software

Cloud platform / Digital twin model / Monitoring system



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List of phenomenas

The SmartSheetPile is a modular product, so the end user can select from a menu list of phenomena being tracked:

“Core” sheet pile behavior

- Corrosion / material loss
- Inclination / tilt
- Position / displacement
- Structural deformation (strain)
- Anchor tension
- Soil pressure
- Shock / vibrations / acceleration
- Force / load applied

Surrounding / environmental information:

- Tidal levels
- Soil inclination
- Settlement
- Ground water levels
- River water level
- Temperature

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Dashboard – Online monitoring

Dashboard – Online monitoring

General / Shock detection

Last 6 months

Indicate identified shocks

Number of shocks registered for the selected period (Z direction)

111

Timestamp	Direction	Amplitude
2023-01-19 12:00:10	Z	2.47
2023-01-20 13:09:40	Z	2.33
2023-01-17 17:54:10	Z	2.20
2023-05-10 16:12:10	Z	2.20
2023-01-19 13:09:50	Z	2.14
2023-06-14 12:55:40	Z	2.09

Shock identification

Vibration energy in direction Z

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Dashboard – Online monitoring

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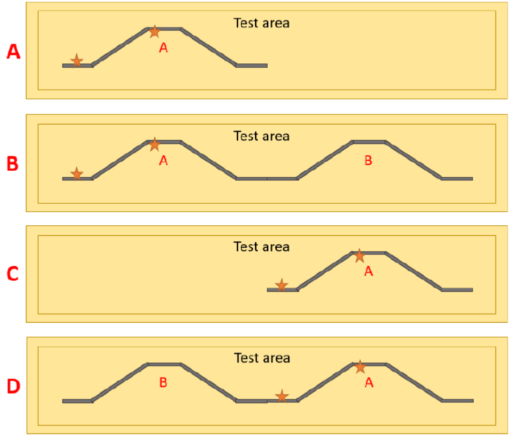
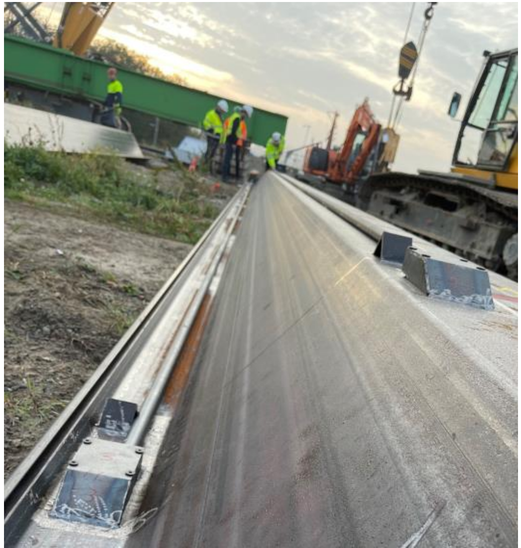
Driving test

- Driving test 10/2023
- Reliability of sensors/cables after sheet piles installation
- Simulate the most extreme conditions
  - Vibro hammer / Impact hammer

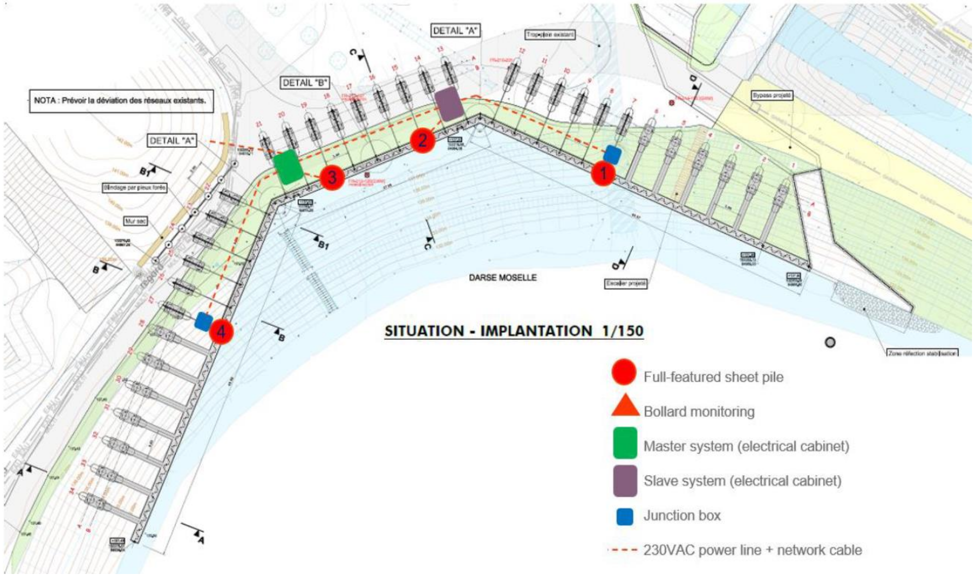




Pilot / breakthrough project:
Port of Mertert - end user P&Ch

➢Port of Mertert:

- New turning point for 135m long vessels



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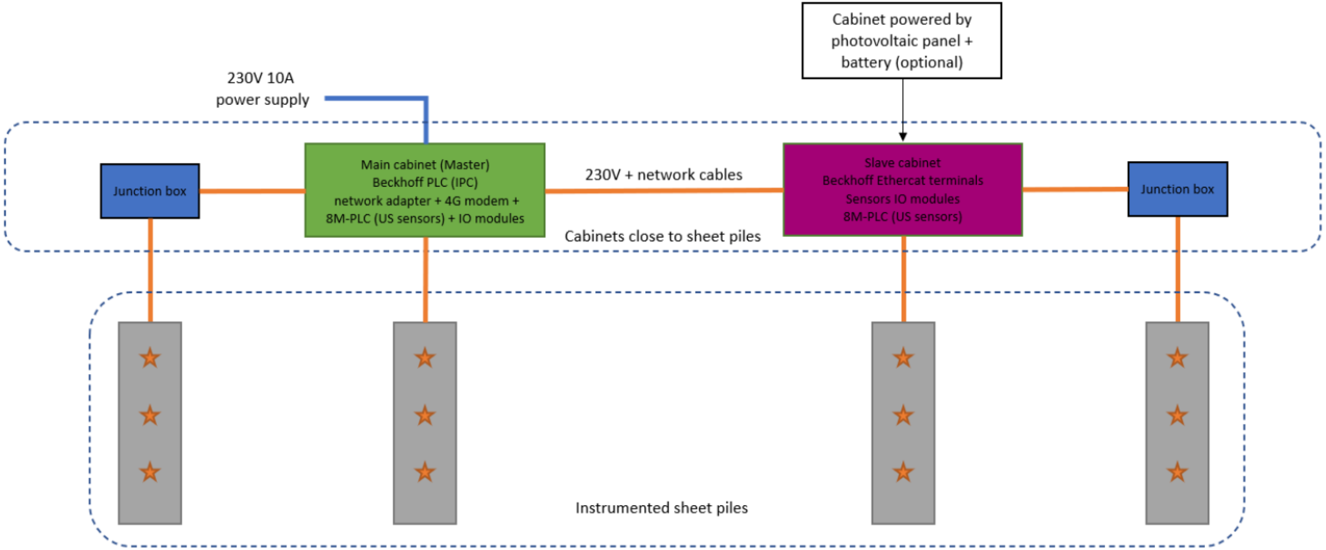
Pilot / breakthrough project: Port of Mertert – end user P&Ch

- Monitor of: Corrosion, river water level, anchor tension, inclination, Strain, bollard mounting, shock, temperature
- +125 sensor covering some 10 different data types on 4 double piles
- 24/7 monitoring dashboard



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Thank you

SUSTAINABLE PLACES 2024

- More on our websites :

  https://sheetpiling.arcelormittal.com/
  https://projects.arcelormittal.com/

- SmartSheetPile - Smart steel solutions for innovative infrastructure Video:

  YouTube:
  https://www.youtube.com/watch?v=nIeiwOUGEes&t=6s

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IN-PLAN

Integrated energy, climate and spatial planning

Binding Energy & Climate Plans Through Integration with Spatial Plans

SUSTAINABLE PLACES 2024

Jérémy Cléro, IEECP

25th September 2024

Co-funded by the European Union under project ID101076428. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

What do local actors lack of?

IN-PLAN

- Capacity and mechanisms to enact and enforce binding energy and climate policies on a local or regional level
- Vertical and horizontal integration or alignment of strategies, plans, and policies
- A systemic, integrated, and consistent approach to energy and climate planning
- Alignment between planning and the allocation of financial resources

IN-PLAN

Spatial planning as a key

How can we make energy & climate plans legally binding?

Spatial/urban plans are legally binding

What if we integrated E&C plans in the spatial plans?

IN-PLAN = Integrated Energy, Climate and Spatial Planning

IN-PLAN objectives

IN-PLAN

Integrate energy, climate and spatial planning (mobility, infrastructure, etc.)

Empower and build up capacity in participating local and regional governments in different governance levels

Matching measures with **local and regional budget lines**

Develop, test, and roll-out the

IN-PLAN practice

a support structure for integrated planning enabling local and regional authorities to implement integrated energy, climate and spatial plans

1- IN-PLAN Practice - Six steps to successful integration

IN-PLAN

Lack of a systemic, integrated, and consistent approach to energy and climate planning

Lack of vertical and horizontal integration or alignment of strategies, plans, and policies

1. **Create a governance structure and plan** to ensure vertical and horizontal cooperation.

2. **Assess the local context for opportunities and barriers.** Review existing plans and legislations to ensure consistency.

3. **Engage stakeholders and citizens from the very beginning.** Create an engagement and implementation strategy to ensure a common strategic vision and common use of planning instruments and tools.

4. **Use data.** Define a data collection and management plan to ensure consistency, reliability and accessibility of data.

5. **Create the plan.** Develop a flexible action, monitoring and continuation plan to ensure compliance and impact.

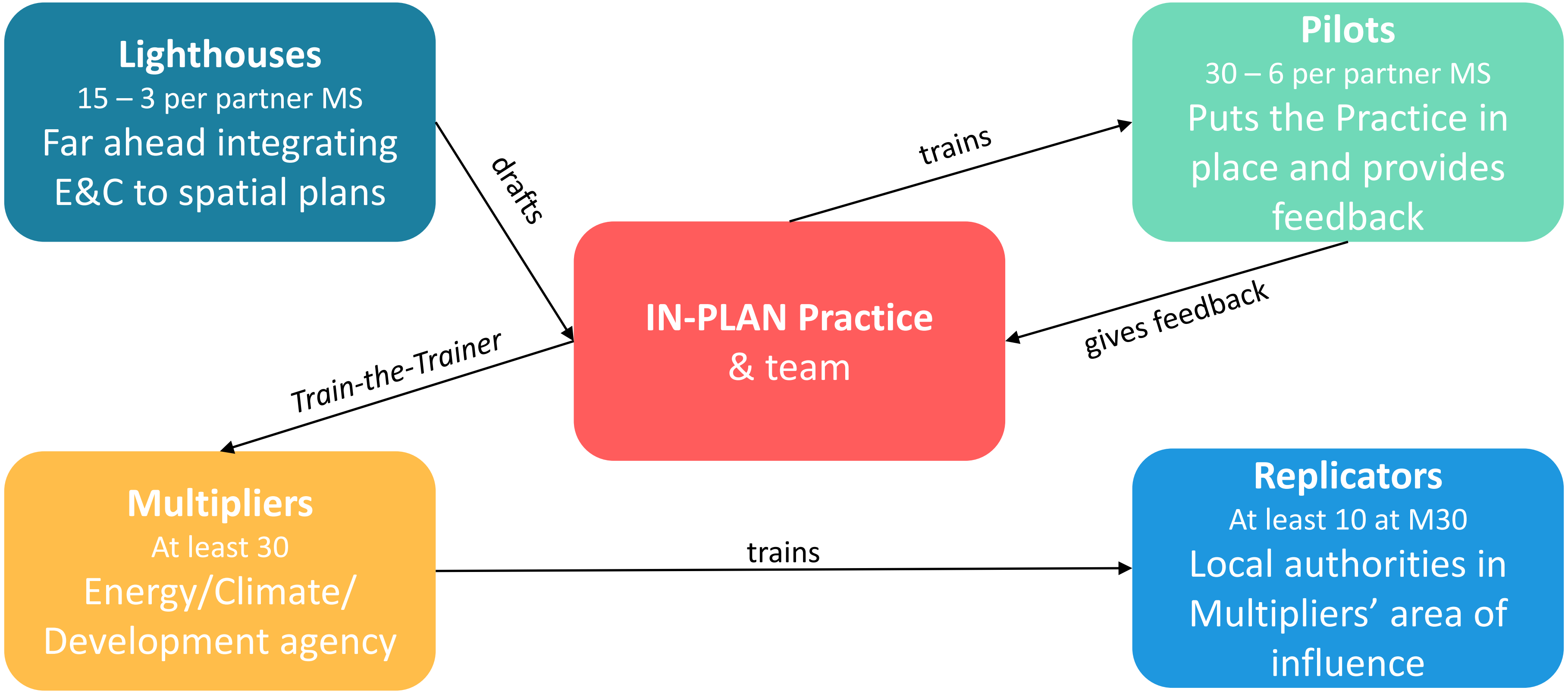
6. **Implement high resolution spatial plans, adopt good practices and use innovative planning-support tools** to support common understanding, clear goals and foresee the challenges and opportunities.

2- Capacity building and replication

4 key actors

Lack of capacity and mechanisms to enact and enforce binding energy and climate policies on a local or regional level

Lack of alignment between planning and the allocation of financial resources



Pilots' feedback

Lack of tools and mechanisms to implement and enforce plans

- Silo thinking
- Difficulties to exchange with other governance levels
- Large cities struggling to exchange with national level

Consideration of other plans in drafting process

Importance of data management

First achievements

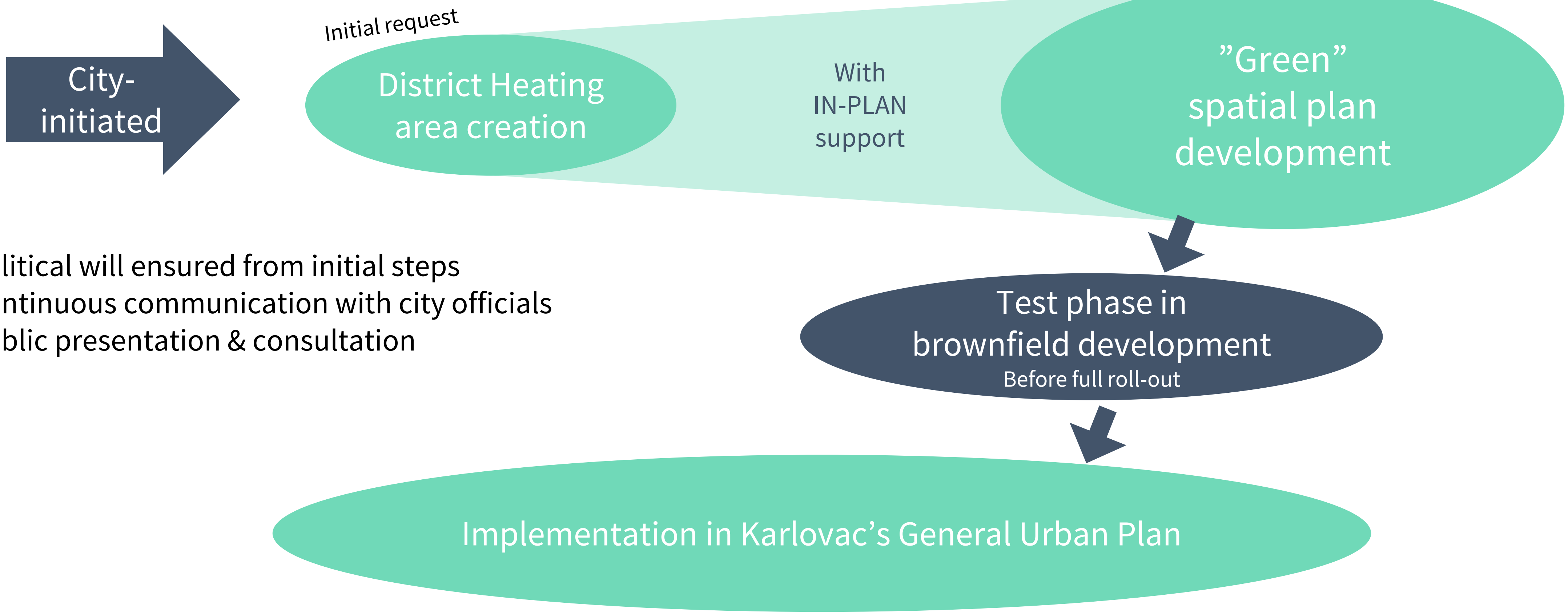
IN-PLAN Practice

With project's team support

Zagreb and Karlovac (HR) developed sub-urban spatial plans including strict energy and climate criteria within the covered zones

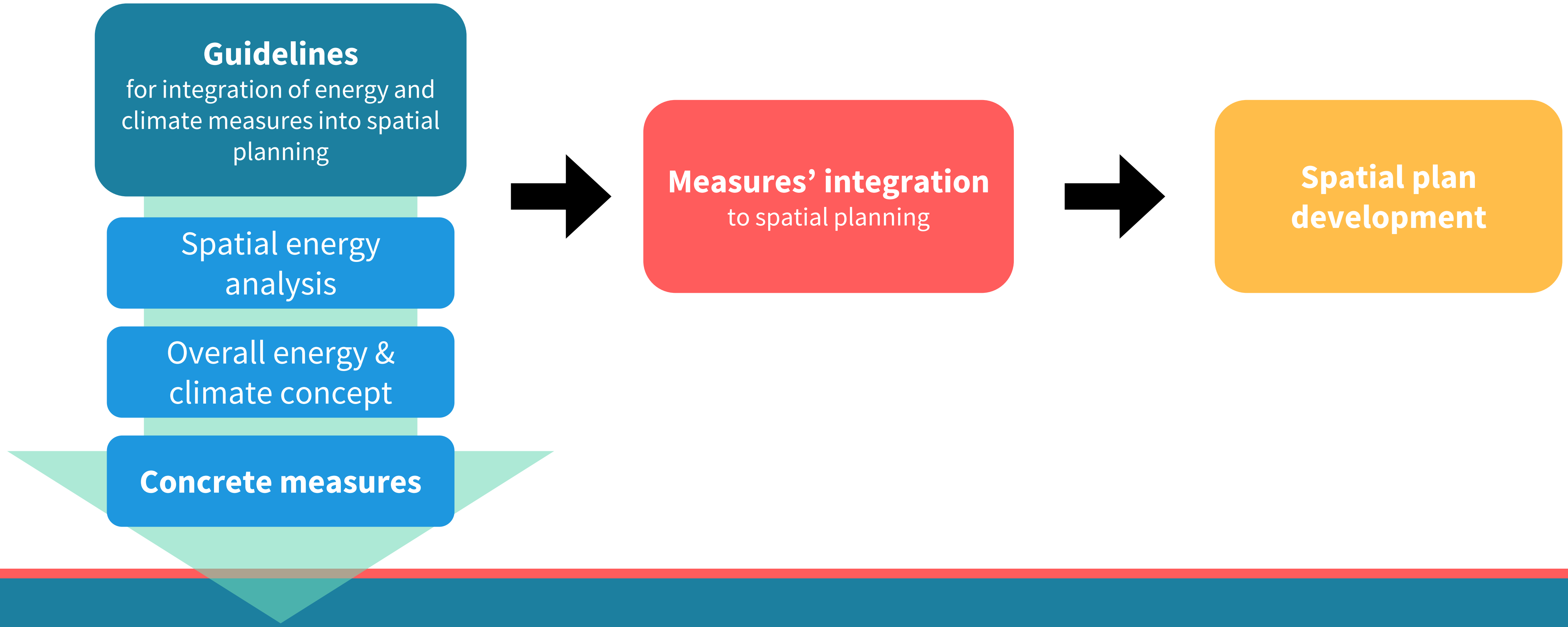
→ **proof of concept**

First pilot: Karlovac, HR



- Political will ensured from initial steps
- Continuous communication with city officials
- Public presentation & consultation

The process



Guidelines
for integration of energy and climate measures into spatial planning
Spatial energy analysis
Overall energy & climate concept
Concrete measures
Measures' integration
to spatial planning
Spatial plan development

Key measures against climate change

Mitigation	Adaptation	Mobility
Energy efficiency of buildings	Green infrastructure Biodiversity & Urban fresh islands	Mobility at rest Parking spots Charging stations
Heating & Cooling supply	Water management Floods & landslides prevention	Infrastructure Public transport Bike lanes
Street lighting		

IN-PLAN

First achievements

IN-PLAN Practice

With project's team support

Zagreb and Karlovac (HR) developed sub-urban spatial plans including strict energy and climate criteria within the covered zones

→ **proof of concept**

Training Multipliers

38 professionals

25 organisations

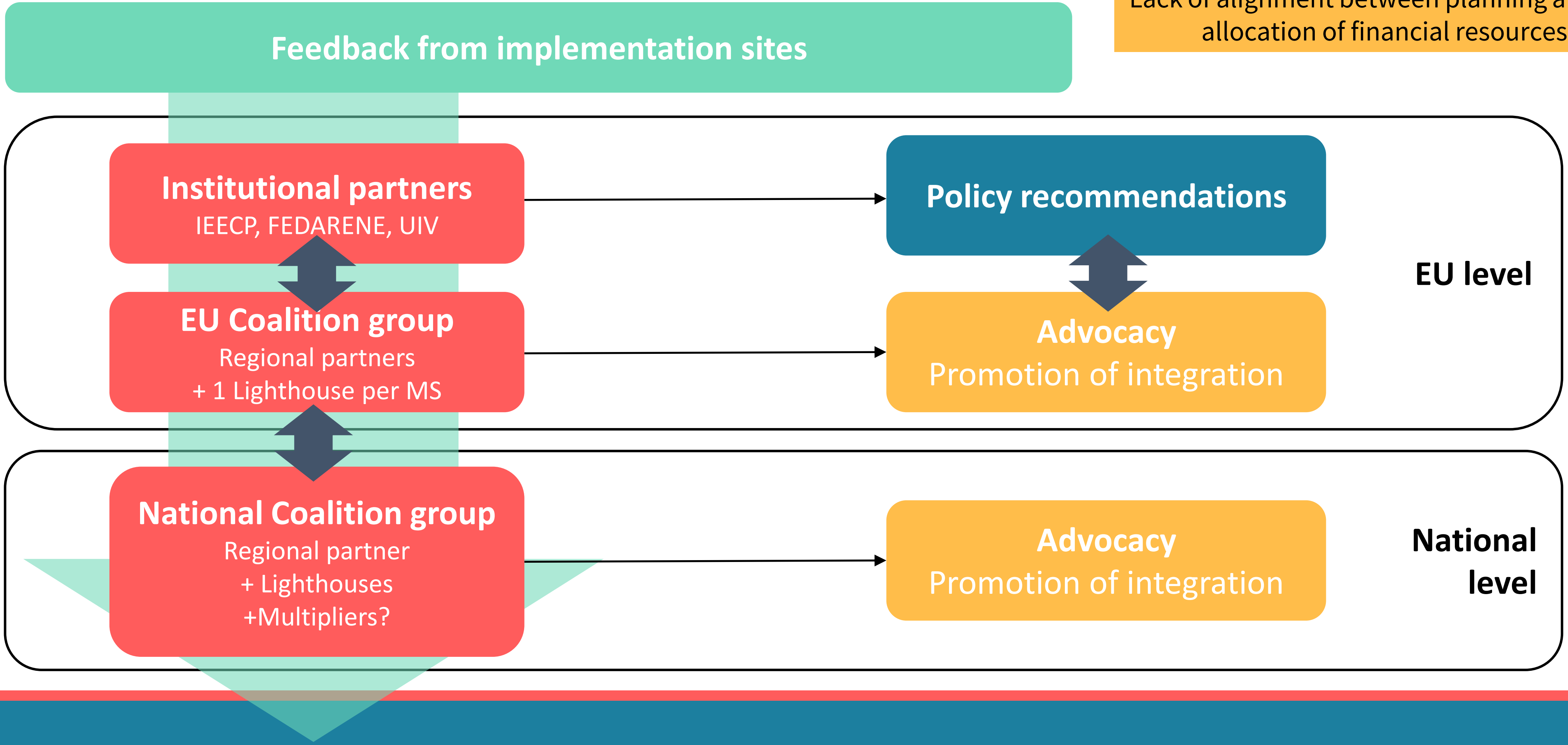
12 countries (11 MS + 1 non-EU)

Become an IN-PLAN Multiplier

3- Policy feedback & institutionalisation

Lack of vertical and horizontal integration or alignment of strategies, plans, and policies

Lack of alignment between planning and the allocation of financial resources



Next steps

Finalise the IN-PLAN Practice
September '24

Turn feedback from pilots into policy recommendations

Train-the-Trainers sessions

Implementation in pilot cities

Replicate

Develop EU and national Coalitions

Let it be known!

Thank you.

For more info, follow our hashtag, visit our website or contact us:

#LifeINPLAN

fedarene.org/project/in-plan/

jeremy@ieecp.org

Become an IN-PLAN Multiplier

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SUSTAINABLE PLACES 2024

Sustainable Places 2024

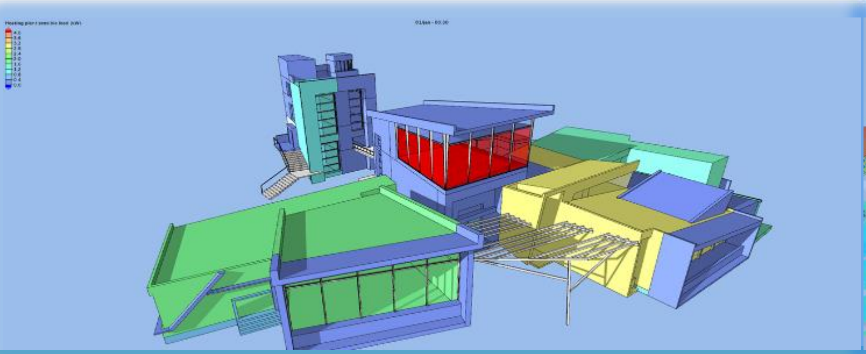
Dr Niall Buckley

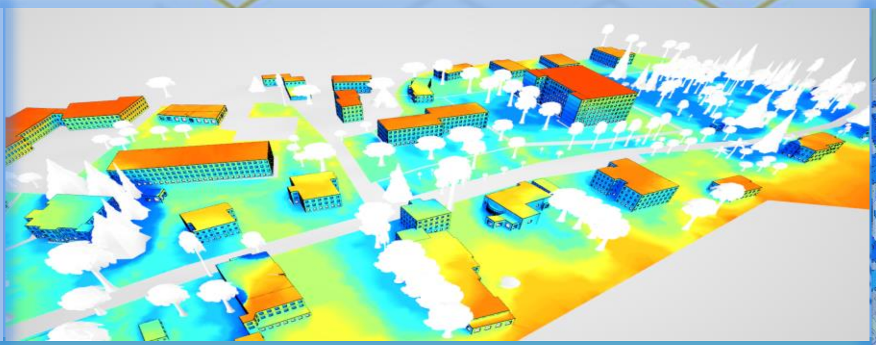
IES

IES Digital Twins

19 Live Horizon Projects in 2024

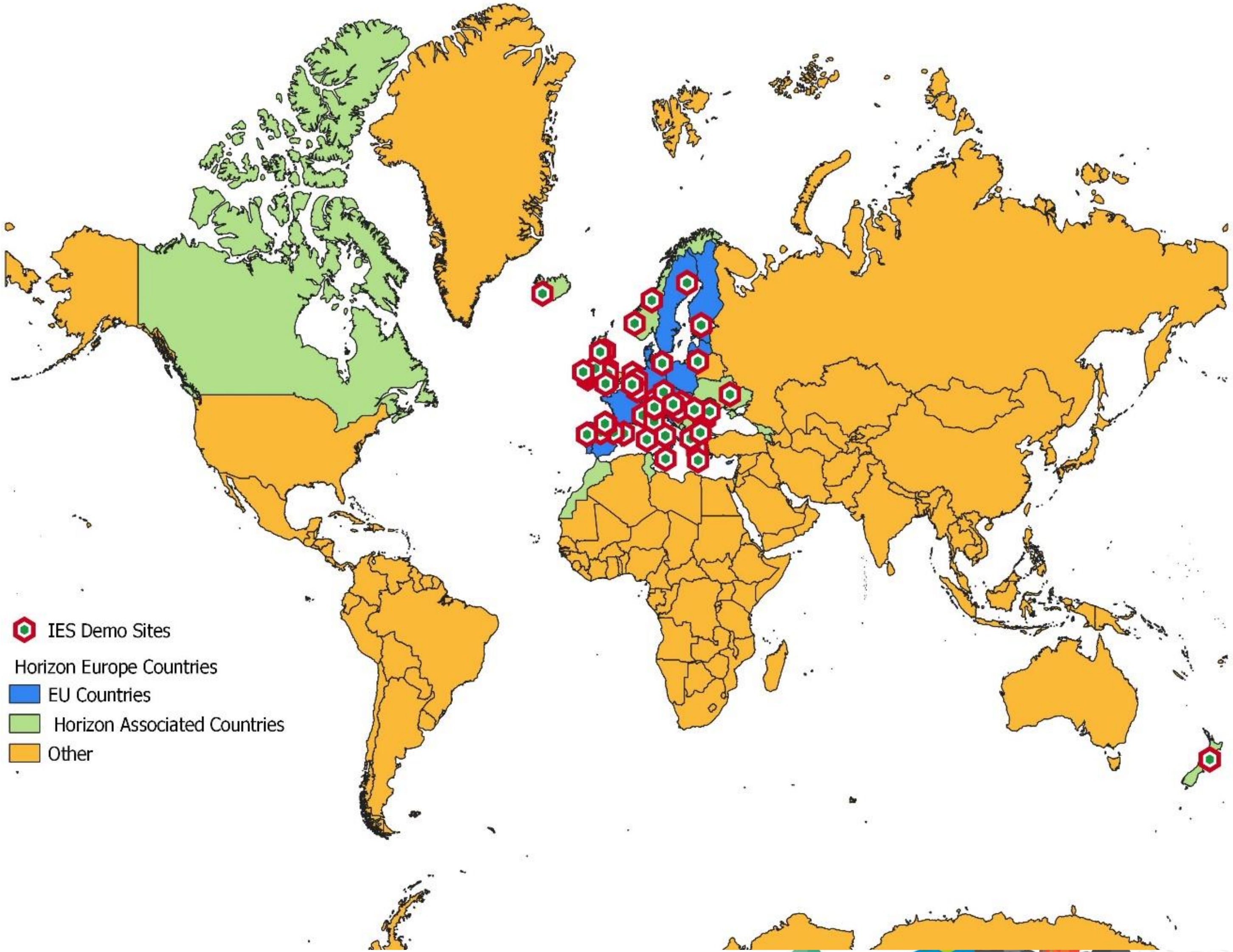
- Energy masterplans
- Decarb Roadmaps
- Environmental assessments
- Positive energy blocks/buildings
- Single building to city scale





Horizon Europe

- IES R&D has been involved in over 60+ cities across eligible Horizon countries
- Partnered with over 400+ private, public, and NGO institutions
- Developed state-of-the-art climate tech that has made millions in revenue and continues to grow in popularity



MINORITY REPORT – Resilience Project

Flooding

Earthquakes

Wildfires

Predict, Identify, and categorise the vulnerability of existing and future buildings and infrastructures towards reducing exposure to hazards using digital twin technologies

MINORITY REPORT – Resilience Project

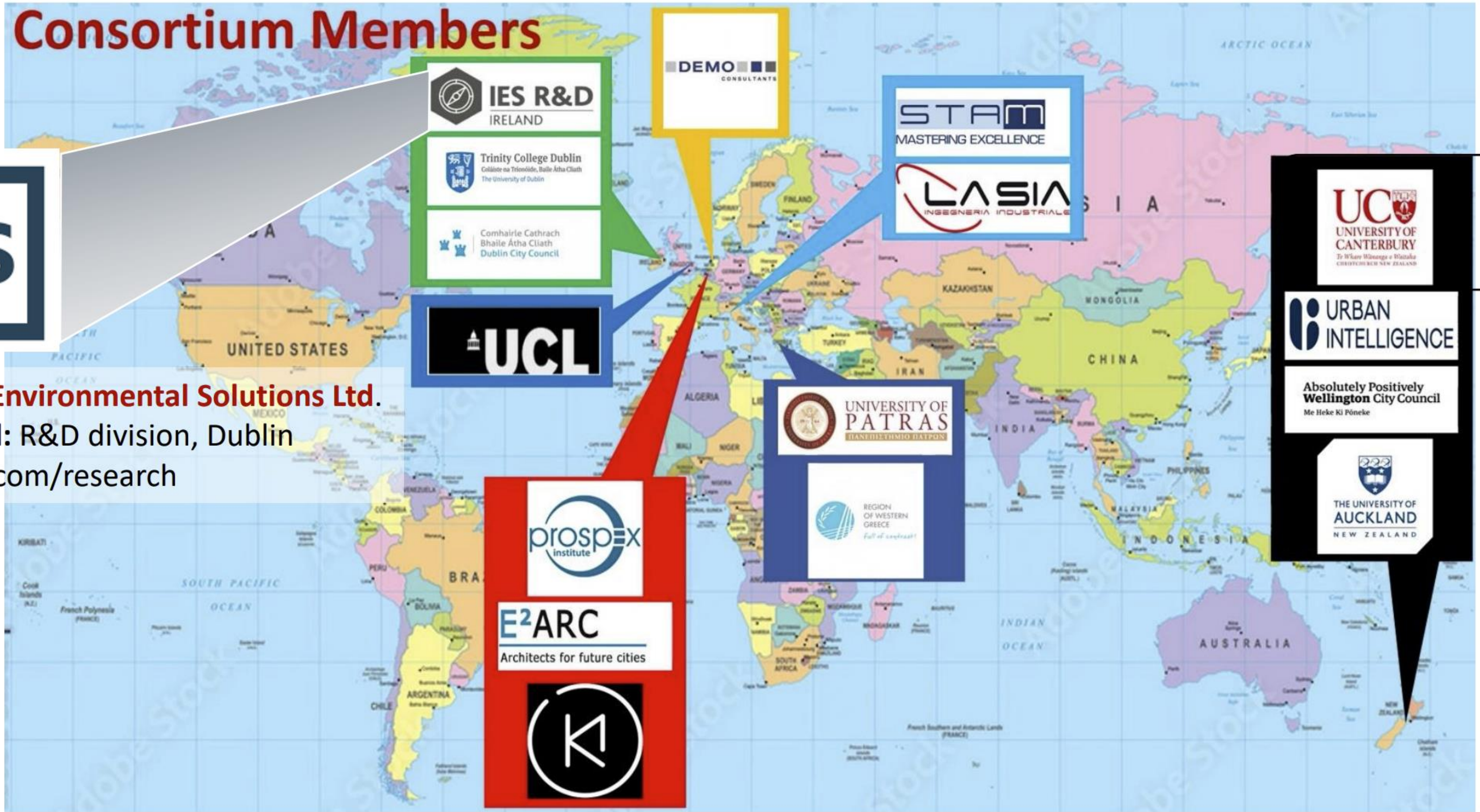
Demo Sites:

Greece

New Zealand

Rep of Ireland

Horizon Europe Collaboration – Minority Report



IES

Integrated Environmental Solutions Ltd.
Project lead: R&D division, Dublin
www.iesve.com/research

Overview
16 Partners
3 City Municipalities
5 universities
8 Private companies

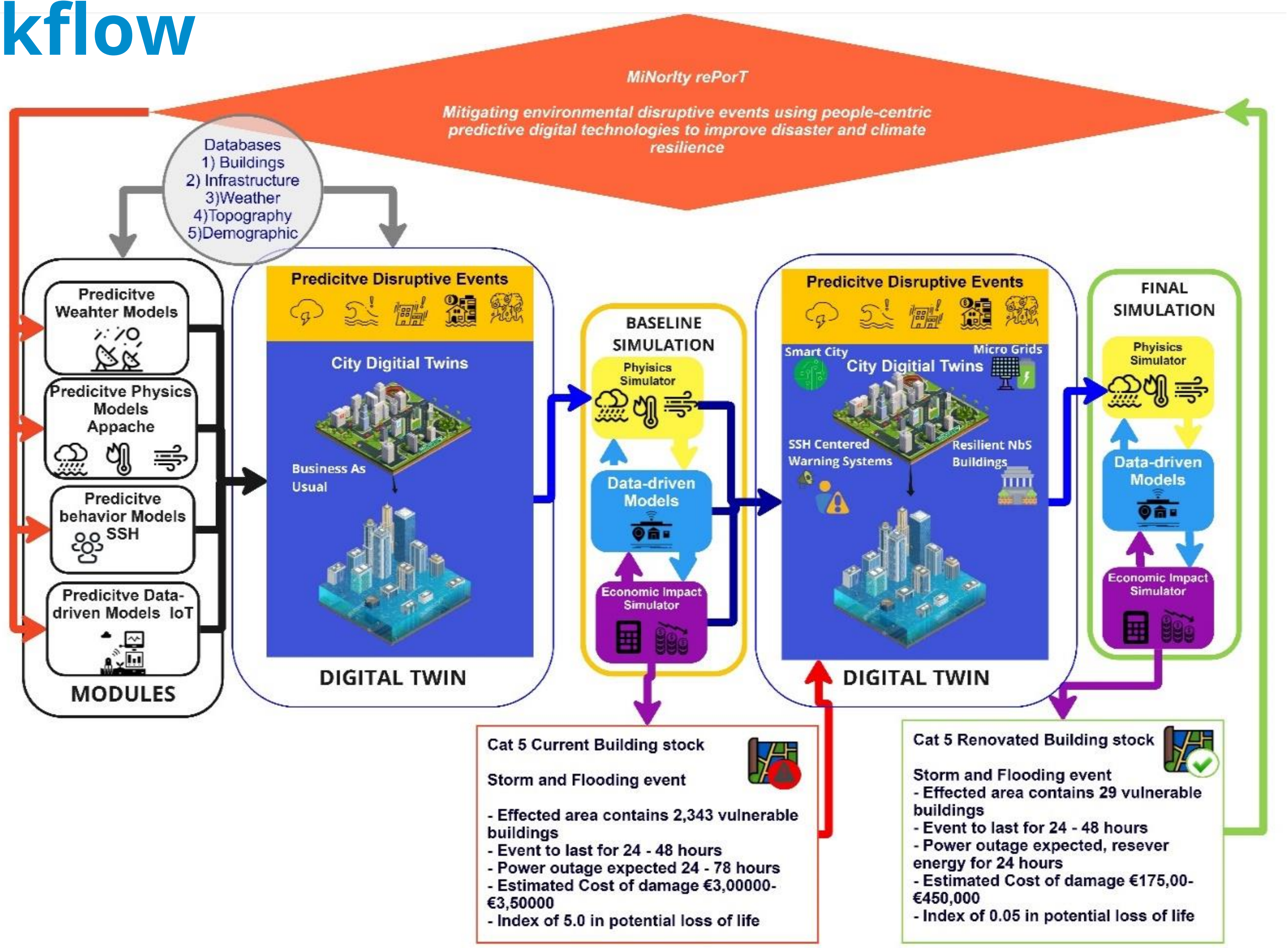
Social scientists, engineers, computer scientists, public reps, climatologists, and risk assessors

Antipode

Working with NZ partners in the opposite time zone and season

- 11 hour time difference
- Spring in NZ and Autumn in Europe
- Finding times to talk are difficult

Workflow



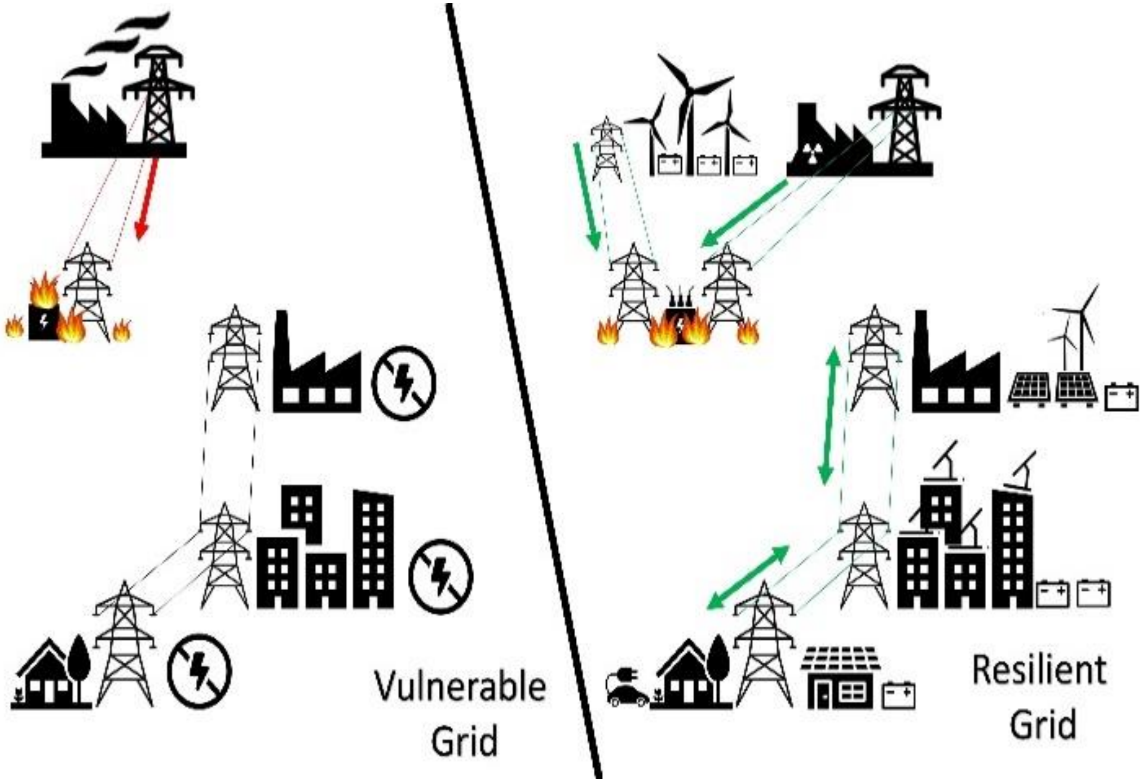
Iterative methodology that identifies optimal scenarios for bounce back ability

MINORITY REPROT

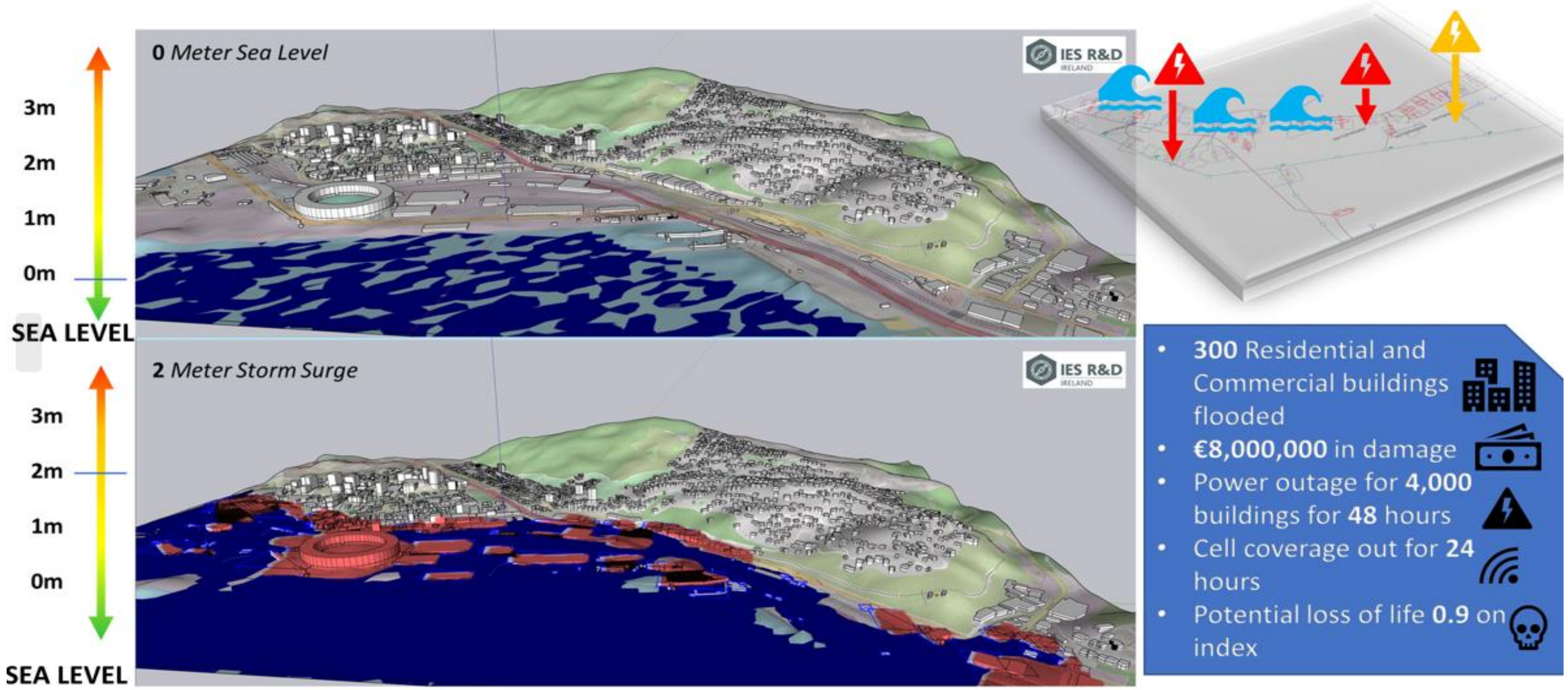
Grid Transition

Paradigm Shift in the grid is enabling more resilient energy transition

https://mmmenglish.com/wp-content/uploads/2021/09/eggsinonebasket.jpg



Building Models to Assess Risk

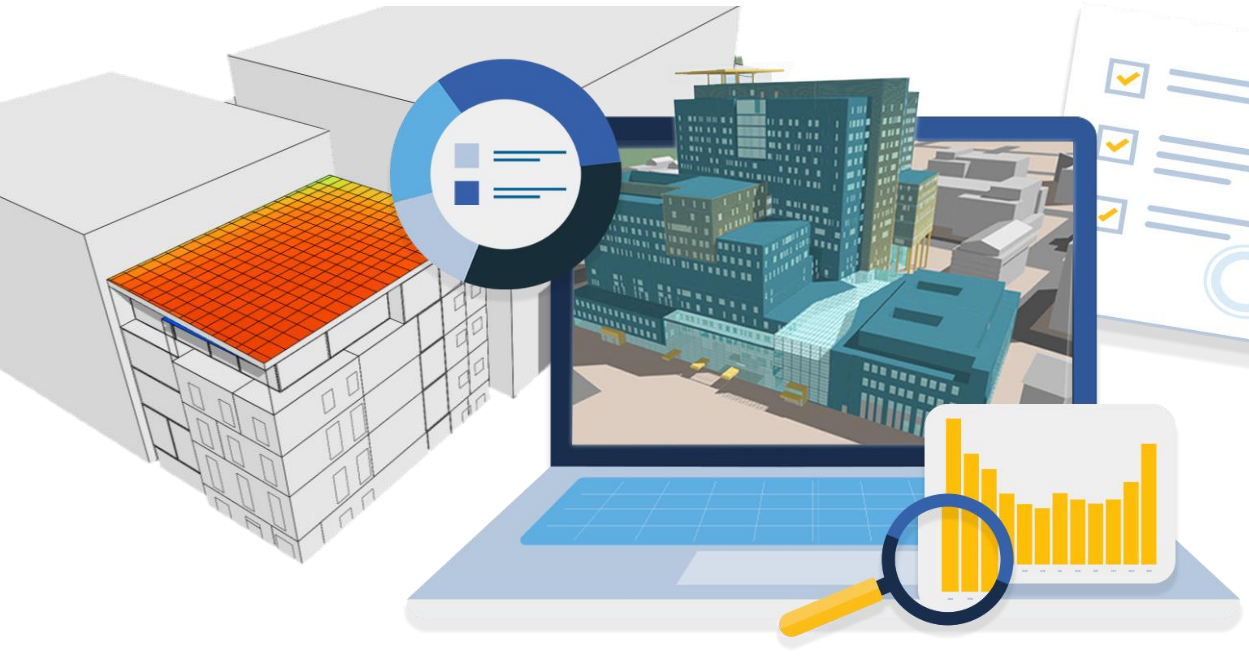


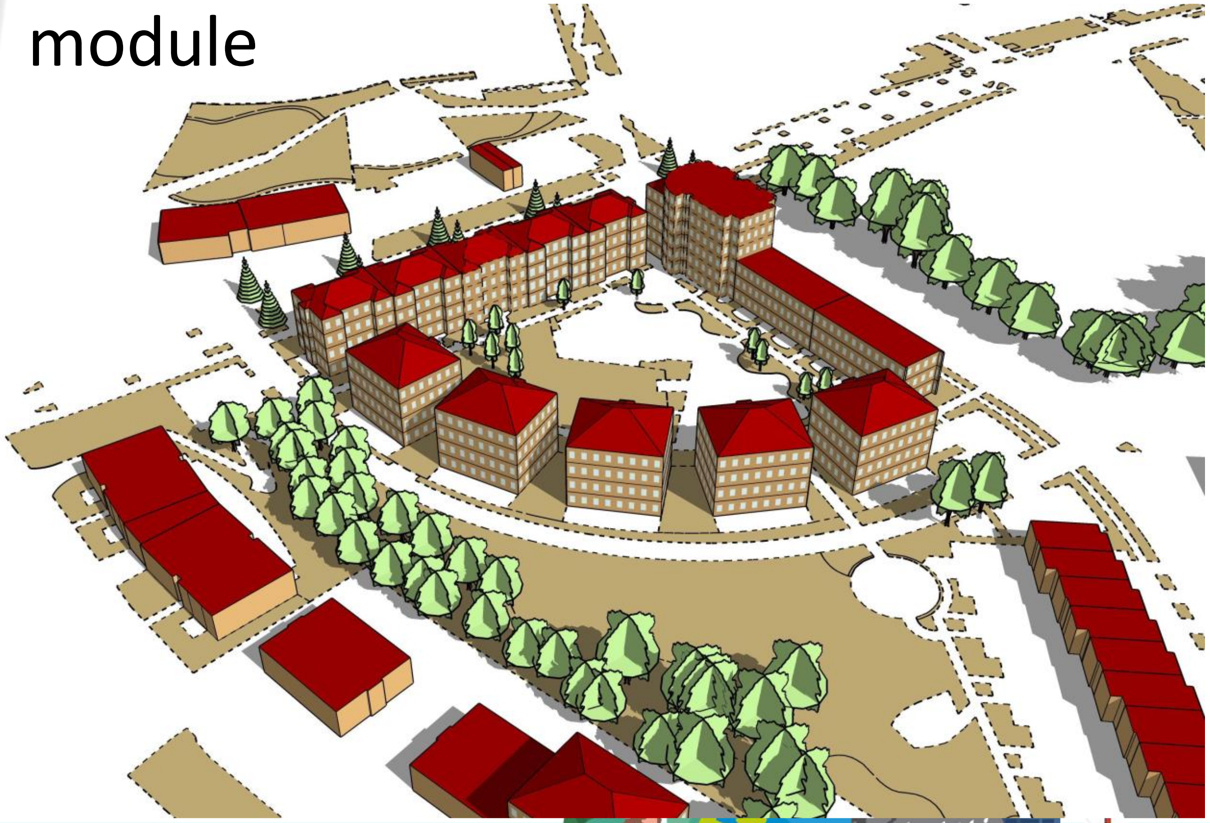
- Digital twins of terrain and Infrastructure to identify areas most at rick of flooding events, wild fires, and earthquakes

- Technical and sociotechnical data will be gathered towards developing sophisticated holistic models on risk

Physics, Technical, and Sociotechnical System Simulations

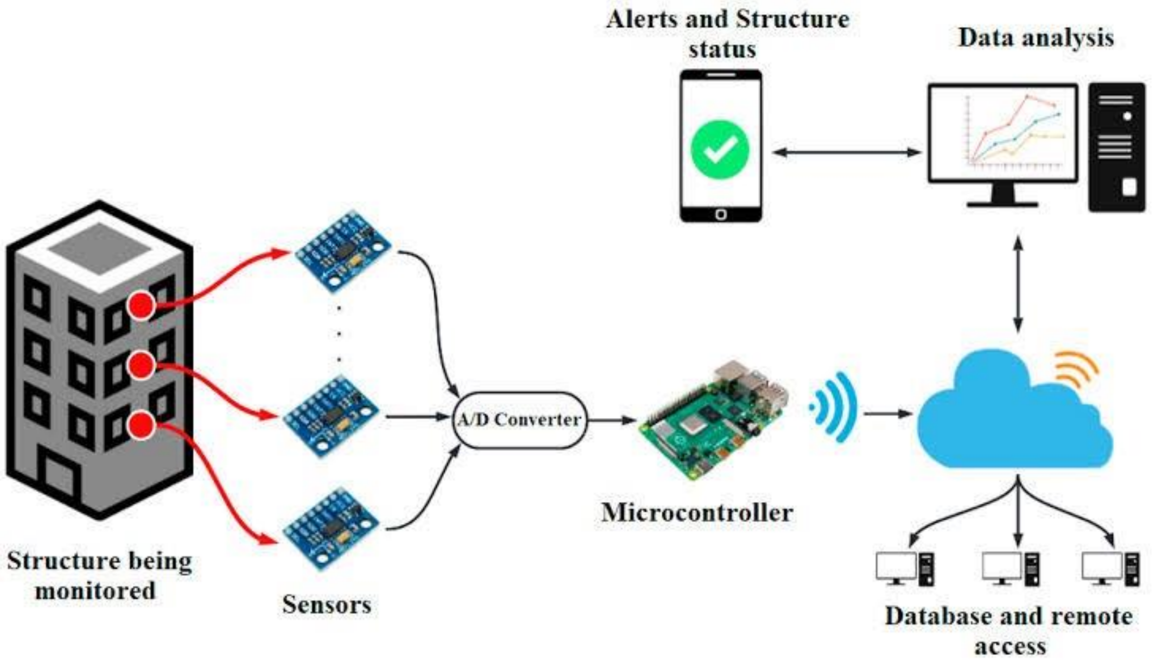
- Environmental , Behavior, Building, Infrastructure, and Geographical data is consumed by predictive module





IoT Services

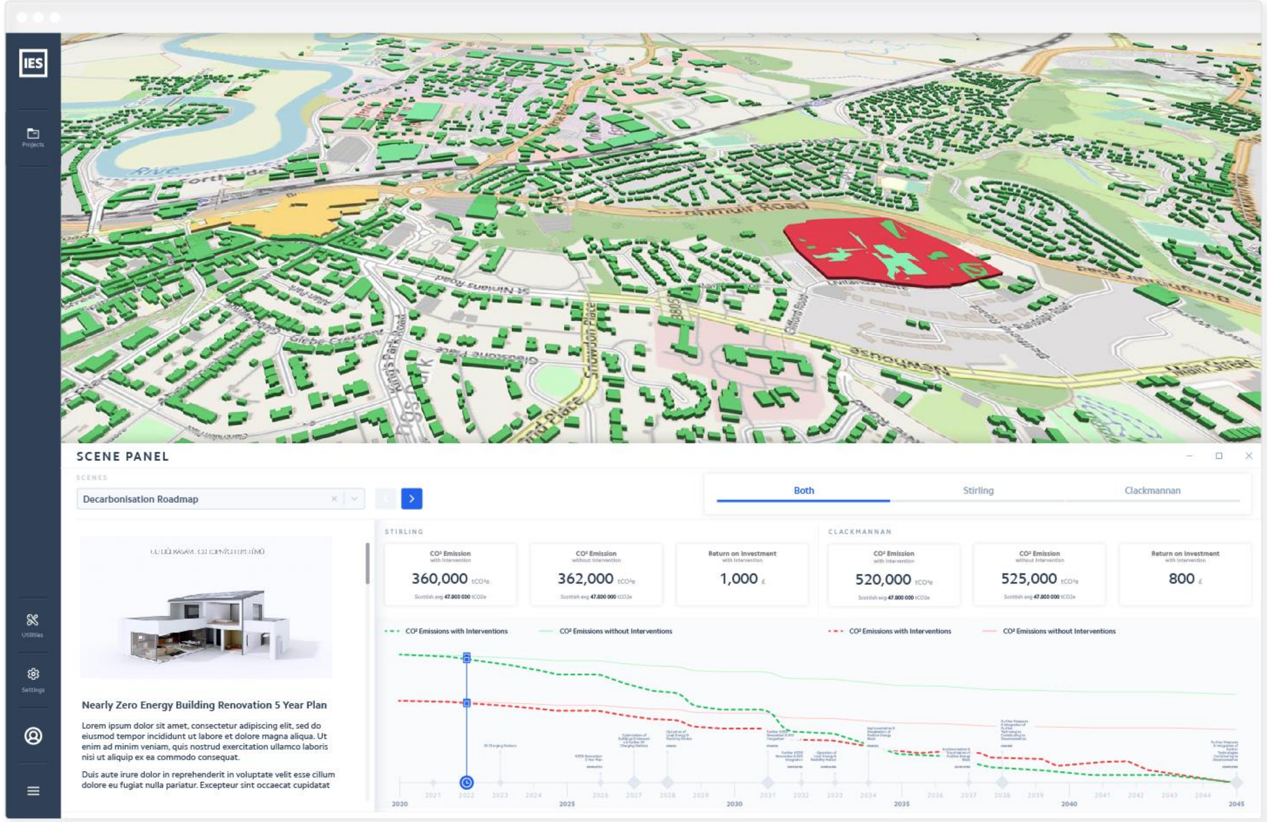
- Each site has their own bespoke risk and needs which require specific sensors in specific locations



https://www.linkedin.com/pulse/recent-trends-structural-health-monitoring-prakashpathi-s-bvz0c/

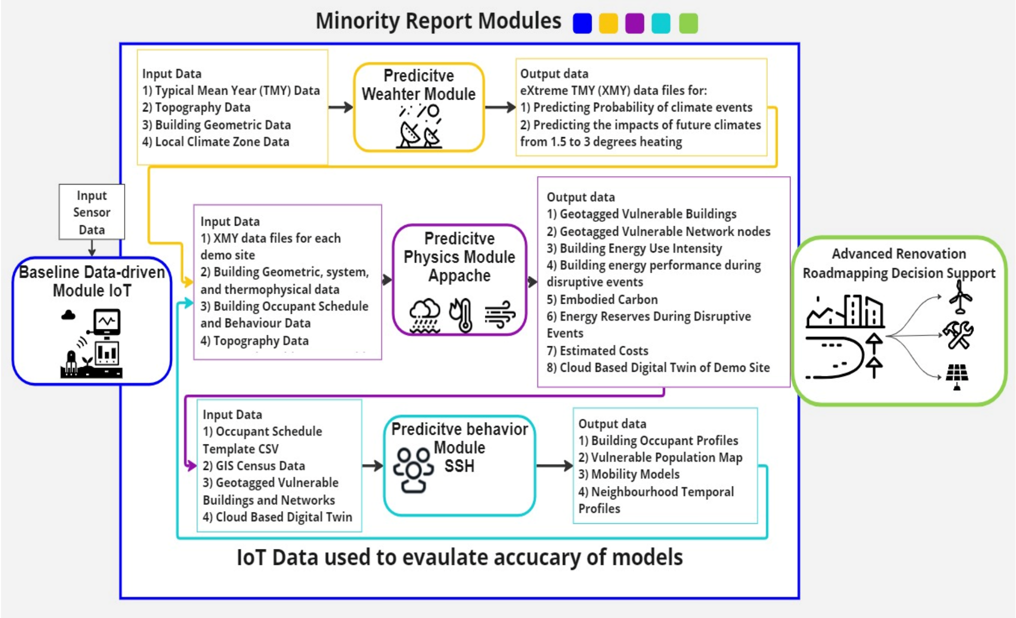
This project has received funding from the European Union's Horizon 2020 Programme under Grant Agreement no 101147385

Results available for users to disseminate optimal scenarios



Tools designed to support people on the ground

UX/UI
Dev
Co-design



End-user
feedback


Stock Images


Stock Images

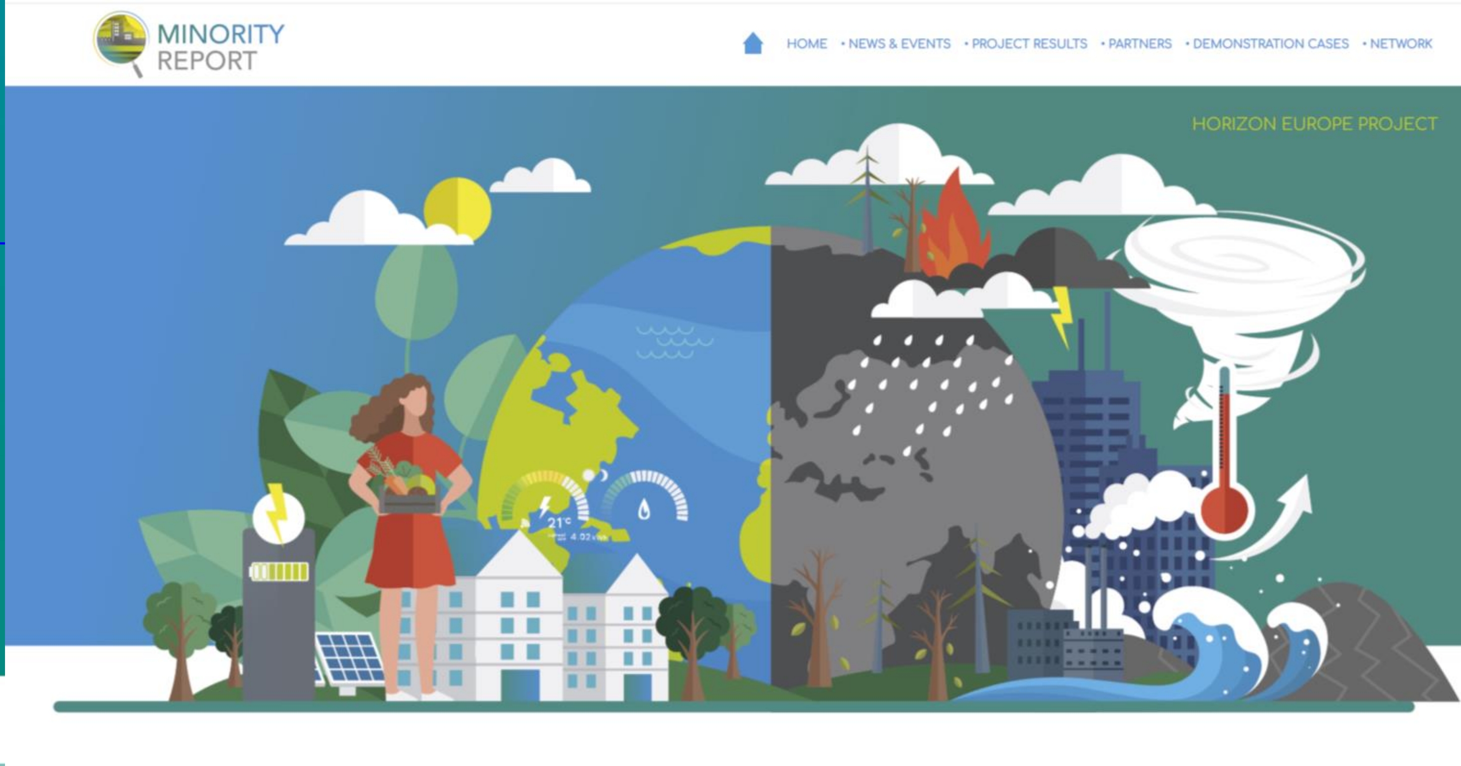
Next Stage

Data gathering

Stakeholder mapping begins

Project website launched

https://www.minorityreport-project.eu/e



www.minorityreport-project.eu/en/

@Minority Report

@EU_MinorityRep

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SmartSPIN

Validation of a smart energy service for the commercial rented sector in Ireland, Spain and Greece

Luciano De Tommasi

Sustainable Places 2024, European Convention Center, Luxembourg

25th September 2024

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033744.

SUSTAINABLE PLACES 2024

Outline

- The **split incentive** issue / the SmartSPIN **concept**
- **Validation** of the SmartSPIN Business model
- **Division of the energy cost saving** between landlord, tenant and ESCO
- **Revenue Streams** for ESCO, Renters and Building Owner
- **Decision making** for ESCO contractual agreements
- Consideration on the **contract duration**
- **Key Performance Indicators** for Demonstration Sites
- Smart Energy Service **Implementation** at Demonstration Sites
- Conclusions

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 10133744.

The split incentive issue

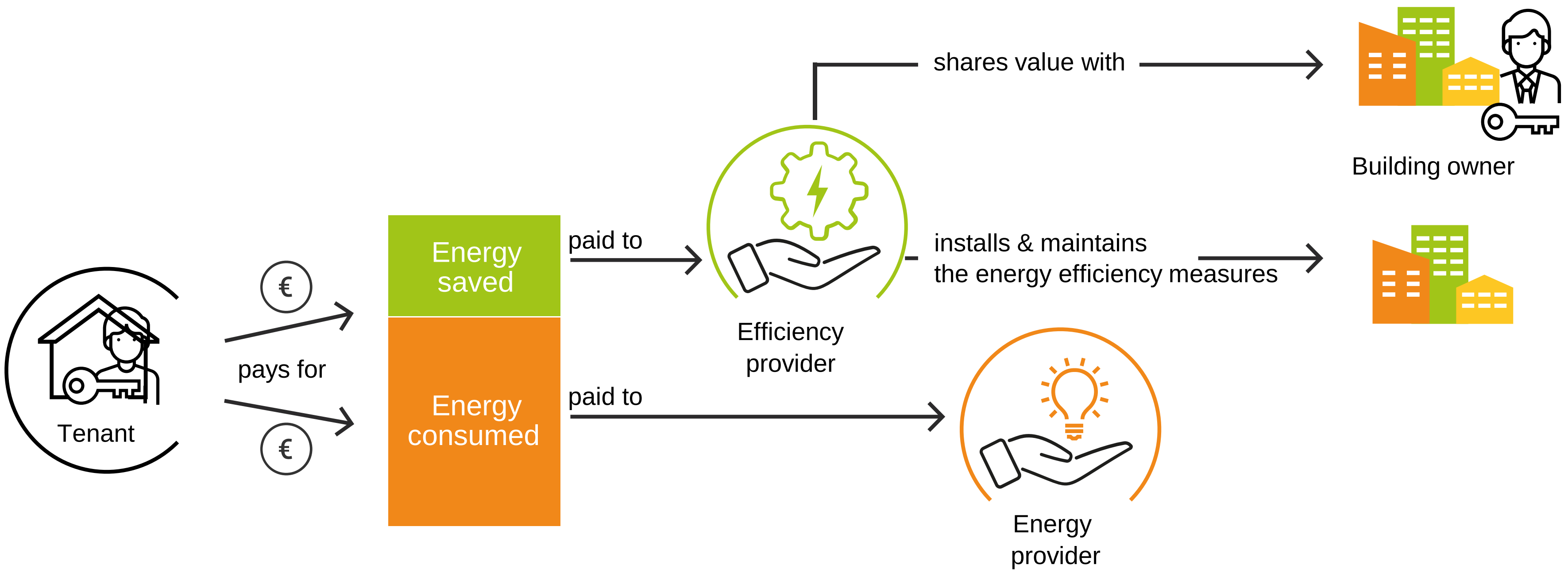
A **split incentive** occurs where the benefits of a transaction do not primarily accrue to the person who pays for it.

The Energy Efficiency Directive (Directive 2012/27/EU) includes a provision in its Article 19(1)(a) recognising the importance of addressing the barrier of split incentives in the building sector.

"Member States shall evaluate and if necessary take appropriate measures to remove regulatory and non-regulatory barriers to energy efficiency, without prejudice to the basic principles of the property and tenancy law of the Member States, in particular as regards: (a) the split of incentives between the owner and the tenant of a building or among owners, with a view to ensuring that these parties are not deterred from making efficiency- improving investments that they would otherwise have made by the fact that they will not individually obtain the full benefits or by the absence of rules for dividing the costs and benefits between them, including national rules and measures regulating decision- making processes in multi-owner properties"

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 10133744.

The SmartSPIN concept



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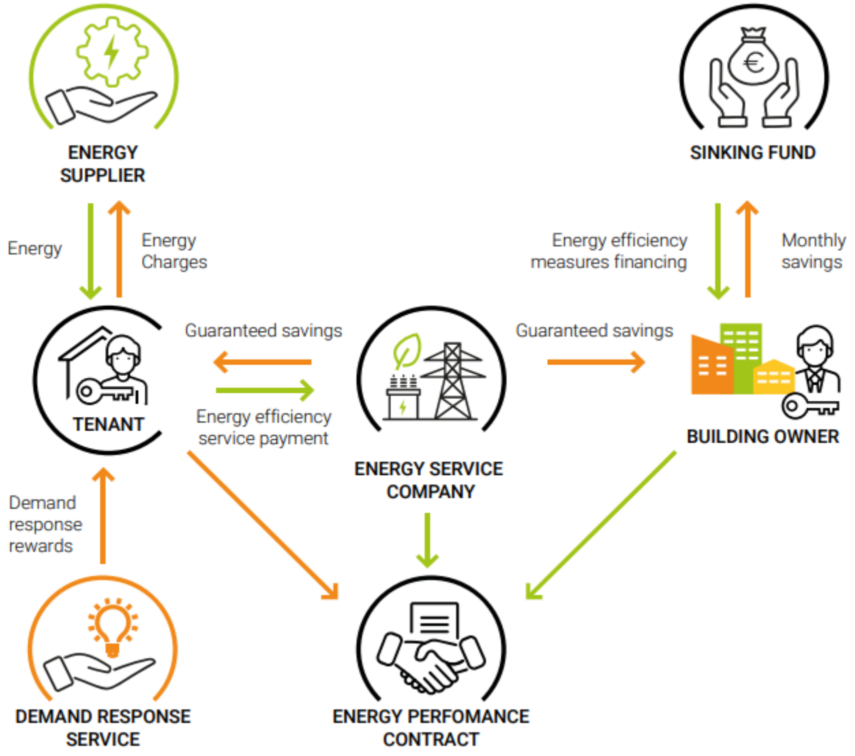
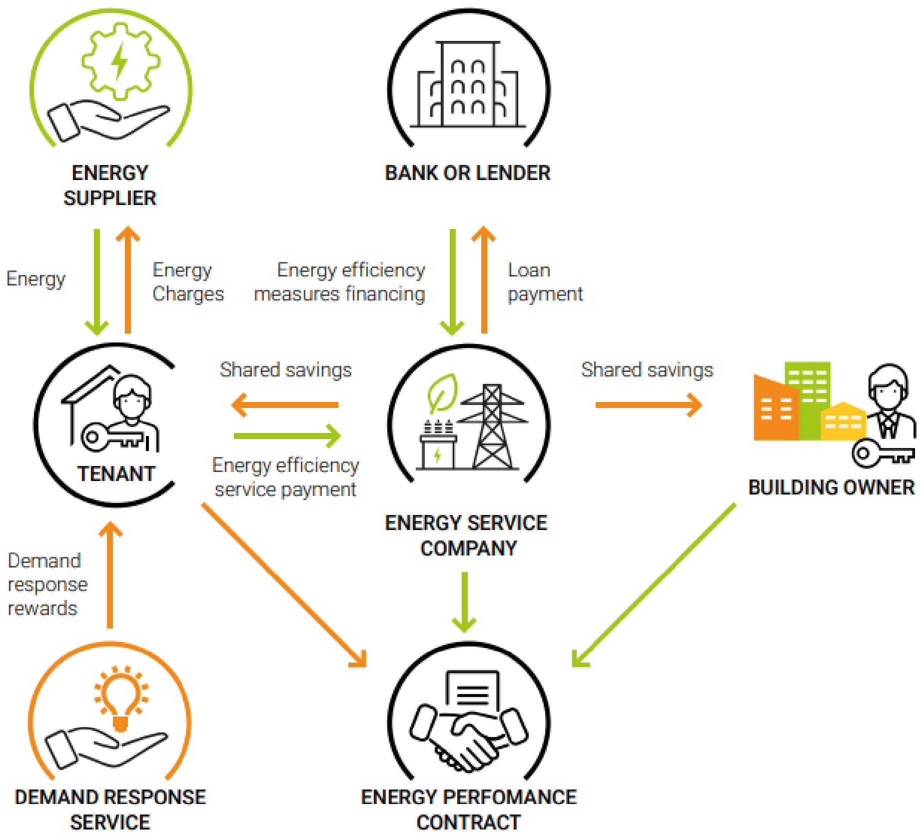
The SmartSPIN concept





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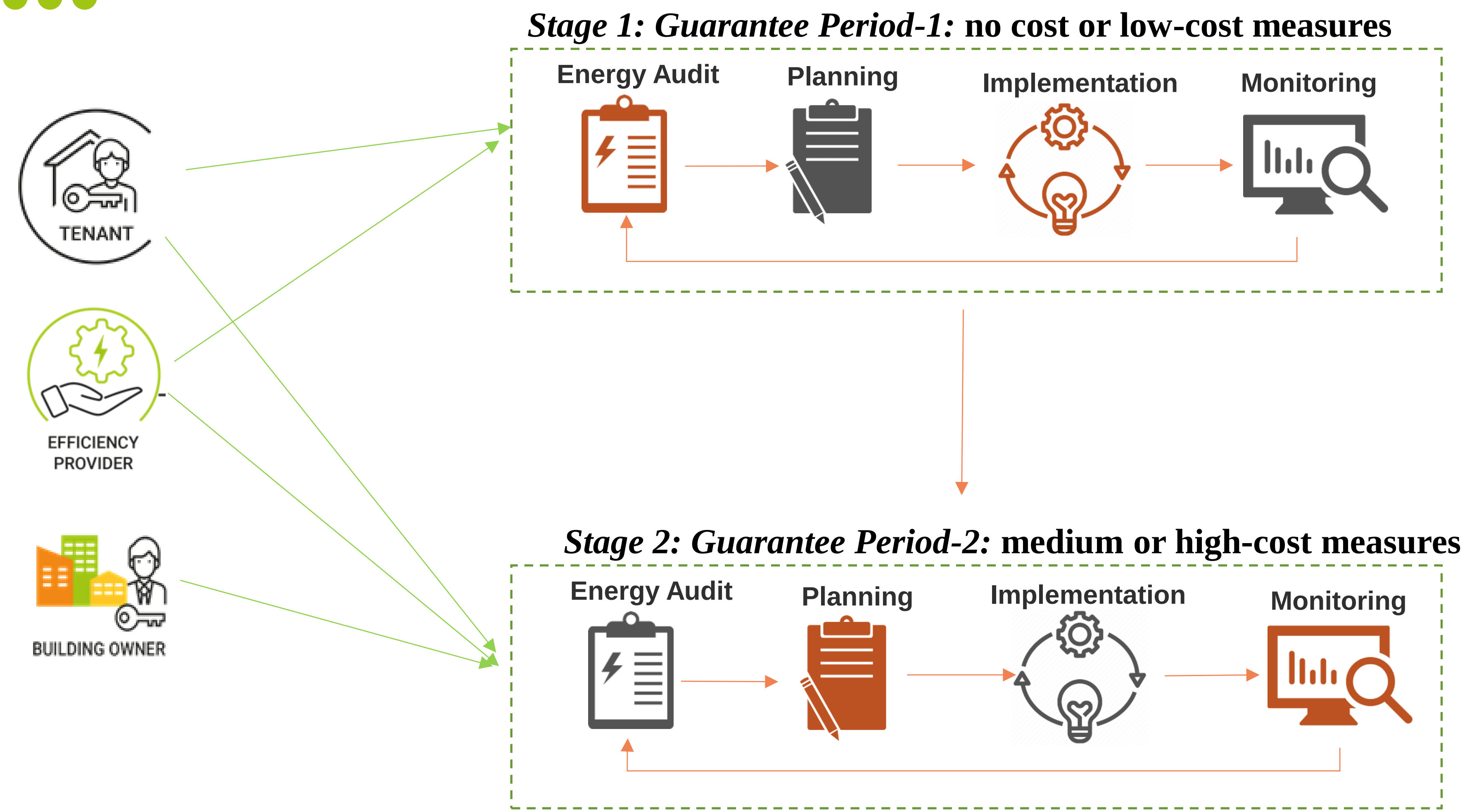
SmartSPIN service implementation



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Validation of the SmartSPIN Business Model

Validation: *Focus on the core aspects of the business model, making it more compact and simpler*

SmartSPIN Business Model

Designed for:	*Designed by:*	*Version:*
Energy Service Companies	SmartSPIN project	2.0

Key Partners

Materials and components suppliers (smart devices, renewable energy sources, energy storage components and infrastructure, e-mobility infrastructure, smart monitoring & management platform).

Building automation and technology installers.

Building services engineering companies.

Project financiers.

Energy Performance Contracting Facilitators.

Building services engineers and designers.

Energy efficiency consultants.

Key Activities

Select of one or more energy efficiency measures. Elaborate an implementation plan for energy efficiency measures.

Define the energy efficiency service price (service fee paid by clients) and plan of payments.

Implement agreed energy efficiency measures.

Collect energy consumption data (system monitoring) and optimise the installed measures.

Run the energy performance contract. Measure and verify energy savings and determine recurring payments of clients.

Perform system maintenance regularly.

Train clients on how to use of their equipment and appliances to reduce energy consumption.

Key Resources

Capital from project financiers and grants for the installation of energy efficiency measures.

Contractual templates to implement the smart energy service in commercial rented properties.

Energy efficient equipment and measures. Technologies for smart controls. Building Management Systems. Meters, sensors, data loggers.

Gamification app, building performance diagnostic app, measurement and verification app.

Value Propositions

Increased value of the property after installation of energy efficiency measures and BMS upgrades.

Renovated property and non-energy benefits such as increased indoor comfort (e.g. thermal comfort and air quality).

The service fee paid monthly by the renters to the ESCO for the energy efficiency service.

The monthly payment performed by ESCO to the building owner to share the value of the energy savings achieved by renters.

The service fee paid by the building owner to the ESCO (optional, applicable only if the building owner occupies part of the building).

The responsibility taken by the ESCO for the installation, commissioning, monitoring and regular maintenance of equipment, devices and systems and the provision of guaranteed energy savings to their clients.

Customer Relationships

Agreement between ESCO and clients about energy efficiency measures to be installed and the subject responsible for project financing (ESCO or building owner).

Negotiation about the recurring service fee payment performed by each client to the ESCO.

Invoice for the energy efficiency service sent by ESCO to clients.

Receipt for the recurring payment received by the building owner from the ESCO.

Channels

Website and blog.
Printed posters displayed at strategic locations. Printed or digital flyers or brochures.
Social media channels.
Printed or emailed newsletters.
Press releases. TV or radio advertisements.
Outreach at trade shows and sectoral events.
Outreach via building owners and managers associations.
Business referral.

Customer Segments

Building owners and renters of different typologies of commercial properties, such as:

- Industrial buildings (e.g. manufacturing facilities, warehouses, etc)
- Retail (e.g. clothing stores, commercial banks, restaurants, etc)
- Office buildings
- Healthcare facilities
- Hotels and hospitality buildings
- Special or mixed purpose buildings (e.g., airports, shopping centres, recreational centres)

Cost Structure

Purchase cost of equipment and energy efficiency measures. Financing costs. Installation costs. Operation and Maintenance costs. Costs for consultants and contractors. Costs associated with the measurement and verification of energy savings. ESCO personnel costs. Recurrent monetary reward to the building owner. Marketing and advertisement costs.

Revenue Streams

Main revenue stream associated with the value of part of the energy savings obtained by the clients, i.e., renters and building owner (the latter only if they occupy part of the building). Revenue stream for the operation and maintenance service. Additional revenue stream for equipment rent, in case the ESCO owns the equipment and rents it to the client for a fixed monthly fee. All the revenue streams are collected through the service fee.

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Validation of the SmartSPIN Business Model

Validation: *Value proposition matching customer's wants, needs and fears*

Value Proposition Canvas

Designed for: Energy Service Companies
Designed by: SmartSPIN
Version: 1.0

Product

Benefits

- Delivers *energy efficiency gains* and *energy cost reductions* to clients that occupy rented commercial properties.
- Minimizes the performance risks providing a minimum level of *guaranteed energy savings*.
- Provides a *comprehensive service* encompassing selection of energy efficiency measures, their installation, optimised system operation and maintenance, measurement and verification of energy savings.

Features

The *Smart Energy Service* will:

1. *Design* a building retrofit and building systems upgrades in collaboration with the client.
2. Implement, monitor and optimise selected *energy efficiency measures*.
3. *Measure and verify* the energy savings periodically (e.g. monthly or quarterly).
4. Provide a *compensation* to the clients if the contractual guaranteed energy savings are not achieved.
5. Reward the building owner proportionally to the savings achieved by the renters.

Experience

ESCO's clients gain certainty about the energy savings that will be achieved because the ESCO bears the performance risk of the project.

Building owners are incentivised in taking the responsibility for an investment in energy efficiency because they are rewarded by the ESCO depending on the amount of savings achieved by the renters.

The ESCO acts as a one-stop shop providing a comprehensive service, that does not require building owners and renters to liaise with multiple contractors.

The ESCO takes the responsibility not only to install equipment and energy efficiency measures, but also to maintain them and operate them in an optimised manner.

Customer

Wants

Building owners want: 1) Renovate their buildings to increase their value on the rental market. 2) A revenue stream from an energy efficiency project. 3) Assistance with project financing, or identification of available grants that can support the purchase/installation of suitable energy efficiency measures. 4) Select and install affordable energy efficiency measures with a short payback time. 5) An energy performance contract (EPC) of not too long duration to maximise the rewards from the installed energy efficiency measures and mitigate the risk that some renters would leave, making the EPC no longer sustainable.
Renters want: 1) Rent a renovated and comfortable property. 2) Increase their energy efficiency.

Needs

- A detailed *energy audit* to accurately evaluate the expected energy savings and the ability of the selected energy efficiency measures in achieving them.
- To minimize the *technology risks* due to improper system design, improper equipment selection, unexpected equipment deterioration.
- *Training* to operate the newly installed equipment according to the prescribed operation schedule and optimal control strategy and procedures.
- A flexible *EPC contractual template* including clauses enabling 1) a system monitoring and optimisation period; 2) the building owner to obtain a reward proportional to the energy savings achieved by the renters.

Fears

The energy efficiency measures are not affordable, or their payback time is too long.

The expected energy savings will not be achieved for a variety of reasons such as their inaccurate estimation, low quality of system operation and maintenance, system performance degradation due to equipment wear and tear and operation parameter variations.

Renters do not contribute to the energy efficiency investment, whereas the energy savings that they would achieve cannot be easily shared with the building owner, who takes the responsibility for the investment (split incentive issue).

Product

Smart Energy Service for Commercial Rented Properties.

Ideal Customer

Building owners and renters of commercial rented units.

Substitutes

The main substitute is the traditional method, also known as Design–bid–build or Design–tender, in which the building owner contracts with separate Companies and Consultants for the design and construction of an energy efficiency project.

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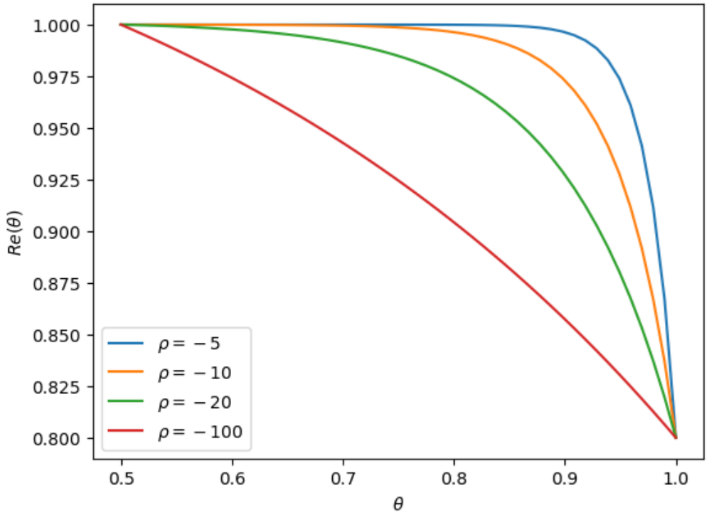
Division of the energy cost saving between landlord, tenant and ESCO

A challenge for the ESCOs is to understand renters' behaviors with respect to energy consumption and determine the division of the savings between the building owner and the renters that maximize the value for the building owner.

$$Q(t) = f(t) \cdot Re(\theta) \cdot K(t)$$

- $K(t)$ is the energy savings potential of the project
- $Q(t)$ are the actual savings
- $f(t)$ is the equipment degradation function (which decreases from 1 to 0 during the project lifetime)
- $Re(\theta)$ is the rebound effect multiplier



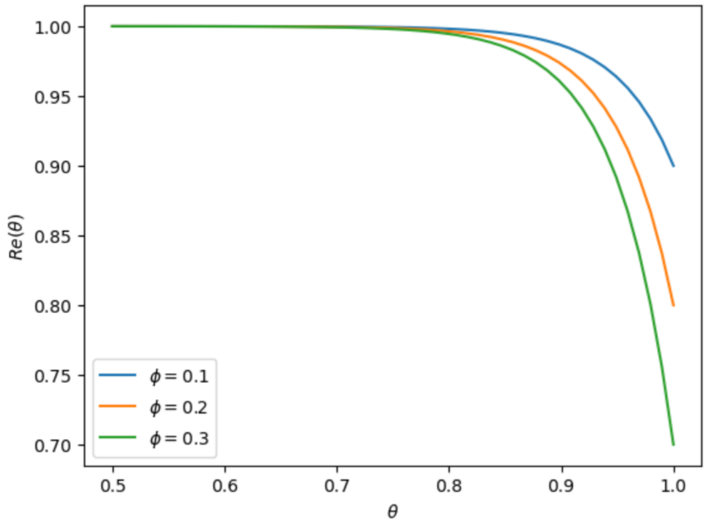
$$Re(\theta) = \alpha_2 + \alpha_1 e^{-\frac{k_2\theta + k_1}{\rho}}$$

φ maximum rebound effect (corresponding to $\theta = 1$)

$$\alpha_1 = \frac{\varphi}{1 - e^{k_1/\rho}}$$

$$\alpha_2 = 1 - \alpha_1$$

ρ the risk tolerance, which accounts for the individual ris attitudes of different renters



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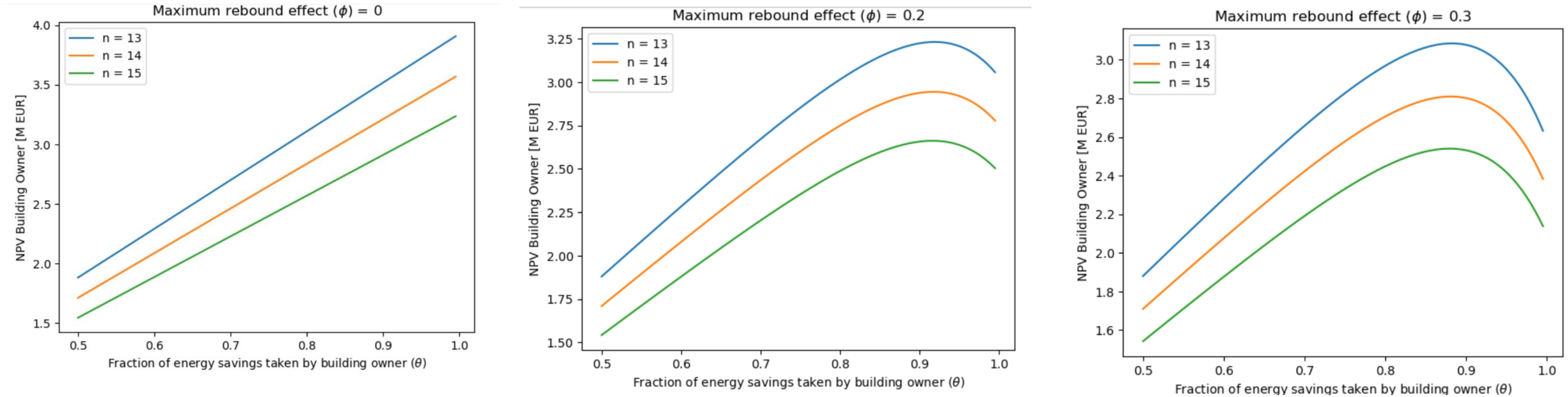
Division of the energy cost saving between landlord, tenant and ESCO



If the renters' rebound effect increases, the fraction of energy savings taken by the building owner which maximizes the NPV for the building owner tends to decrease.

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Revenue Streams for ESCO, Renters and Building Owner

$$R(t) = P_E(t) \cdot Q(t)$$

Revenue stream for ESCO:

$$R_E = \begin{cases} 0, \quad t = 0 \\ R(t) - G - \max[0, \beta(R(t) - G)], \quad t = 1, \dots n \\ 0, \quad t = n + 1, \dots . N \end{cases}$$

Revenue stream for renters:

$$R_R = \begin{cases} 0, \quad t = 0 \\ (1 - \theta)(G + \max[0, \beta(R(t) - G)]), \quad t = 1, \dots n \\ (1 - \theta)R(t), \quad t = n + 1, \dots . N \end{cases}$$

Revenue stream for building owner:

$$R_O = \begin{cases} 0, \quad t = 0 \\ \theta(G + \max[0, \beta(R(t) - G)]), \quad t = 1, \dots n \\ \theta R(t), \quad t = n + 1, \dots . N \end{cases}$$

- $R(t)$ revenue stream from energy savings
- $P_E(t)$ energy price
- G guaranteed energy savings
- β fraction of energy savings exceeding the threshold G shared by the ESCO with the building owner
- n contract duration
- N equipment duration in years
- θ fraction of the energy savings kept by the building owner

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Net Present Value for ESCO, Renters and Building Owner

Net Present Value for ESCO:

$$NPV_E = (\gamma - 1)I_C + \sum_{t=1}^{n} \frac{R(t) - G - max[0, \beta(R(t) - G)] - I_{OM}(t)}{(1 + r_E)^t}$$

Net Present Value for renters:

$$NPV_R = \sum_{t=1}^{n} \frac{(1 - \theta)(G + \max[0, \beta(R(t) - G)])}{(1 + r_R)^t} + \sum_{t=n+1}^{N} \frac{(1 - \theta)R(t)}{(1 + r_R)^t}$$

Net Present Value for building owner:

$$NPV_O = -\gamma I_C + \sum_{t=1}^{n} \frac{\theta(G + max[0, \beta(R(t) - G)])}{(1 + r_O)^t} + \sum_{t=n+1}^{N} \frac{\theta R(t) - I_{OM}(t)}{(1 + r_O)^t}$$

- I_C capital investment required for the energy efficiency measures
- $I_{OM}(t)$ operation & maintenance costs
- r_E, r_R, r_O interest rates applied to ESCO, renters and building owner
- γ fraction of the capital investment performed by the building owner
  $0 \leq \gamma \leq 1$

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Decision making for ESCO contractual agreements

*The approach proposed is to **maximize the NPV for the building owner, while requiring a minimum NPV for the ESCO.** In this way, the proposed Smart Energy Service is promoted by the ESCO maximizing the benefits for the building owners. This approach is the right one **to foster the market development of this kind of SES.***

$$n_{opt}, \gamma_{opt} = arg \max_{n,\gamma} NPV_O$$

subject to:

The building owner has a budget constraint: $\gamma I_C \leq I_{max,C}$

The building owner has a budget constraint: $NPV_E \geq NPV_{E,min}$

- The building owner wants to **reduce the contract duration *n*** as a longer duration would reduce NPV_O (the ESCO would get a fraction of the energy savings for more time).
- The building owner wants to reduce the fraction of the investment γ borne (wishing the ESCO to provide ideally all the capital, i.e. γ = 0).
- γ = 0 is not necessarily the best choice because that leads to the longest contract duration ensuring $NPV_E \geq NPV_{E,min}$
- *Increasing **γ** allows the ESCO to reduce **n***, therefore an optimal trade off should be found.

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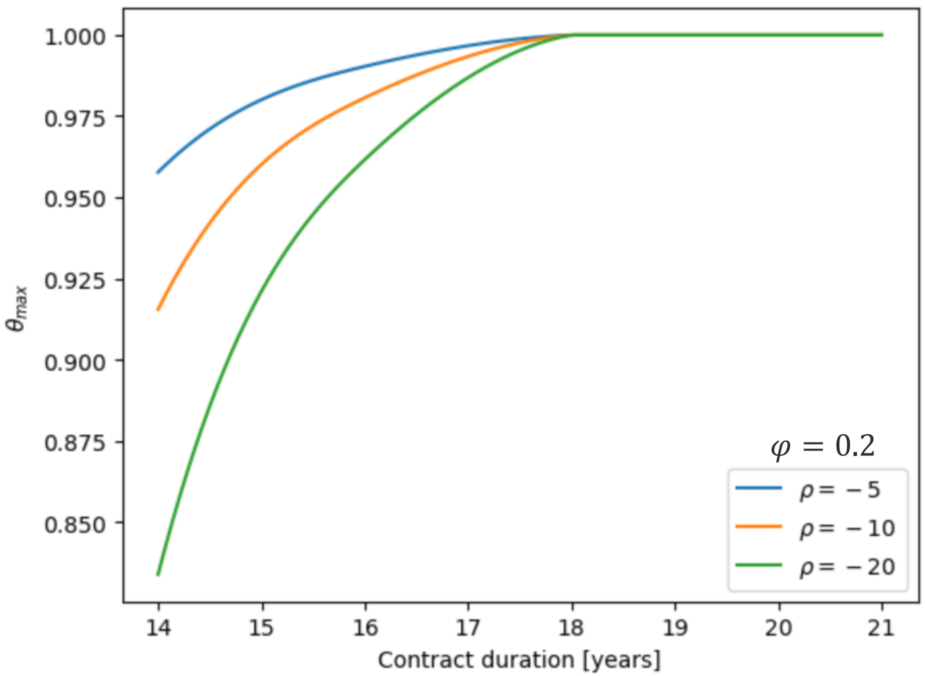
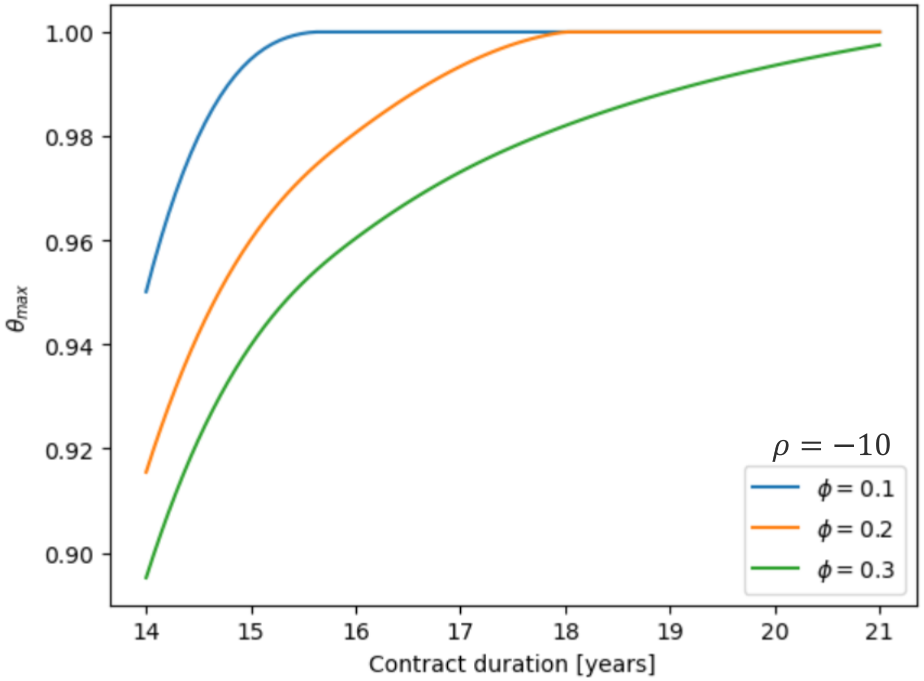
Decision making for ESCO contractual agreements





To ensure that $\mathrm{NPV_E} > 0$ for a certain contract duration the fraction of energy savings taken by the building owner must be $\theta \leq \theta_{max}$ to prevent a too high increase in renters' energy consumption (rebound effect) that would reduce the energy savings and determine economic losses for the ESCO, i.e. $\mathrm{NPV_E} < 0$

$I_C = 3.84$ M€; $G = 250$ k€/year; β=0.2; N = 25; $I_{OM}(t) = \left(\frac{1}{1.025}\right) I_C e^{\left(-\frac{\sigma_H^2 t}{2} + \sigma_H \varepsilon_H \sqrt{t}\right)}$ where $\sigma_H = 0.25$ and ε_H=0.01; $\gamma = 1$ $r_O = r_R = 0.031$; $r_E = 0.06$

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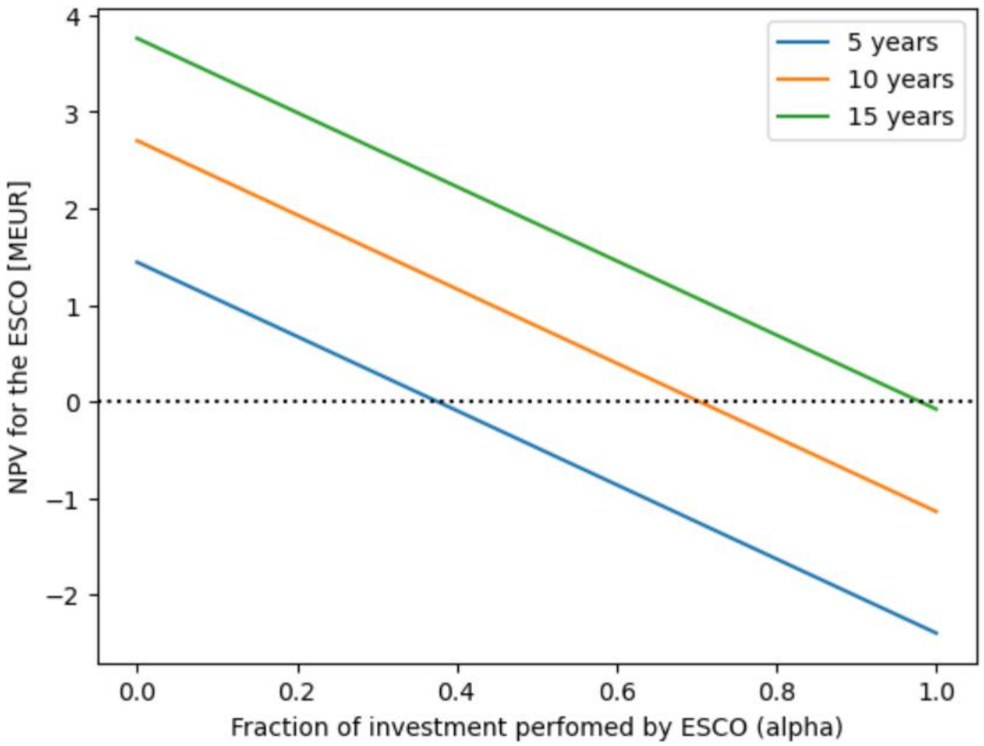
Consideration on the contract duration

- The **long contract duration** of the SES is a barrier with respect to contract signature in the commercial rented sector, because in many cases *such duration* can be **longer than the tenancy contract**.

- To mitigate the barrier of long contract duration:
  1. The building owner should *contribute as much as possible to the capital investment* required to implement the energy efficiency measures.
  2. The rebound effect of the renters should be reduced *sharing part of the energy savings with them*; otherwise, the *increased energy consumption of the renters may reduce the energy savings* and require a longer contract.



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Key Performance Indicators for Ireland

30 Herbert Street, Dublin

Project Performance Indicator	Planned	Current estimation
Floor Area (m^2)	7,100	
Baseline Electricity Consumption (GWh/year)	0.89	0.89
Baseline Natural Gas Consumption (GWh/year)	0.91	0.91
Renewable Electricity Generation (GWh/year)	0.03	0
Primary Energy Saving triggered by the project (GWh/year)	0.29	**0.16**
Reduction in GHG emission triggered by the project (tonnes CO2eq/year)	59	**43.65**
Investment in sustainable energy triggered by the project (€M)	0.5	**0.07**

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Key Performance Indicators for Greece

Project Performance Indicator	Planned	Current estimation
Floor Area (m^2)	3,400	
Baseline Electricity Consumption (GWh/year)	0.40	0.40
Baseline Natural Gas Consumption (GWh/year)	0.00	0.00
Renewable Electricity Generation (GWh/year)	0.17	0.17
Primary Energy Saving triggered by the project (GWh/year)	0.45	0.45
Reduction in GHG emission triggered by the project (tonnes CO2eq/year)	137	137
Investment in sustainable energy triggered by the project (€M)	0.17	0.17

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Key Performance Indicators for Spain

Project Performance Indicator	Planned	Current estimation
Floor Area (m^2)	156,066	
Baseline Electricity Consumption (GWh/year)	9.21 (GA)	7.66 (2021)
Baseline Natural Gas Consumption (GWh/year)	1.41	1.41
Renewable Electricity Generation (GWh/year)	1.16	**2.08***
Primary Energy Saving triggered by the project (GWh/year)	3.99	**4.81****
Reduction in GHG emission triggered by the project (tonnes CO2eq/year)	617	**743**
Investment in sustainable energy triggered by the project (€M)	6.71	6.71

* Plenilunio: 1.369 GWh/year; La Gavia: 0.707 GWh/year
** Plenilunio (electricity): 2.65 GWh/year, La Gavia (electricity): 2.07 GWh/year, Total natural gas: 0.09 GWh/year

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Key Performance Indicators total

Project Performance Indicator	Planned	Current estimation
Floor Area (m^2)	166,566	166,566
Baseline Electricity Consumption (GWh/year)	11.54	9.99
Baseline Natural Gas Consumption (GWh/year)	3.93	3.93
Renewable Electricity Generation (GWh/year)	1.36	**2.25**
Primary Energy Saving triggered by the project (GWh/year)	4.72	**5.42**
Reduction in GHG emission triggered by the project (tonnes CO2eq/year)	812	**923.65**
Investment in sustainable energy triggered by the project (€M)	7.38	**6.95**

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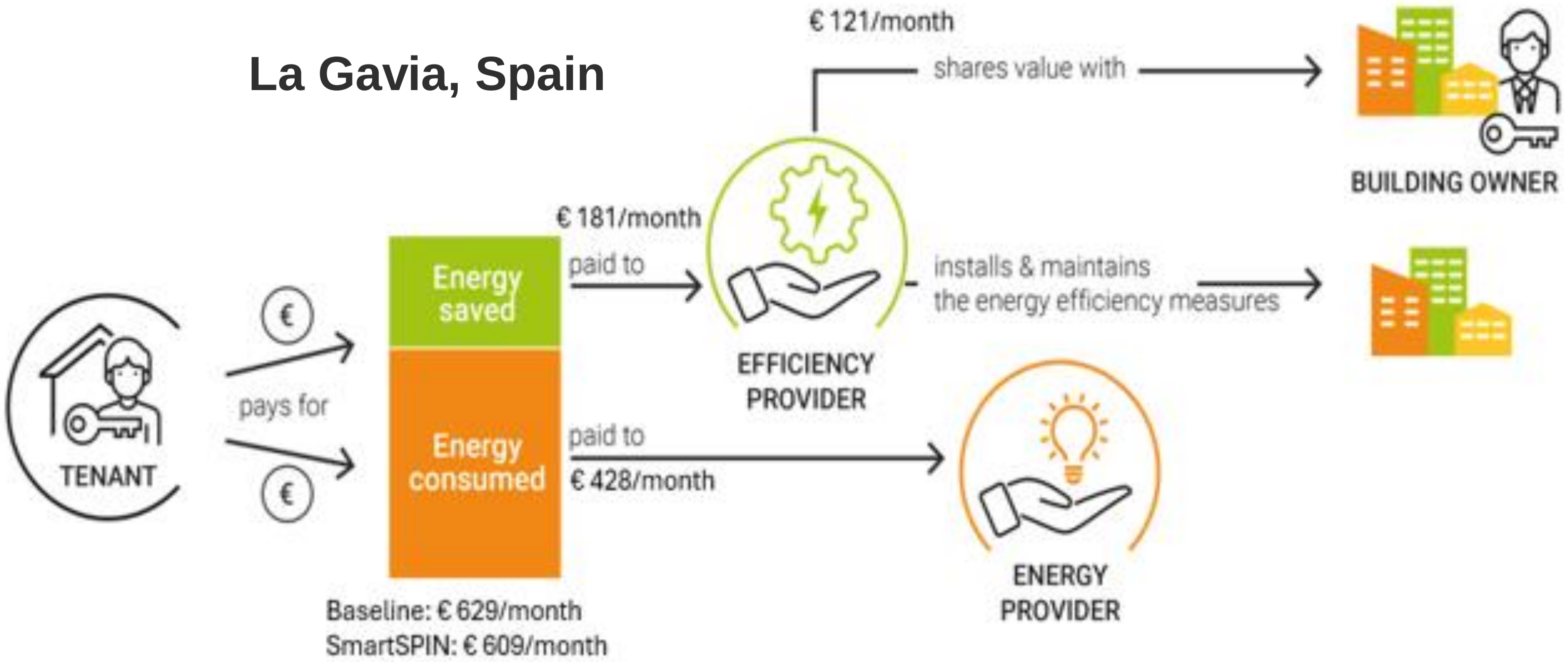
Smart Energy Service at Demonstration Sites

La Gavia, Spain



Indicative agreement for average renter to be presented to building owner and renters

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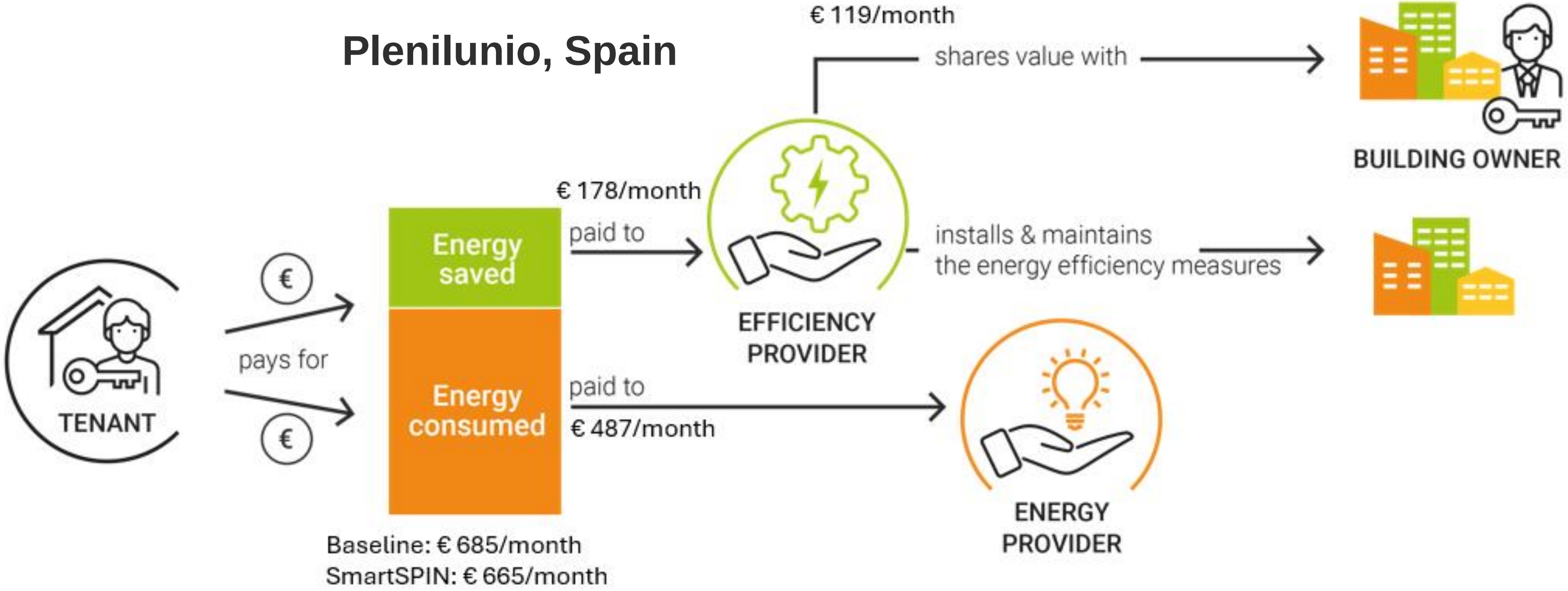
Smart Energy Service at Demonstration Sites

Plenilunio, Spain



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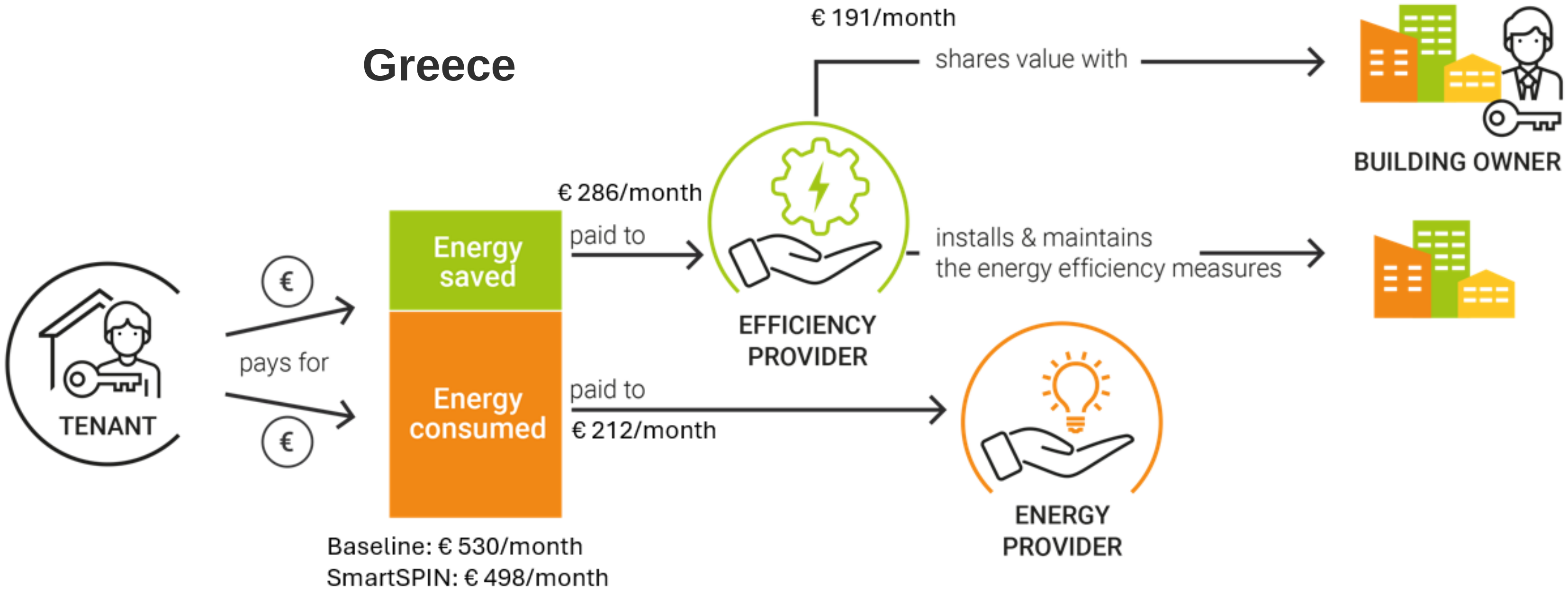
Smart Energy Service at Demonstration Sites

Greece



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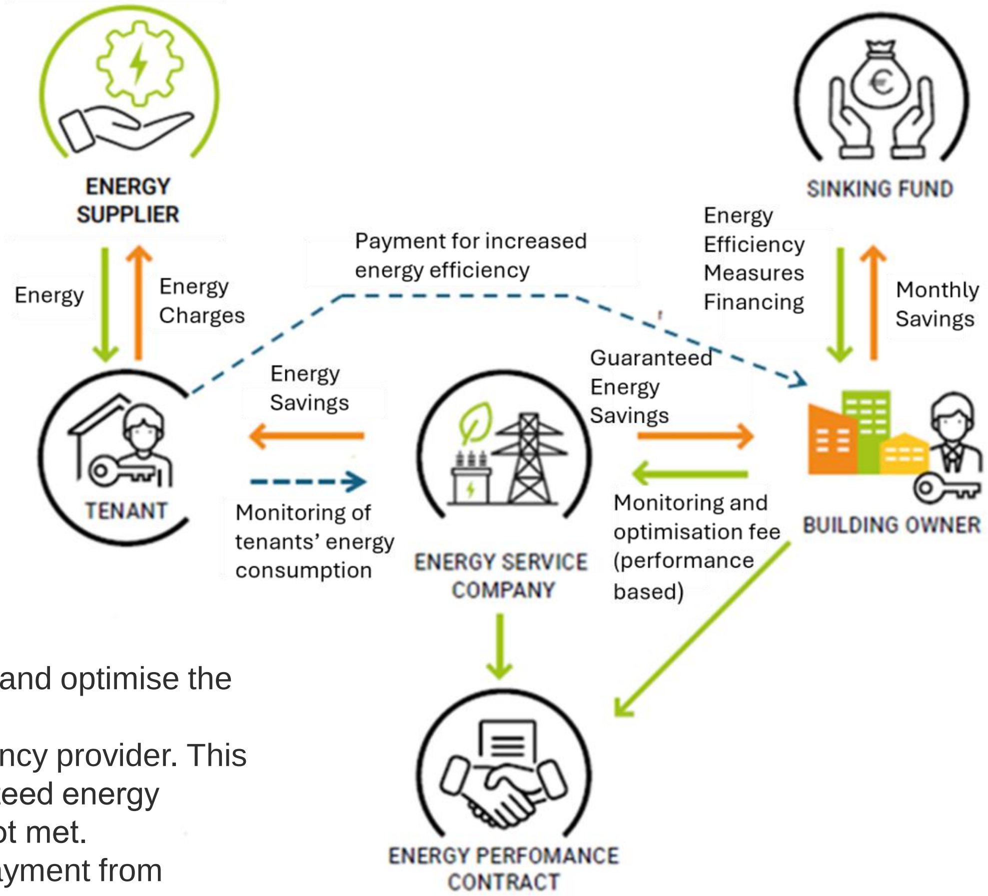
Smart Energy Service at Demonstration Sites

Ireland



- The energy efficiency provider will monitor the system, measure the energy savings, and optimise the system if necessary.
- The building owner will pay a **monitoring and optimisation fee** to the energy efficiency provider. This fee is performance based and it will be about €1,000/month if the contractual guaranteed energy savings are met and will be lowered to €500/month in case the energy savings are not met.
- During the first two years after the installation of the BMS upgrade there will be no payment from tenants for the energy efficiency service. Tenants' payments will be implemented after the end of the monitoring/optimisation period.

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Conclusions

- This presentation has discussed key steps undertaken to validate a **Smart Energy Service** suitable for **commercial rented properties**.

- As part of its validation, the SmartSPIN business model has been refined and fine tuned considering both **qualitative aspects** (CANVAS templates) and its **quantitative formulation**.

- **The Key Performance Indicators** and Smart Energy Service's **Implementation aspects** at Demonstration Sites have been reviewed showing its effectiveness in reducing the barriers of the **split incentive** and **long contract duration**.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 10133744.

Luciano De Tommasi, Senior Research Engineer, IERC

Ruchi Agrawal, Researcher, IERC

Thank you!

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