THESEUS
Hub4Circularity

Hubs4Circularity
COMMUNITY OF PRACTICE

WEBINAR 28 April 2026

Session 1: Regional Matchmaking, Regional Circular Economy (RCE)

Dr. Babis Manousiadis - Lead Project Manager of Theseus H4C

Session 2: MFA & DPP for sophisticated waste valorization and upcycling

Dr. Lucyna Łękawska-Andrinopoulou – Senior Researcher, Project Manager

ICCS. I-Sense Research Group

Funded by the European Union

Funded by the European Union's Horizon Europe Research and Innovation Actions programme under grant agreement No 101095303.

THESEUS

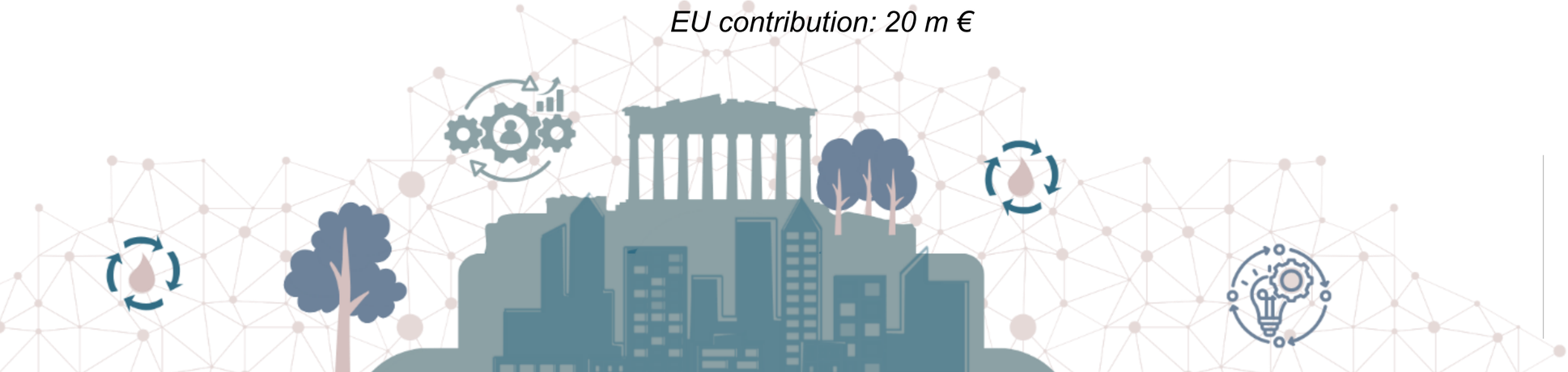
Hub4Circularity

A First-of-a-kind **Hub for circularity** demonstrator for Attica and peripheral regions

HORIZON-CL4-2024-TWIN-TRANSITION-01-38
Hubs for circularity for industrialized urban peripheral areas

Duration: *60 months, December 2024 - November 2029*

Total Budget: 23,5 m €
EU contribution: 20 m €



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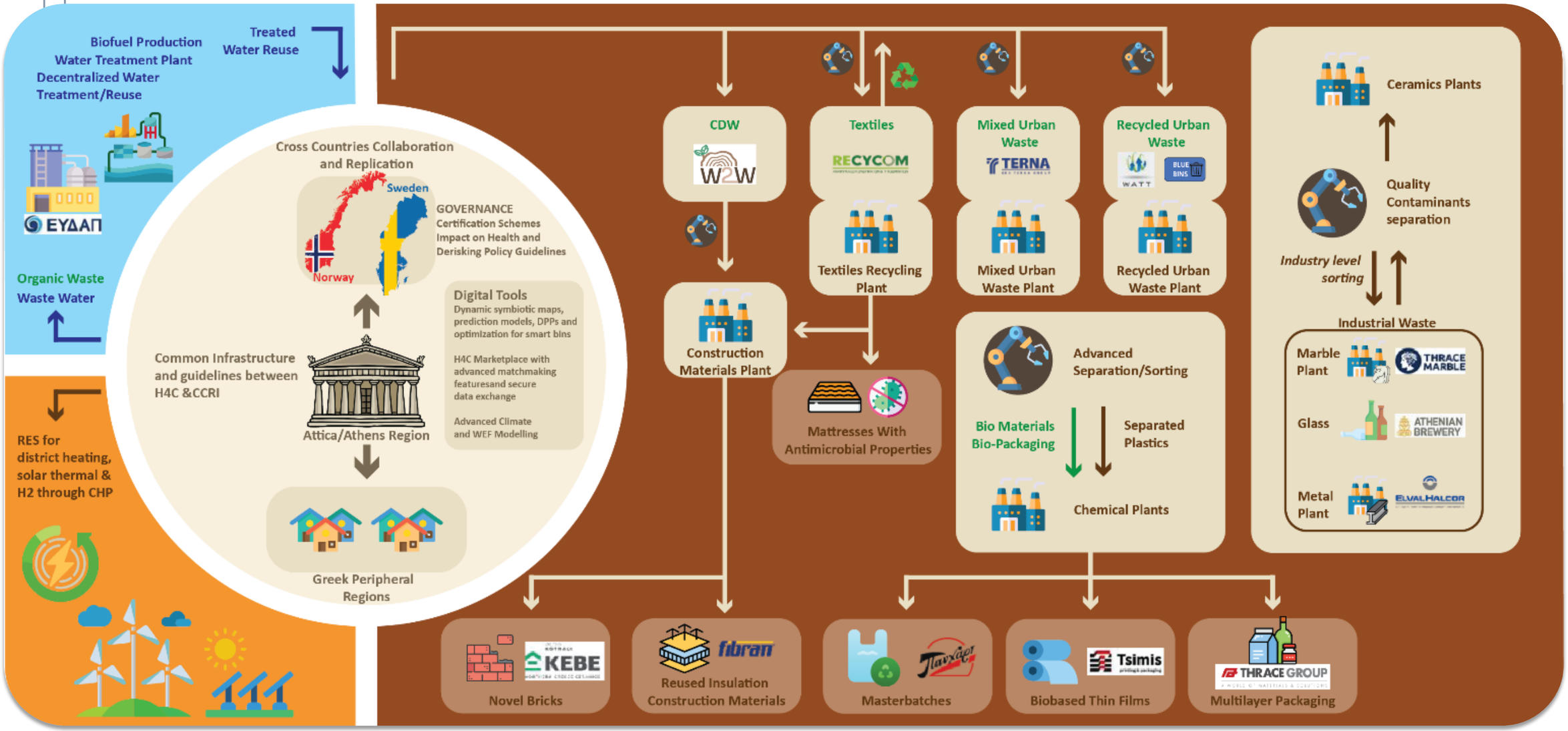
In a nutshell



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Session 1:
Regional Matchmaking, Regional Circular Economy (RCE)

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Lead Project Manager of Theseus H4C

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Why Regional?

From Industrial Symbiosis to Industrial-Urban Symbiosis & Hubs4Circularity

Different regions, activities, potential etc.

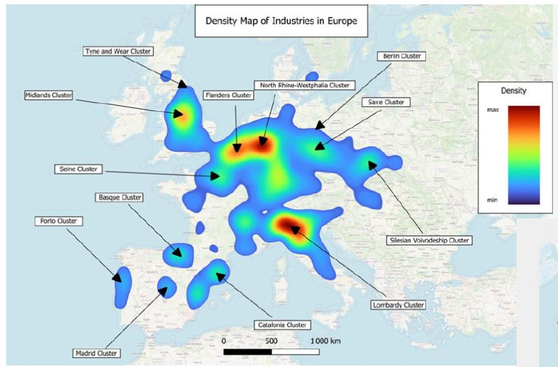


Figure 7. Regional assessment of H4C potential (based on analysis by H4C ECOP)

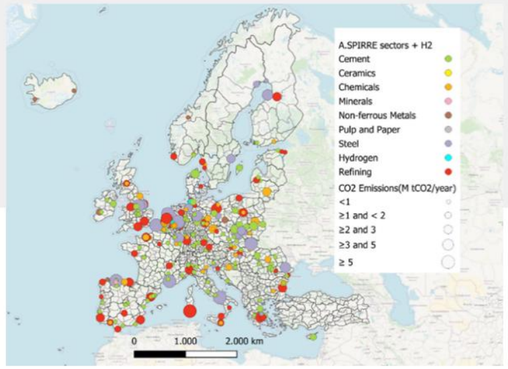


Figure 8 CO_2 emissions in Europe (data from Re4Indsutry project)

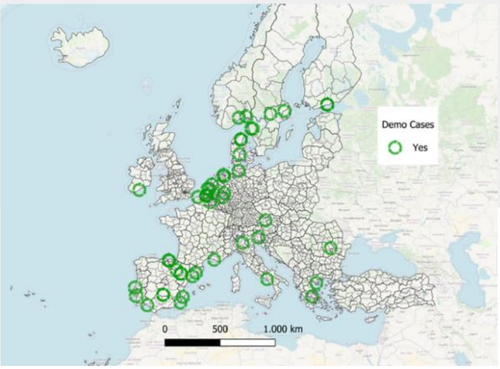


Figure 9 Location of selected demo cases

Source: P4Planet – H4Cs Community of Practice (H4CCoP) Whitepaper

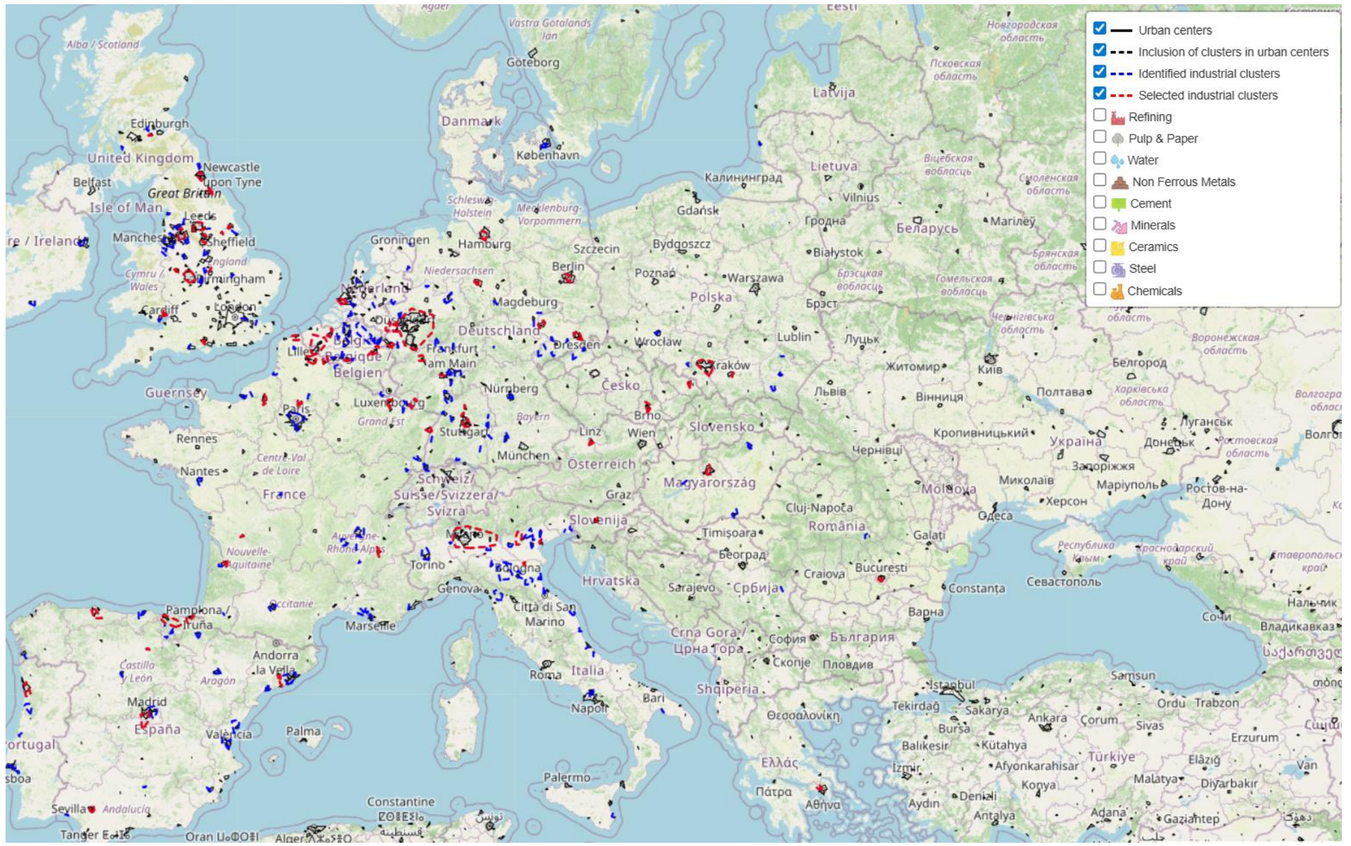
Previous matchmaking frameworks are developed, using multicriteria methods, mainly focused on waste streams and stakeholders' compatibility creating valorization matches or other dedicated to specific resources such as water and sludge.

To support H4C concept, there is a need to align I-US synergies identification and implementation with regional specialities, development strategies and relevant regional science methods.

Thus, Theseus study focuses on the integration of the regional settings, including region's characteristics, strategies, resources and waste, special needs or challenges, called as "Regional Scenery", into the matchmaking framework.

From Industrial Symbiosis to Industrial-Urban Symbiosis & Hubs4Circularity

Different regions, activities, potential etc.



Source: H4Cs Community of Practice (H4CCoP) – I-US potential around EU regions

Relevant outcomes of H4C Community of Practice:

- ✓ Guide to the impacts of industrial-urban symbiosis on local communities
- ✓ Guide to stakeholder engagement
- ✓ Detailed assessment of the potential for deploying I-US based on a detailed assessment of promising EU regions and H4Cs
- ✓ H4C Guide to Governance Models Supporting I-US

From Industrial Symbiosis to Industrial-Urban Symbiosis & Hubs4Circularity

Different regions, activities, potential etc.

H4C Community of Practice: Guide to the impacts of industrial-urban symbiosis on local communities

Environmental impacts

- Reduced inputs for cleaner production and sustainable use of resources
- Less stress on the environment
- Tackling climate change
- Tackling waste at the source

Economic impacts

- Cost savings related to waste management & new revenue streams
- Cost savings related to production and innovative green investment
- Investing resources elsewhere
- Creating the mind shift

Social impacts: benefits for communities

- A cleaner and healthier environment
- A more prosperous region
- Decoupling: the key to our future
- Fostering regional identity and belonging
- New forms of governance
- Raising awareness about sustainability

H4C Community of Practice: Guide to stakeholder engagement

Strategic engagement to advance I-US

Stakeholder type/role	Benefit provided by stakeholder to programme	Benefit provided to stakeholder by industrial urban-symbiosis programme
Investor: • Public sector, Government, EU, Private investors • Third Sector	Finance the programme's running costs	Desired outcomes from programme (e.g., meeting objectives)

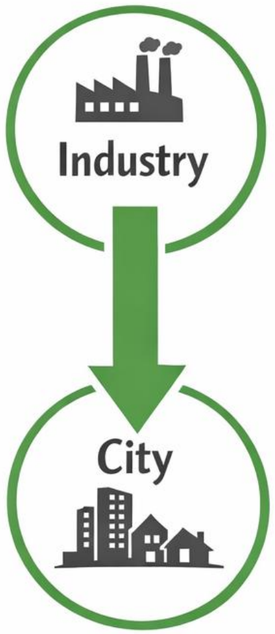
Stakeholder type/role	Benefit provided by stakeholder to programme	Benefit provided to stakeholder by industrial urban-symbiosis programme
Initiator: • Government • Trade associations • Private companies • Entrepreneurs • NGOs	Creates stakeholder interest and enabling environment	Desired outcomes from programme (e.g. meeting policy requirements) Various

Stakeholder type/role	Benefit provided by stakeholder to programme	Benefit provided to stakeholder by industrial urban-symbiosis programme
Policy makers • European Commission • National, regional, local government	Creates drivers Creates market conditions	Delivers policy objectives Builds understanding of policy

Stakeholder type/role	Benefit provided by stakeholder to programme	Benefit provided to stakeholder by industrial urban-symbiosis programme
Legitimisers: • NGOs, Regulators, Trade associations, Business organisations • Leading companies, • Government departments, • Verification bodies	Legitimise participation	Further reputation as leader, provider of opportunities, problem solver, being seen to be knowledgeable or useful.

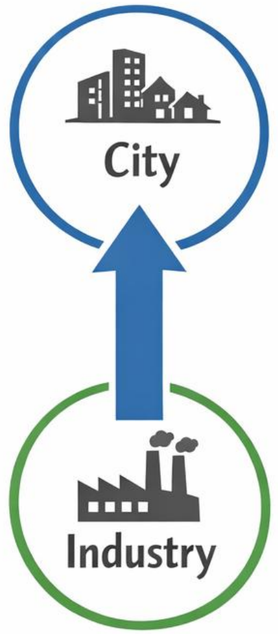
Regional Circular Economy (RCE)

- ✓ **Circular Economy (CE)** is implemented as **Industrial Symbiosis (IS),** focusing on industrial ecosystems and extending into cities via **Industrial-Urban Symbiosis (I-US).**
- ✓ Another similar concept is **Circular Cities and Regions Initiative (CCRI)** having the opposite direction, from urban extending into industrial environment.
- ✓ **Hub4Circularity (H4C)** concept emerges as the next evolutionary stage, combining I-US and CCRI, mainly at regional level:
  - proposing systemic solutions
  - integrating multiple regional stakeholders
  - introducing a variety of different operational models, due to the different regional settings.
- ✓ **H4C is the main vehicle for the Regional Circular Economy (RCE),** as the integration of CE practices into the overall sustainable regional development strategy, based on regional science principles.



CE / IS to I-US

Industrial to Urban



CCRI to Industry

Urban to Industrial

From Industrial Symbiosis to Industrial-Urban Symbiosis & Hubs4Circularity

Industrial Symbiosis^2 Hubs 4 Circularity

IS2H4C project focuses on deploying **systemic industrial symbiosis** through innovative technologies like carbon capture and electrolysis. The initiative is driven by the vision of resource efficiency, renewable energy production, waste prevention, and fostering industrial-urban-rural symbiosis.

Funded by the European Union

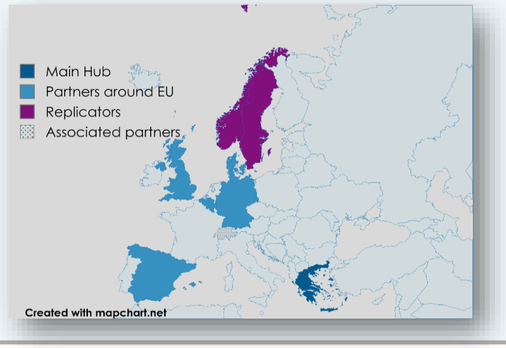
This research was financially supported by the European Union's Horizon Europe research and innovation program under **grant agreement No 101138473 (project IS2H4C).**

THESEUS

Hub4 Circularity

The establishment of a **first-of-a-kind** hub for circularity in Greece from the **region of Athens/Attica** towards whole country, closing loops through Industrial-Urban symbiosis to become climate neutral by 2050, in line with Processes4Planet partnership objectives.

Coordinated by **ICCS**



Funded by the European Union

This research was financially supported by the European Union's Horizon Europe research and innovation program under **grant agreement No 101095303.**

Governance & Cooperation

4 Critical Domains to be studied, identified in Theseus & IS2H4C:

A) Existing facilitators and/or institutional authorities

Existing coordination processes or conditions to be exploited

B) Strong sectors and resources, spatial & special characteristics

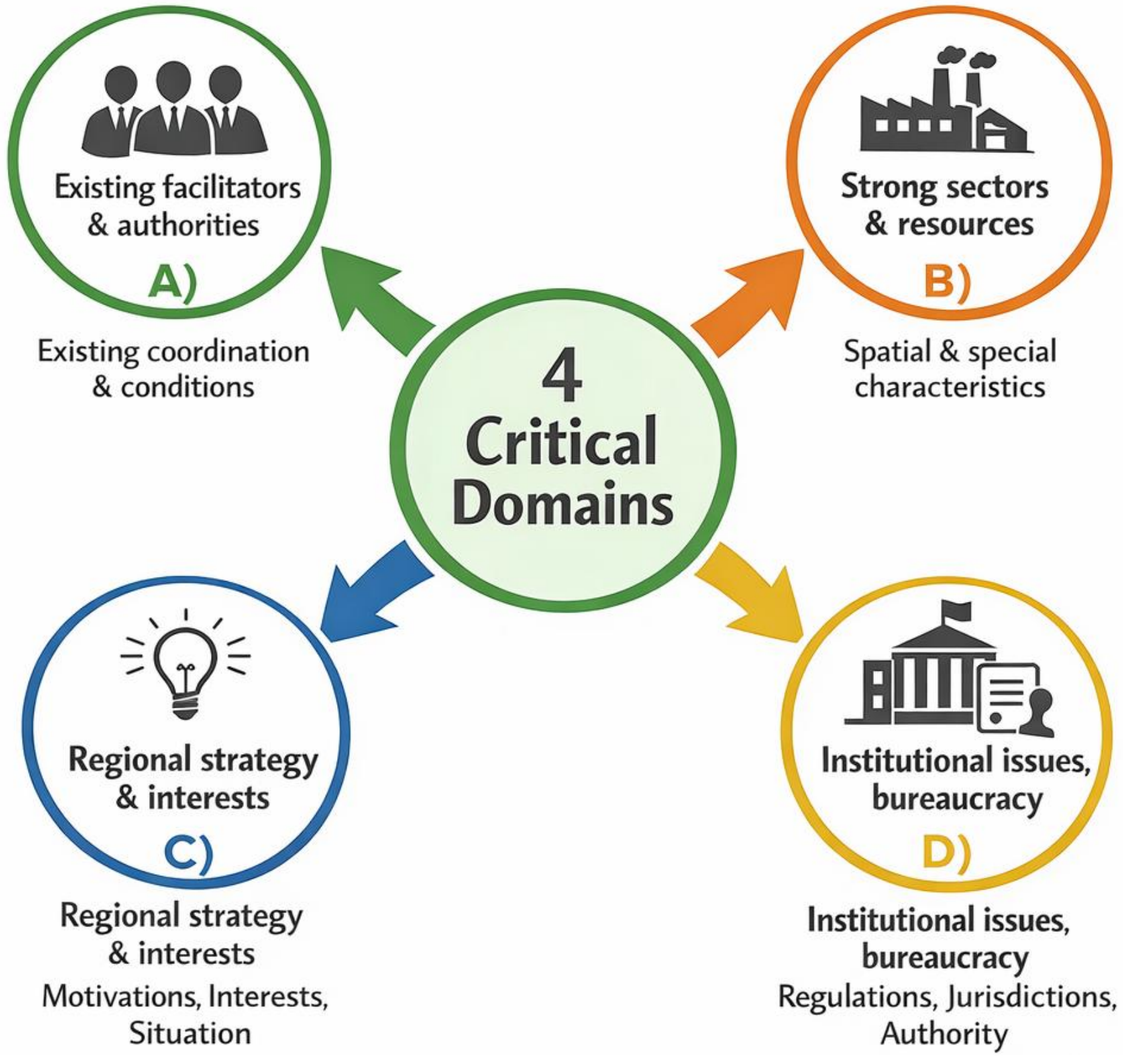
Dominant activities, dependencies, spatial patterns, proximity to other special region/area

C) Regional Strategy, political & other interests

Motivations, Interests, level of understanding, political situation, social participation

D) Institutional issues, bureaucracy

Regulations and the permissions, Jurisdiction & authority, Overlaps. Not focused on laws but on who is making the decisions.



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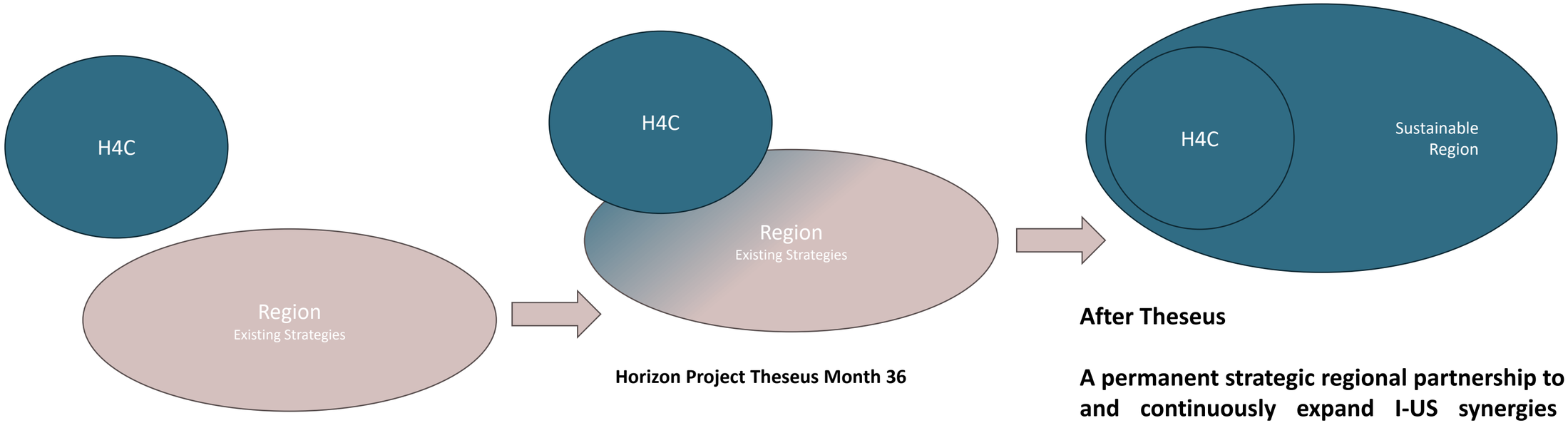
THESEUS H4C VISION



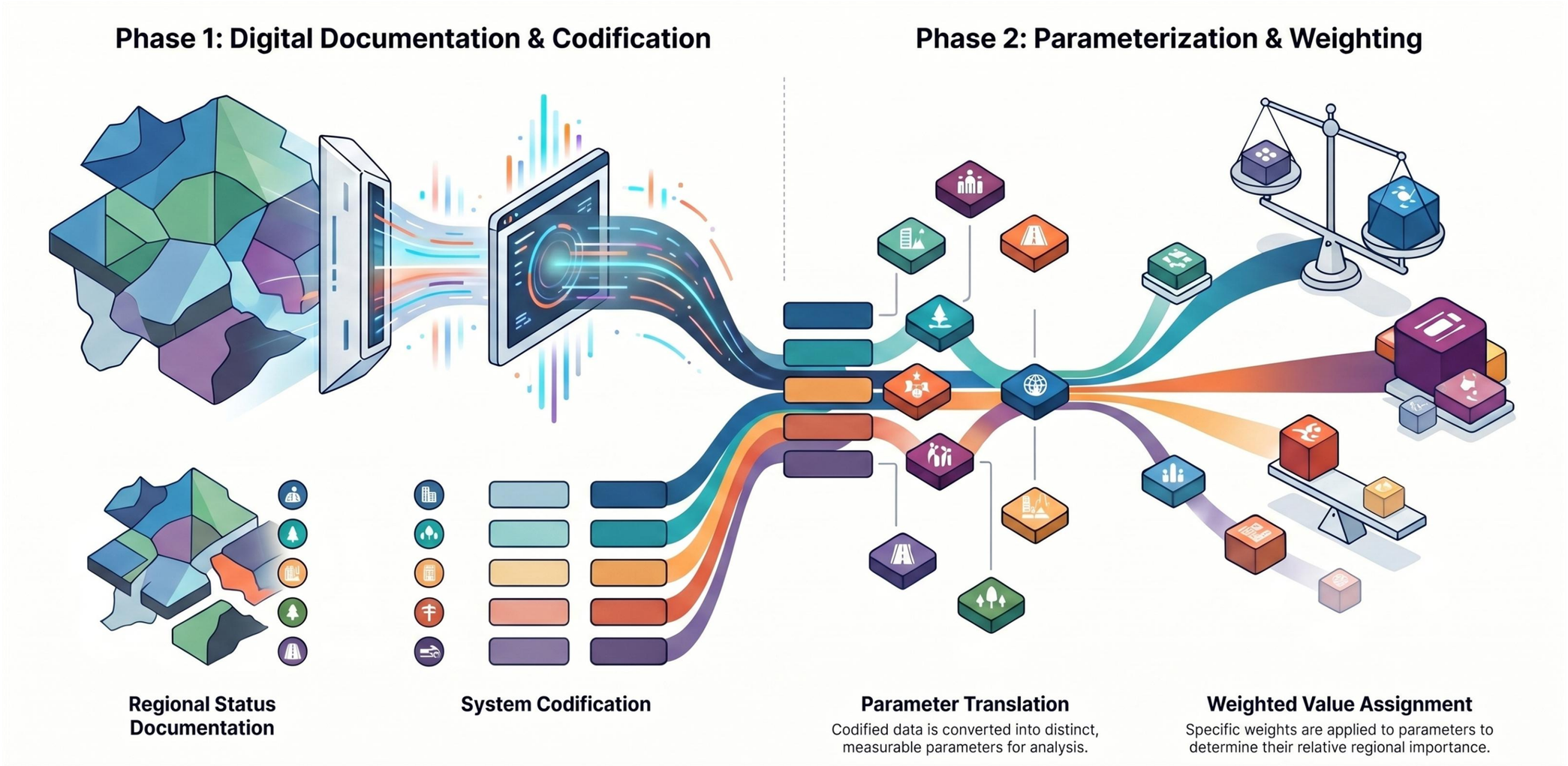
Horizon Project Theseus Month 1

Horizon Project Theseus Month 36

After Theseus

A permanent strategic regional partnership to operate and continuously expand I-US synergies toward regional resilience, competitiveness and sustainability

Regional Matchmaking



Physical Region → Digital Representation of Region: The Regional Scenery

Matchmaking Framework for CE/I-US synergies facilitation

Theseus will expand and enhance the logic established in the previous research within project **IS2H4C** which is also a H4C, financially supported by the European Union's Horizon Europe research and innovation program under grant agreement No 101138473.

1st level Regional Scenery
- Questionnaire on regional information

2nd level Reuse Priority
- Prioritize synergies based on waste importance/relevance for the region

3rd level Regional Impact
- Prioritize synergies based on impact factors

Level 1 includes data gathering to form the regional scenery:
Depict the size and the impact of each material/waste/water/energy flow to the region

Level 2 includes a first prioritization based on waste importance/relevance for the region:
e.g., in islands the water, in intense urban areas the municipal wastes

Level 3 includes based on the regional impact of the synergies:
e.g., in an area the water scarcity may be a criticality, whether in another area water is not a problem, but GHG emissions are.

The term region in this study is referred to Nomenclature of territorial units for statistics (NUTS) 2 level.

Regional Matchmaking Framework

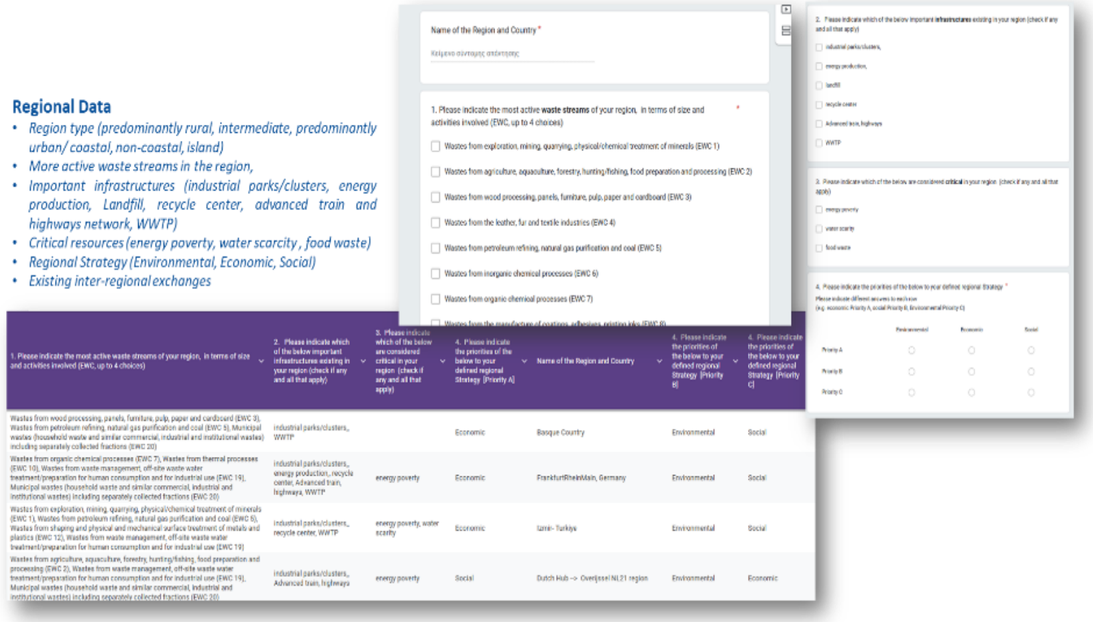
1st level Regional Scenery
- Questionnaire on regional information

2nd level Reuse Priority
- Prioritize synergies based on waste importance/relevance for the region

3rd level Regional Impact
- Prioritize synergies based on impact factors

Level 1: Regional data collection via a questionnaire:

- Region type
  (coastal, non-coastal, island, predominantly rural, intermediate, predominantly urban)
- Most active waste streams in the region (EWC codes)
- Important infrastructures
  (e.g., energy, landfill, recycling center, WWTP)
- Critical resources
  (e.g., due to energy poverty, water scarcity, food waste)
- Regional Strategy
  (Priorities on Environmental, Economic and Social)



Regional Matchmaking Framework

Based on the Questionnaire, 2 Tables are produced:

Questionnaire of 1st level → 2 Matrixes per hub (0≤weights≤1)

- **Matrix 1** displays the "magnitude" of resources in the specific hub
- **Matrix 2** displays impact factors that matter more in the specific hub

Regional Factors	Factors magnitude
Energy consumption (X1)	F1
reclaimed water (X2)	F2
Landfill reduction (X3)	F3
GHG emissions (X4)	F4
Jobs created (X5)	F5
GDP growth (X6)	F6

Matrix 2 Impact

EWC	Weight
1	w.1.1
2	w.1.2
3	w.1.3
4	w.1.4
5	w.1.5
6	w.1.6
7	w.1.7
8	w.1.8
9	w.1.9
10	w.1.10
11	w.1.11
12	w.1.12
13	w.1.13
14	w.1.14
15	w.1.15
16	w.1.16
17	w.1.17
18	w.1.18
19	w.1.19
20	w.1.20
21 (wastewater)	w.1.21
22 (sludge)	w.1.22
23 (electricity)	w.1.23
23 (heating)	w.1.24

Matrix 1 Magnitude

Level 2: all the different potential synergies are being identified (by matching input/output streams and services). The results are sorted based on results from Table 1

Level 3: A total **regional impact factor** = sum (Xi*Fi) is calculated:

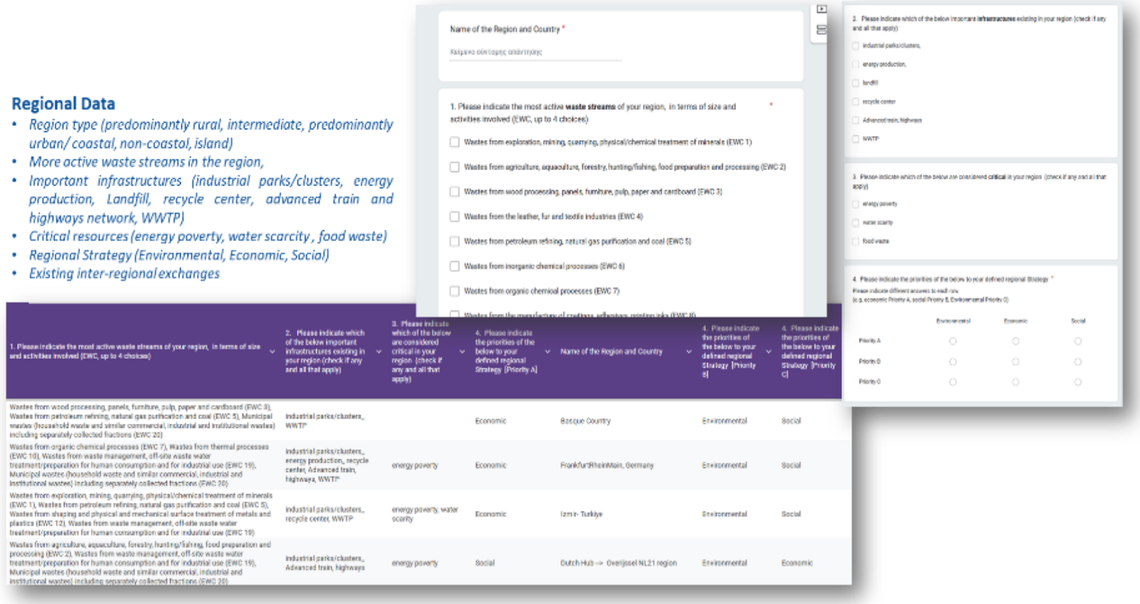
- Xi (X1-X6): calculated via standardized ways (LCA, emission factors).
- Fi (F1-F6): impact factors indicating the importance of corresponding Xi.

Regional Matchmaking Framework

Matrix Based Scoring

Regional Data

- *Region type (predominantly rural, intermediate, predominantly urban/ coastal, non-coastal, island)*
- *More active waste streams in the region,*
- *Important infrastructures (industrial parks/clusters, energy production, Landfill, recycle center, advanced train and highways network, WWTP)*
- *Critical resources (energy poverty, water scarcity , food waste)*
- *Regional Strategy (Environmental, Economic, Social)*
- *Existing inter-regional exchanges*



Stakeholder needs and high-level objectives

Questionnaire of 1st level → 2 Matrixes per hub (0≤weights≤1)

- **Matrix 1** displays the "magnitude" of resources in the specific hub
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Matrix 2 Impact

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9	w.1.9
10	w.1.10
11	w.1.11
12	w.1.12
13	w.1.13
14	w.1.14
15	w.1.15
16	w.1.16
17	w.1.17
18	w.1.18
19	w.1.19
20	w.1.20
21 (wastewater)	w.1.21
22 (sludge)	w.1.22
23 (electricity)	w.1.23
23 (heating)	w.1.24

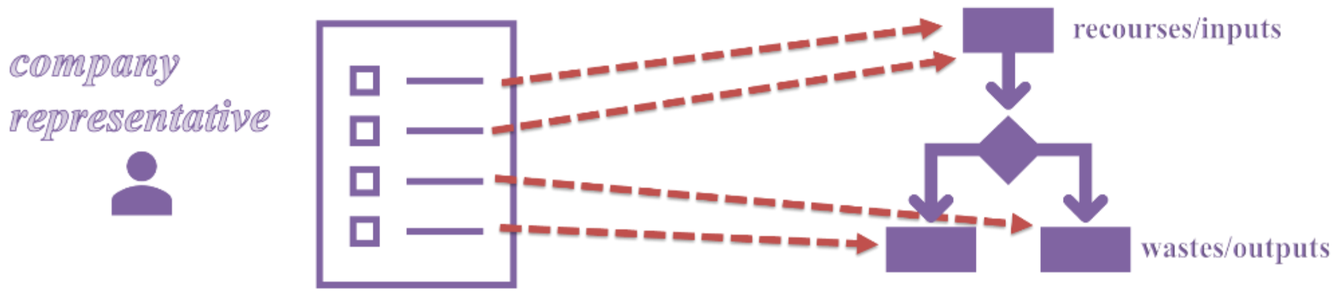
Matrix 1 Magnitude

Regional Matchmaking Framework

Use case #1 - Industry/Organization level

User is a company representative, R&D manager, etc.

- **Step 1:** User registers and fills in data for the region and for its recourses/inputs & wastes/outputs.
- **Step 2:** User can search for potential synergies based on its resources
- **Step 3:** A technical-based prioritized list of all feasible matches is displayed
- **Step 4:** User can request the calculation of the regional impact factor for enhanced prioritization



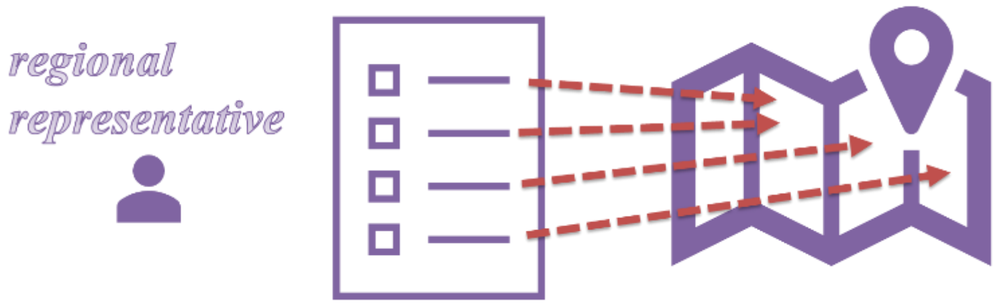
Regional Matchmaking Framework

Use case #2 - – Regional Level

User is a regional representative (manager, government, association, etc.).

Organizations of the region have already filled in data for its resources/waste/service

- **Step 1:** User can search for potential synergies between all the companies in the region
- **Step 2:** A technical-based prioritized list of all feasible matches is displayed
- **Step 3:** User can request the calculation of the regional impact factor for enhanced prioritization



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[9] P4Planet – H4Cs Community of Practice (H4CCoP) Whitepaper

[10] H4Cs Community of Practice (H4CCoP) reports: Guide to stakeholder engagement, Guide to the impacts of industrial-urban symbiosis on local communities

Thank you!

Charalampos Manousiadis

c.manousiadis@iccs.gr

Session 2:
MFA & DPP for sophisticated waste valorization and upcycling

Dr. Lucyna Łękawska-Andrinopoulou
Senior Researcher, Project Manager

ICCS. I-Sense Research Group

Funded by the European Union

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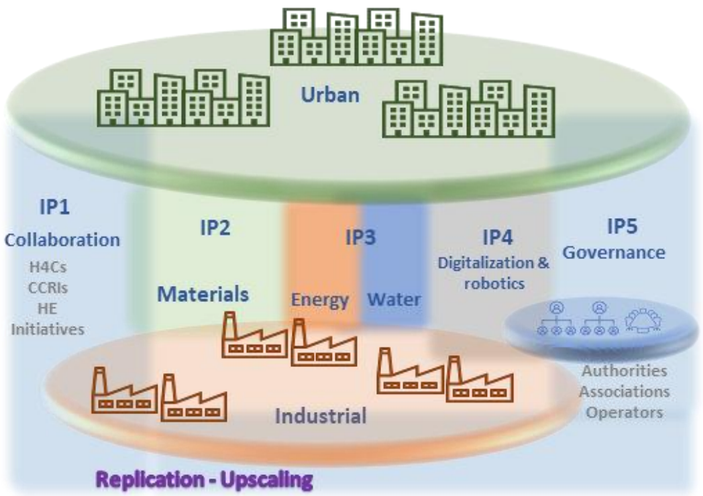
Outline

- What is DPP, what is MFA and why to use them in H4C?
- DPP in THESUS
- MFA in THESUES
- DPP-MFA-Matchmaking: THESEUS circularity framework

Why DPP and MFA for Regions?

Why DPP & MFA in Hubs for Circularity?



- **Material Flow Analysis (MFA) and Digital Product Passports (DPP) are used as tools in THESEUS to *design, optimize and enhance the circularity* in region of Attica**

- **MFA and DPP allow to analyze the system at different levels with an overarching aim to create a link between territorial material flows and product-level traceability**

- **In Theseus DPP and MFA are Key Exploitable Results are developed in IP4 (Digitalization & robotics), operating mainly in IP2 (Materials) and providing input for decision-making and policy alignement in IP5 (Governance)**

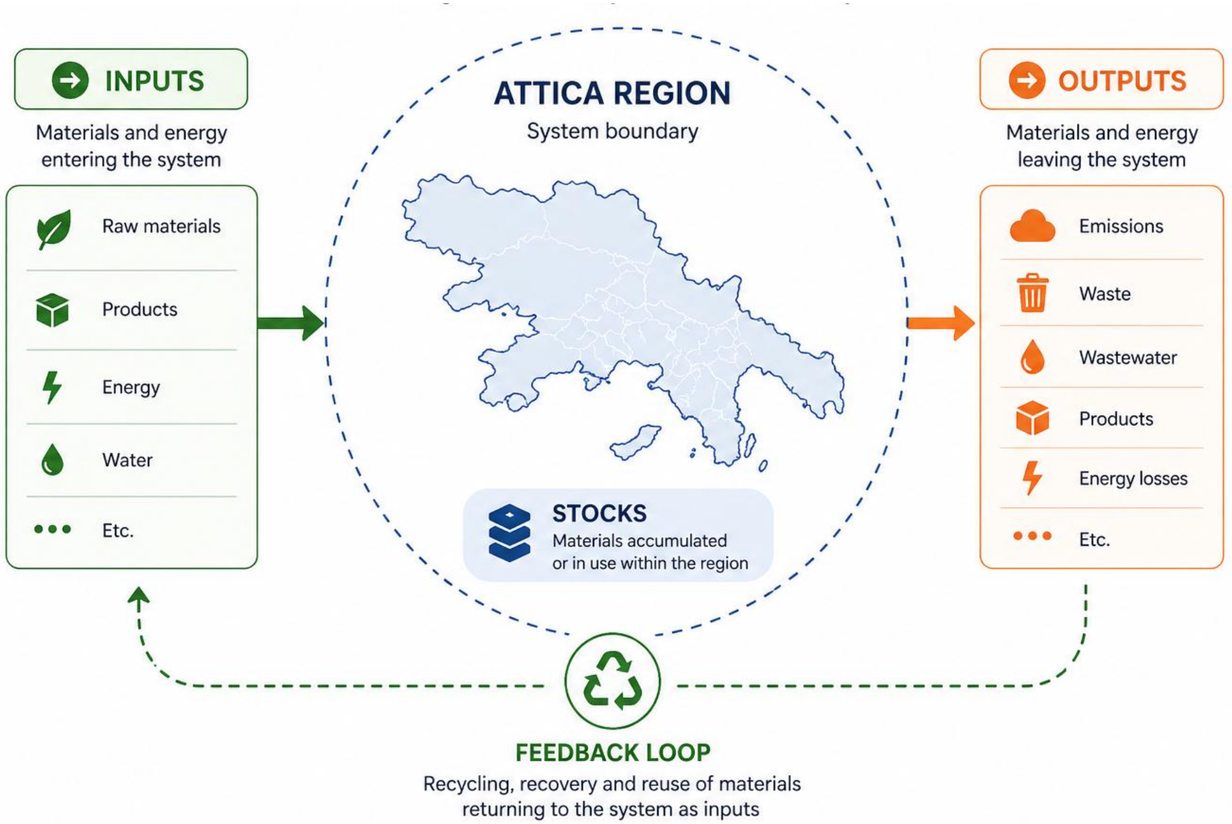
How our DPP supports regional Hubs?

DPP in THESEUS operates at product (micro) level

- Provides composition data (critical for high-quality recycling, upcycling and materials reuse and cross-sectoral collaboration)
- Enables materials and products traceability across value chains
- Improves sorting precision and automation
- Supports compliance by providing accessibility to relevant documents

What is MFA?

- Core concept: Methodology allowing systematic quantification of flows and stocks in a defined system
- Use: Enables analysis of flows (inputs, outputs, stocks), identification of inefficiencies and hotspots, generation of projections and scenarios analysis
- THESEUS: In THESEUS our system is Region of Attica and MFA is used to support circular planning for the H4C

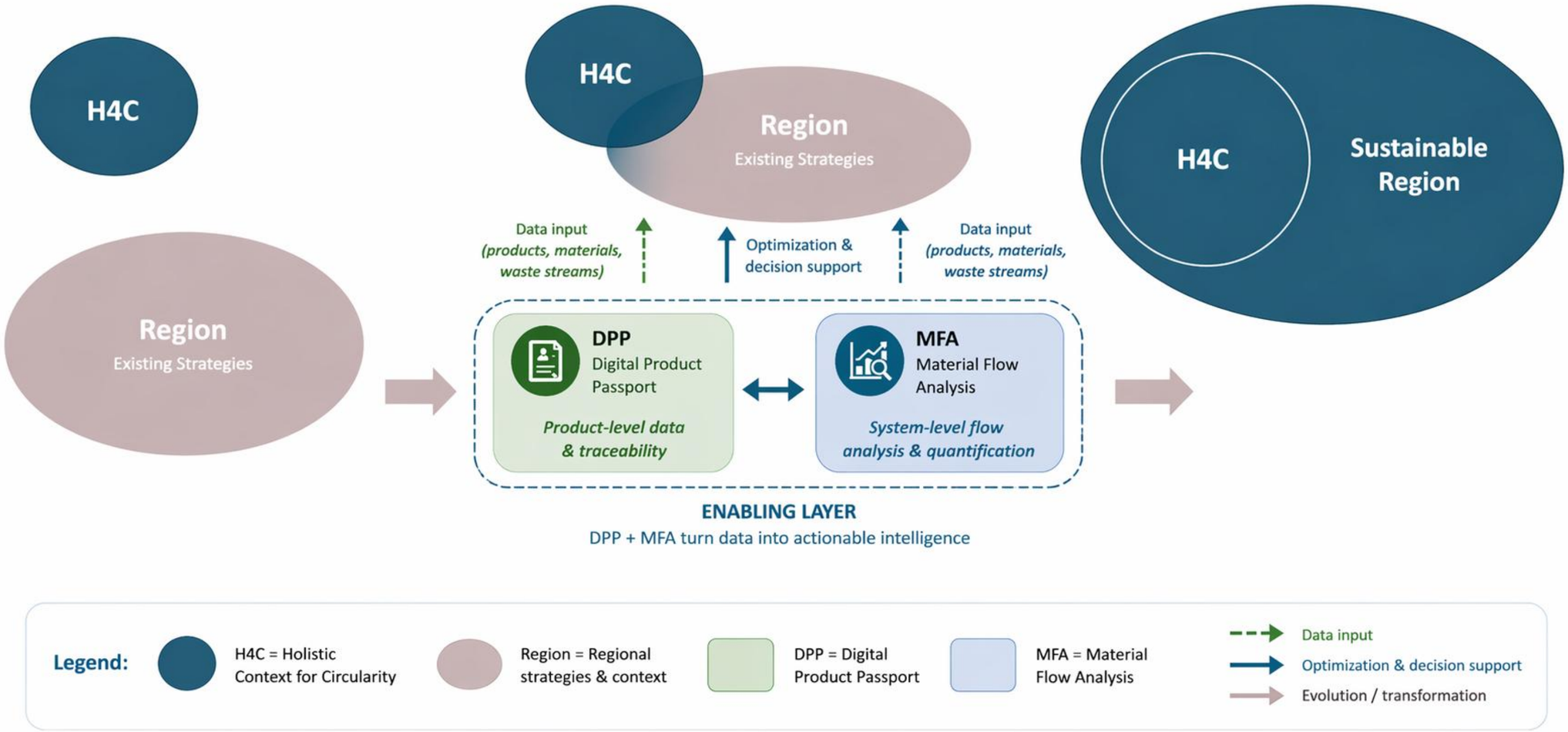


How MFA supports Regional Hubs?

MFA in THESEUS operates at the regional scale (meso)

- **Maps material inflows, stocks and outflows across the region**
- **Identifies hotspots and potential material lossess (landfill, downcycling, export)**
- **Quantifies potential related to secondary resource use**
- **Supports infrastructure planning (e.g. facilities locations)**
- **Enables scenarios analysis and projections generation**
    - ***Material availability and waste generation***
    - ***Impacts related to implementation of policy measures and circular strategies***
    - ***Supports decision making in terms of infrastructure and logistics***
    - ***Guidelines for potential improvements related to resource efficiency and circular flows***

THESEUS H4C VISION enriched by enabling layer



DPP and MFA in regions

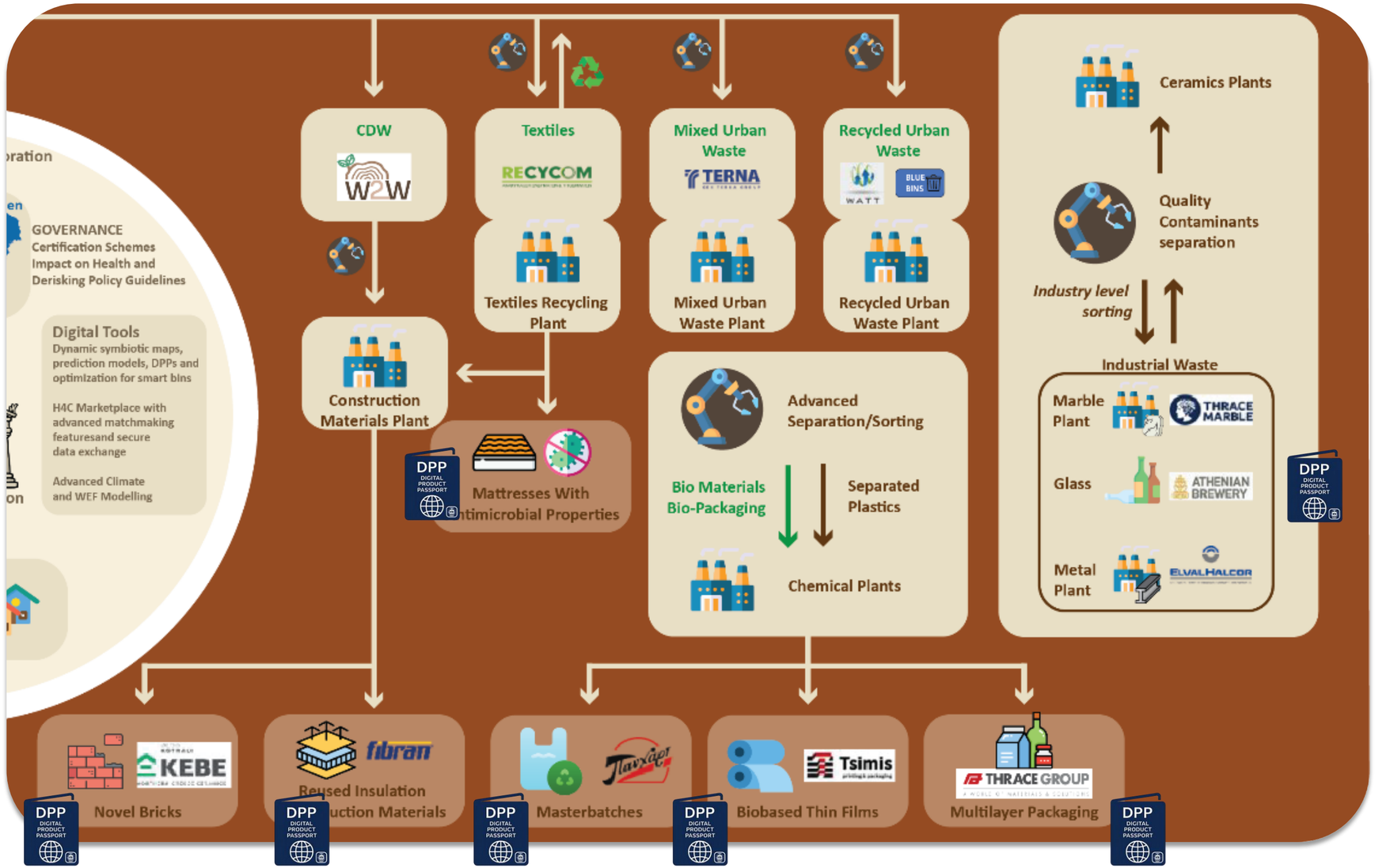
What is the material composition? How can I use the materials at their highest value? → DPP

What materials exist in this region, how much ? Where are the inefficiencies? → MFA

DPP in THESEUS

DPP in Thesus

DPP is created for THESEUS circular products and related material flows



What information will be included in THESEUS products DPP?

Product information

Product identification data

Product Composition and Properties

Economic operator data

Expert information*

Circularity & Sustainability

ESPR Ecodesign parameters
Obs! Energy related

LCA

Repair and reuse

Compliance

Certifications

Others

e.g. Storage instructions, handling and maintenance

THESEUS Digital tools**

Tool 1

Tool 2

Traceability

Actor - time – location***

THESEUS DPP users & their access rights

*Accessible only to expert users assigned by industrial partners

** Differentiated role based views (basic vs advanced)

*** Updates allowed to authorized actors only

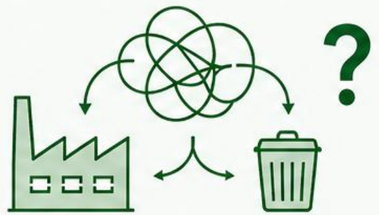
Always aligned with ongoing legislation efforts!

MFA in THESEUS

MFA for regional planning in Attica

- Regional planning through MFA-based scenario analysis
- Align regional strategies with EU, national and regional policy frameworks

1 THE CHALLENGE



- **Complex** and fragmented material flows
- **Limited** data and visibility
- **Uncertainty** in planning infrastructure and investments
- **Policy targets** without clear implementation pathways

2 MFA ANALYSIS

- **Maps** regional material flows (stocks, inflows, outflows)
- **Identifies** hotspots, leakages and opportunities
- **Develops** policy-based scenarios aligned with EU and national policies
- **Supports** evidence-based decision-making

3 THE IMPACT

- Better regional matching & investment decisions
- Optimized infrastructure and resource use
- Increased circularity and high-value recovery
- Stronger alignment with EU and national policies
- Transition towards resilient, low-carbon regional systems

Policy relevance & policy measures for Attica

Local Strategies and Relevant Plans

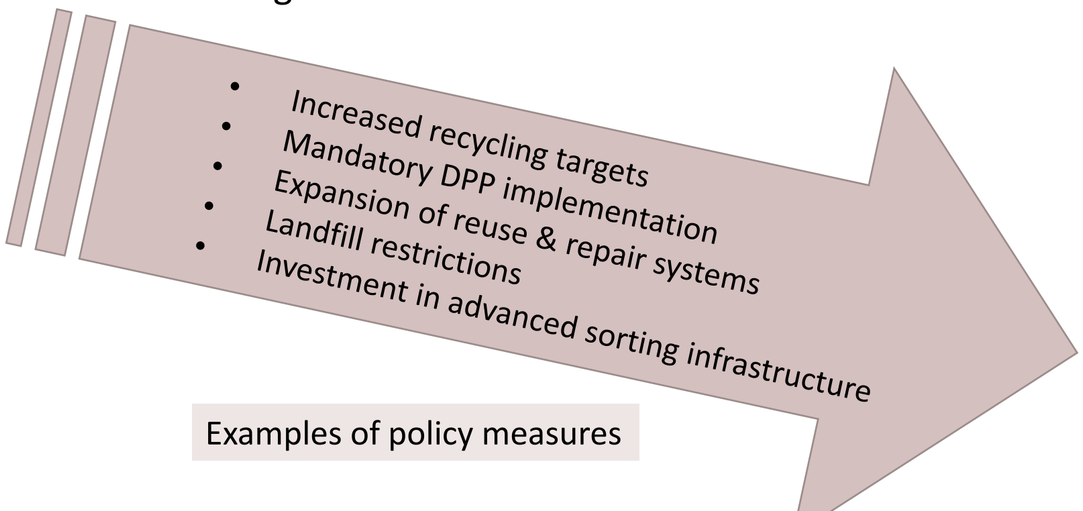
- Attica Regional Operational Programme 2021–2027 (ΠΕΠ Αττικής 2021–2027)
- Athens Climate Action Plan (Municipality of Athens, June 2022)
- Mission Label – Climate-Neutral and Smart Cities (Athens)
- Sustainable Urban Mobility Plans (SUMPs) (Σχέδια Βιώσιμης Αστικής Κινητικότητας)
- Climate Change Observatory of the Attica Region
- Other Local Initiatives and Instruments
- Regulatory Plan of Athens-Attica
- Regional Climate Adaptation Plan for Attica
- Regional Waste Management Plan of Attica
- Smart City and Digital Innovation Strategies in Attica
- Regional Innovation and Entrepreneurship Support Initiatives in Attica
- Sustainable Urban Mobility Plans (SUMPs) in Attica
- Climate and Environmental Monitoring Platforms in Attica

National Strategies and Relevant Plans

- Operational Programme “Competitiveness”
- National Strategy for Circular Economy
- National Action Plan for Circular Economy
- National Energy and Climate Plan
- National Recovery and Resilience Plan
- National RIS3 Framework and Smart Specialization Priorities
- Additional Sector-Specific National Plans

EU Strategic Frameworks

- EU Circular Economy Action Plan
- European Green Deal
- Next Generation EU and Recovery Instruments
- EU Mission on Climate-Neutral and Smart Cities
- Circular Cities and Regions Initiative and Hubs for Circularity
- Other Relevant EU Programs and Networks



Reuse & Repair growth with adoption at system level

Scenario example for Attica region, Greece

Policy

EU: Circular Economy Action Plan, Ecodesign for Sustainable Products Regulation

National: National Strategy & Action Plan for Circular Economy, National Recovery & Resilience Plan

Regional: Regional Waste Management Plan of Attica, Smart City & Digital Innovation Strategies in Attica

Outcome *(Expected)*

→ Repair and reuse centers availability increases

→ Infrastructure establishment

→ More durable products available

→ Information about secondary materials and repair options widely available due DPP implementation

→ Matchmaking and second-hand platforms and markets become more popular

MFA projections

Local secondary materials use ↑

Primary materials use ↓

Local materials demand ↓

Materials import ↓

Waste generation ↓

Product lifetime ↑

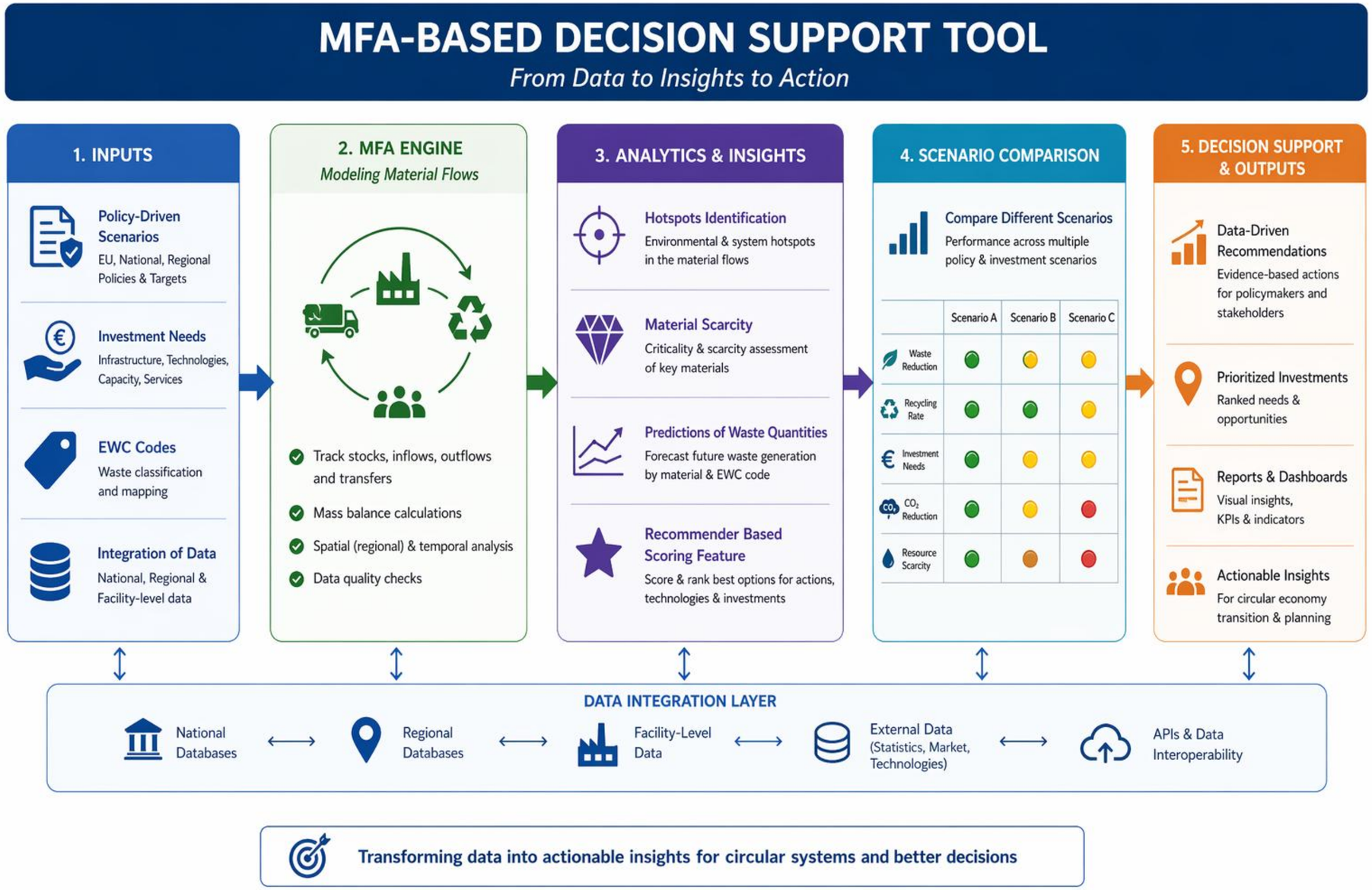
THESEUS MFA Projections

Timeline

Short term 2025-2030 Preparatory & Needs	Mid term 2030-2050 Expansion	Long term 2050+ Functional system
• Materials flows changes • Waste generation trends • Infrastucture & logisitics needs defined	• Evolution of secondary material availability and decrease of demand • Technology uptake, solutions scaling	• Operating circular economy ecosystem • Circular loops based on high value materials functioning across region

MFA tool

THESEUS and beyond



DPP-MFA-Matchmaking: THESEUS circularity framework

Linking product data, regional insights and actors to drive circularity

THESEUS circularity framework elements

What? How? Who?

	DPP	MFA	Matchmaking
Regional level		✓	✓
Product level	✓		✓
Decision Level	✓	✓	✓
Information	Composition & traceability	Flow mapping & quantification	Demand & material visibility
Insights	Product and life cycle insights: repair, reuse, end-of-life	Hotspots, trends, scenario based projection	Matchmaking opportunities
Actions	Compliance & transparency	System optimisation, investment & logistics planning	Business decisions, supply-demand alignment

DPP provides information → MFA generates context → Matchmaking allows action

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*Presentation uses AI generated icons

THESEUS

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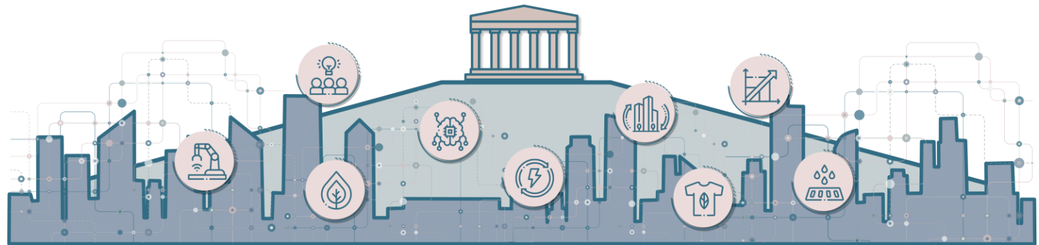
Follow us:
@Theseus
Hub4Circularity

Contact: info@theseus-h4c.eu

Coordinator: Dr. Angelos Amditis
a.amditis@iccs.gr

Project Manager: Charalampos Manousiadis
c.manousiadis@iccs.gr



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