RADAR – R&D and Adoption Dynamics for Assessment and Response

System dynamics modelling for ex-ante impact assessment of R&I policy

A demonstration project

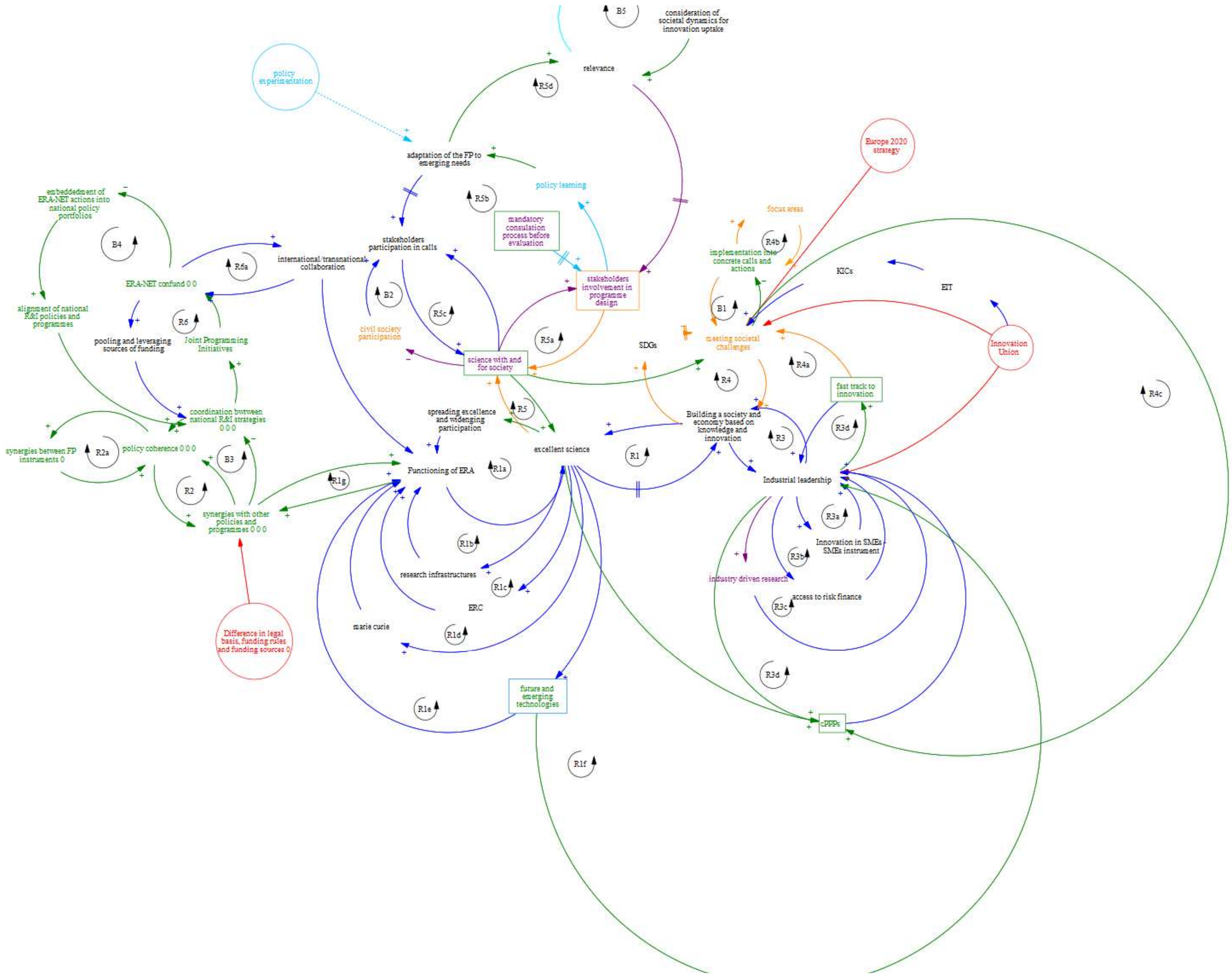
Igor Oliveira
Bianca Cavicchi

Initiatives at DG R&I

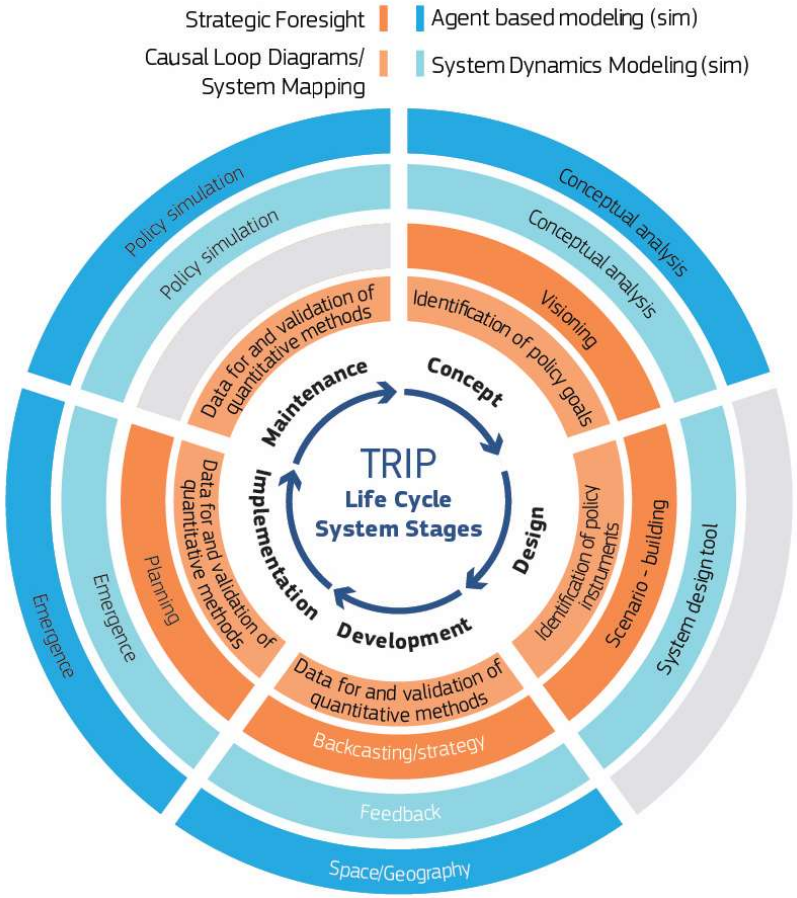
STUDY ON THE EVOLUTION OF THE FRAMEWORK PROGRAMME FOR R&I

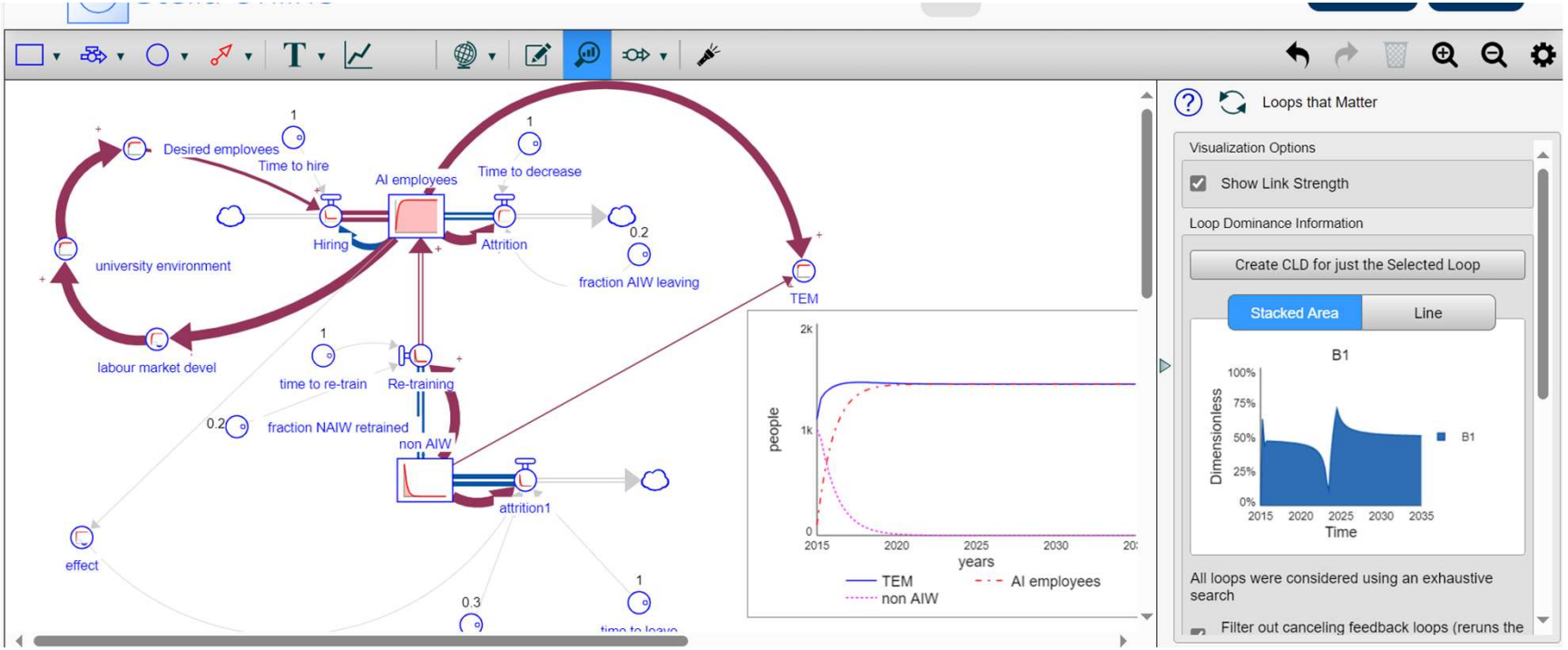
EXPERT STUDY ON SYSTEM-BASED METHODS FOR TRANSFORMATIVE INNOVATION POLICY

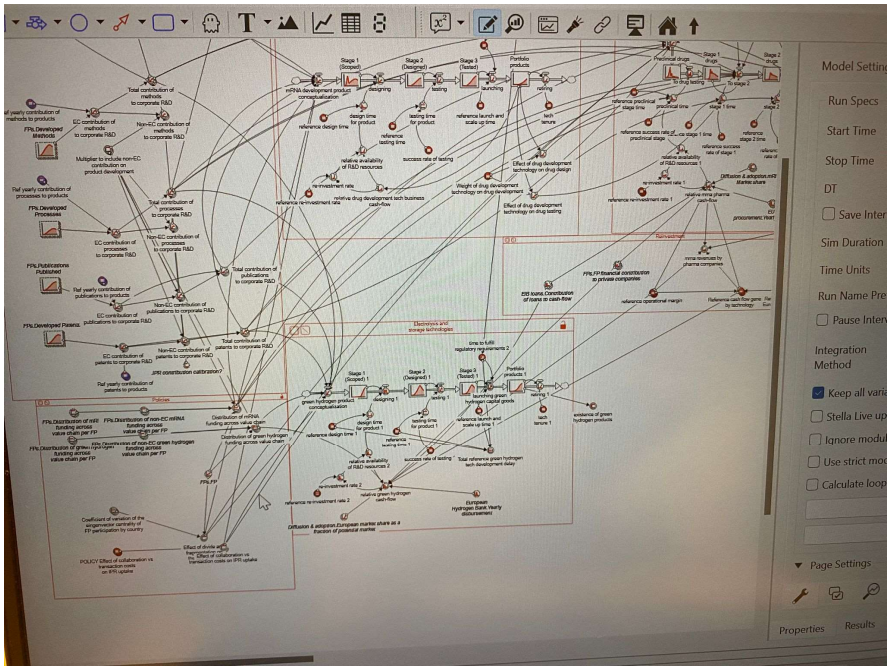
TRAINING SYSTEM DYNAMICS SIMULATION



B5
consideration of societal dynamics for innovation uptake
relevance
R5d
policy experimentation
adaptation of the FP to emerging needs
R5b
policy learning
mandatory consultation process before evaluation
stakeholders involvement in programme design
focus areas
Europe 2020 strategy
embeddedment of ERA-NET actions into national policy portfolios
B4
ERA-NET cofund 0 0
R6a
international/transnational collaboration
stakeholders participation in calls
B2
R5c
implementation into concrete calls and actions
R4b
KICs
EIT
alignment of national R&I policies and programmes
R6
pooling and leveraging sources of funding
Joint Programming Initiatives
civil society participation
science with and for society
R5a
SDGs
B1
meeting societal challenges
Innovation Union
R4a
R4
fast track to innovation
R4c
spreading excellence and widening participation
R5
coordination between national R&I strategies 0 0 0
Building a society and economy based on knowledge and innovation
R3
R3d
synergies between FP instruments 0
R2a
policy coherence 0 0 0
B3
excellent science
R1
Functioning of ERA
R1a
R1g
Industrial leadership
R2
synergies with other policies and programmes 0 0 0
R3a
Innovation in SMEs - SMEs instrument
R1b
R3b
research infrastructures
industry driven research
R1c
ERC
access to risk finance
R3c
marie curie
R1d
Difference in legal basis, funding rules and funding sources 0
R3d
future and emerging technologies
R1e
cPPPs
R1f


Strategic Foresight
Causal Loop Diagrams/ System Mapping
Agent based modeling (sim)
System Dynamics Modeling (sim)
Policy simulation
Policy simulation
Conceptual analysis
Conceptual analysis
Visioning
Identification of policy goals
Data for and validation of quantitative methods
Maintenance
Concept
TRIP
Life Cycle System Stages
Implementation
Development
Design
Data for and validation of quantitative methods
Identification of policy instruments
Scenario - building
System design tool
Planning
Emergence
Emergence
Data for and validation of quantitative methods
Backcasting/strategy
Feedback
Space/Geography


Desired employees
Time to hire
AI employees
Time to decrease
Hiring
Attrition
0.2
fraction AIW leaving
university environment
TEM
labour market devel
time to re-train
Re-training
0.2
fraction NAIW retrained
non AIW
attrition1
effect
0.3
1
people
2k
1k
0
2015
2020
2025
2030
years
TEM
AI employees
non AIW
Loops that Matter
Visualization Options
Show Link Strength
Loop Dominance Information
Create CLD for just the Selected Loop
Stacked Area
Line
B1
100%
75%
50%
25%
0%
Dimensionless
2015
2020
2025
2030
2035
Time
B1
All loops were considered using an exhaustive search
Filter out canceling feedback loops (reruns the


Model Settings
Run Specs
Start Time
Stop Time
DT
Save Interval
Sim Duration
Time Units
Run Name Prefix
Pause Interval
Integration Method
Keep all variables
Stella Live update
Ignore module errors
Use strict model errors
Calculate loops
Page Settings
Properties
Results

- Concrete application of system dynamics in R&I policy ex-ante impact assessment
- Build a calibrated model of R&I value chain, from early R&D funding to adoption&diffusion, through tech development, and building impact pathways with competitive sustainability
- Identify EU data limitations
- Provide strategic reflections for FP10 ex-ante impact assessment

Project objectives

Project scope

Policy

FP for R&I

Transformative innovation (sustainability & growth)

Technology

mRNA

Green hydrogen

Geography

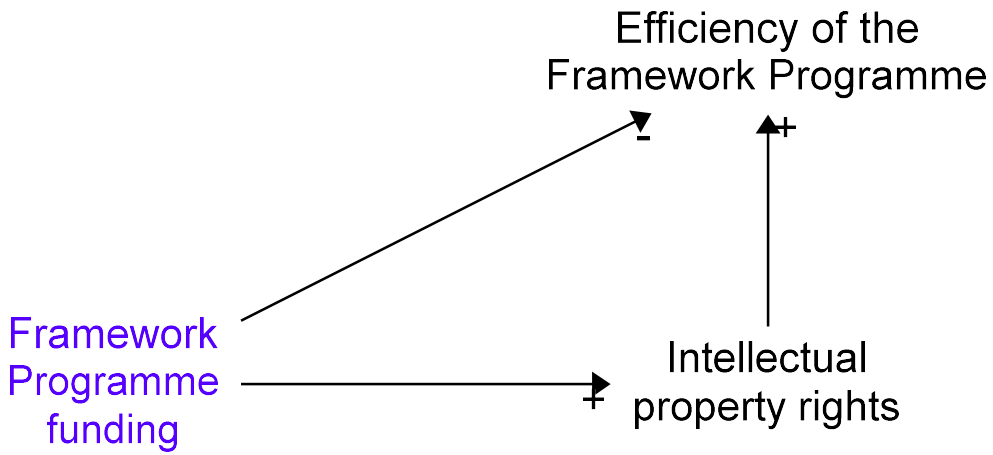
Europe (diffusion)

FP countries (R&D)

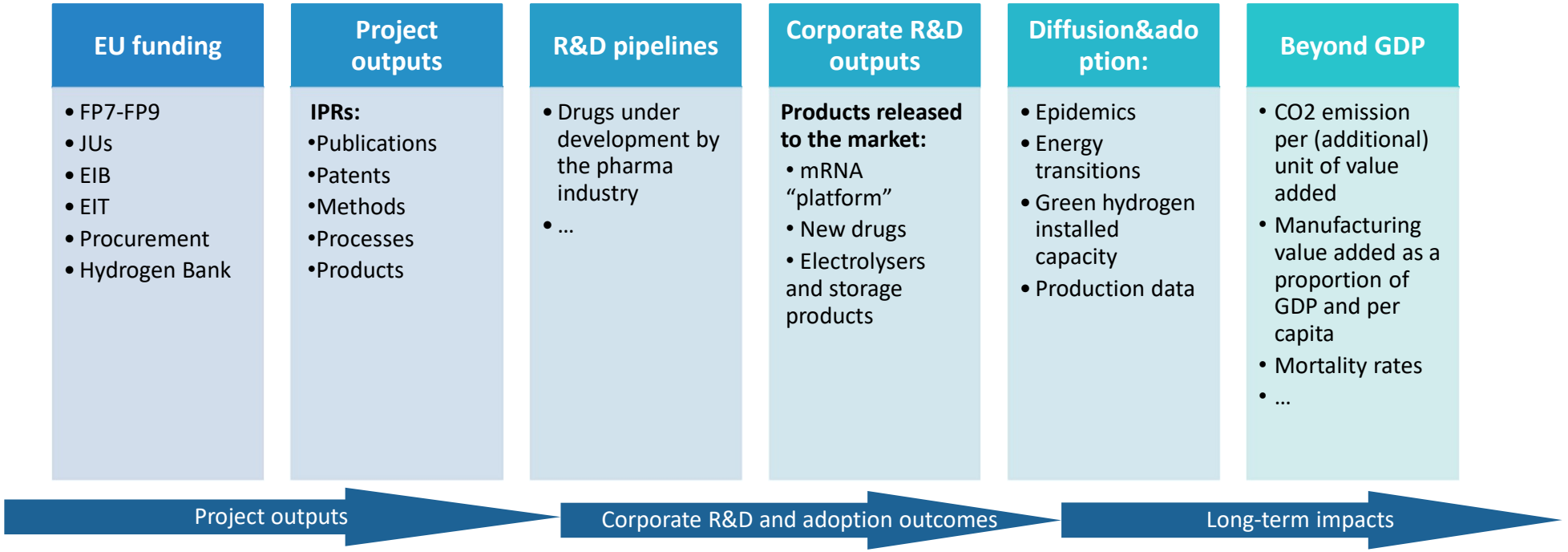
R&I process

From early stages public R&D to innovation diffusion, through corporate R&D

Common view of R&I evaluation

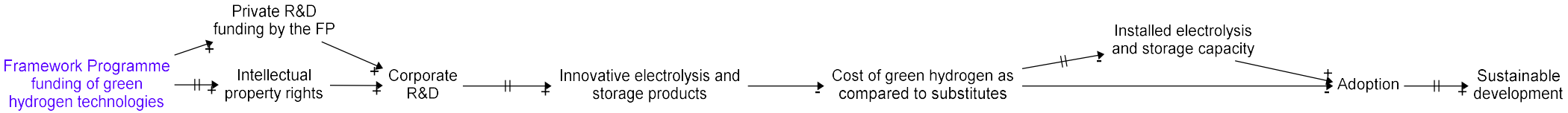


Expanded view of R&I evaluation

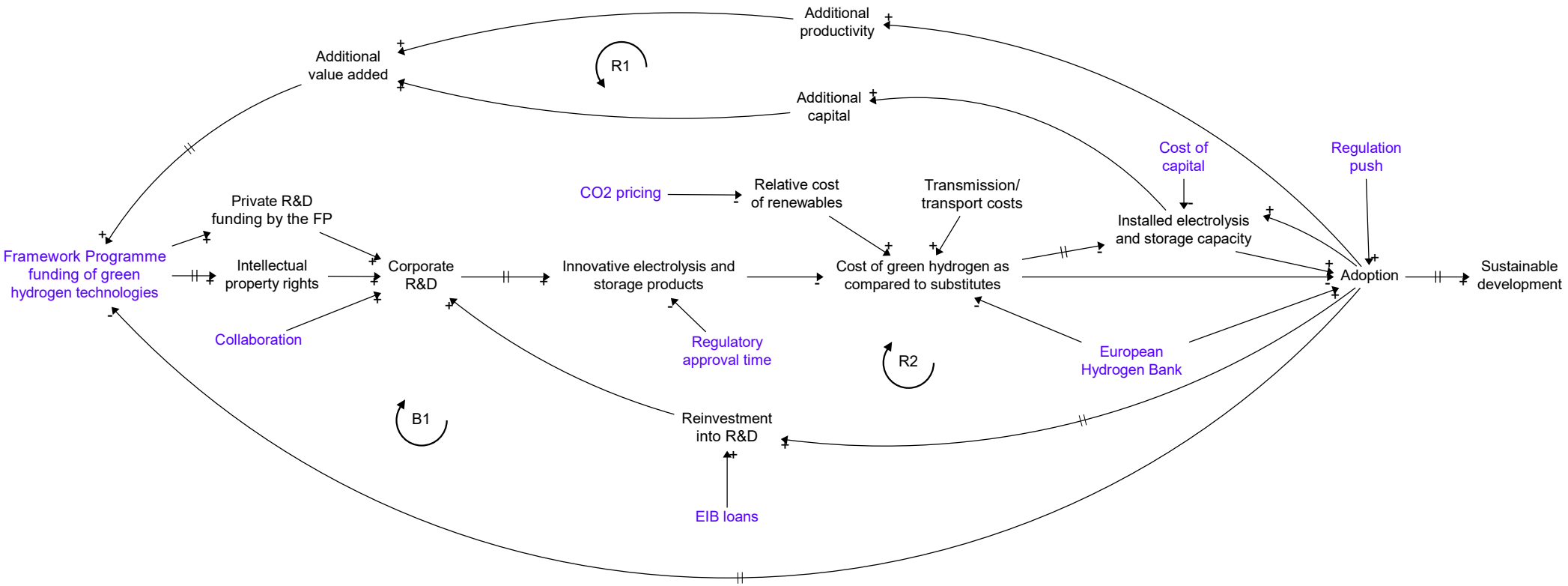


Inputs-Outputs-Outcomes-Impact

Expanded view of R&I evaluation (green hydrogen)



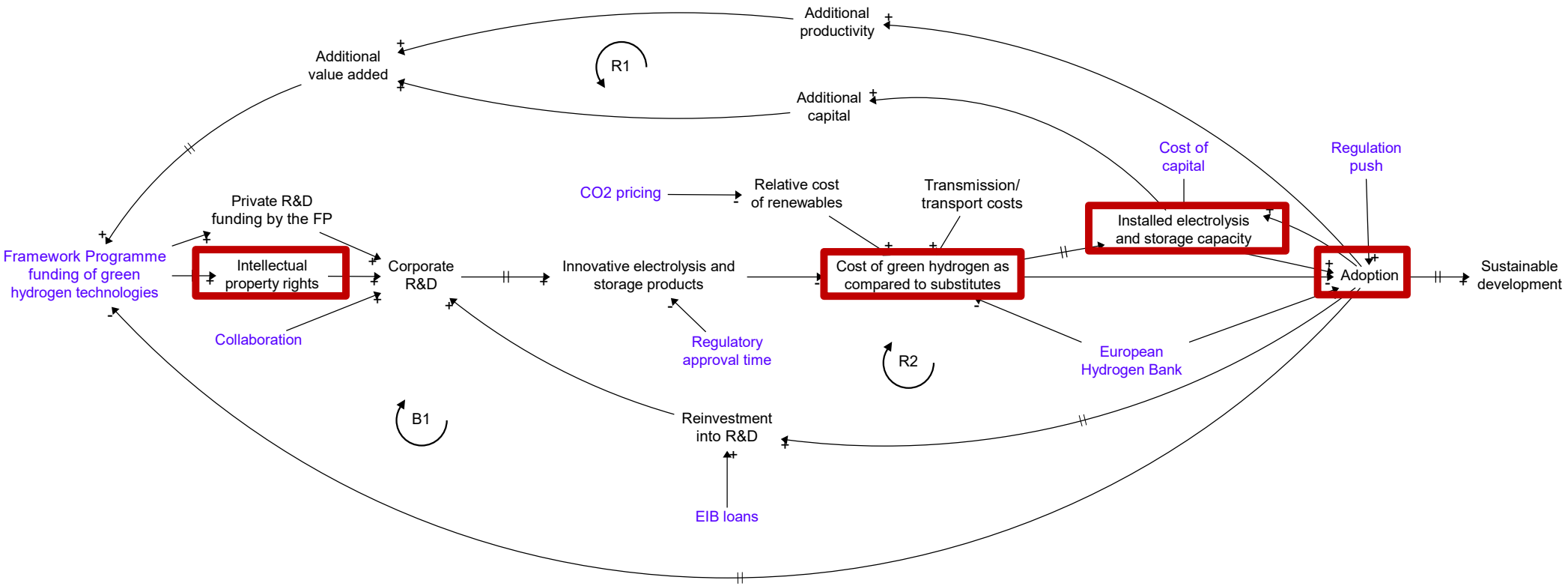
The view represented in the model (green hydrogen)



Key assumptions

- This is only one among many possible representations of an innovation system. Accumulation of systemic capabilities (e.g., support orgs) is not considered
- FP process stays stable (budgeting, project selection, disbursement) but focus across value chains can vary
- Macroeconomic conditions stay stable, apart from the impact of these specific technologies and cost of capital variations defined by the user of the model
- Contribution of non-EC players to R&D pipelines kept constant across all scenarios
- Human capital availability considered unconstrained when companies re-invest or increase installed capacity
- Apart from covid, drugs for other diseases are developed according to current industry pipeline
- Diminishing returns of drug development technology

The view represented in the model (green hydrogen)



Datasets in use

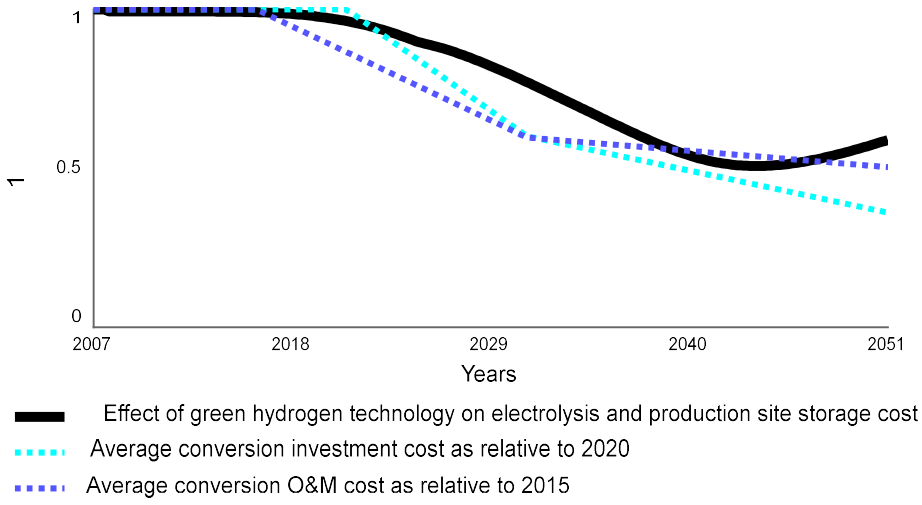
European Commission

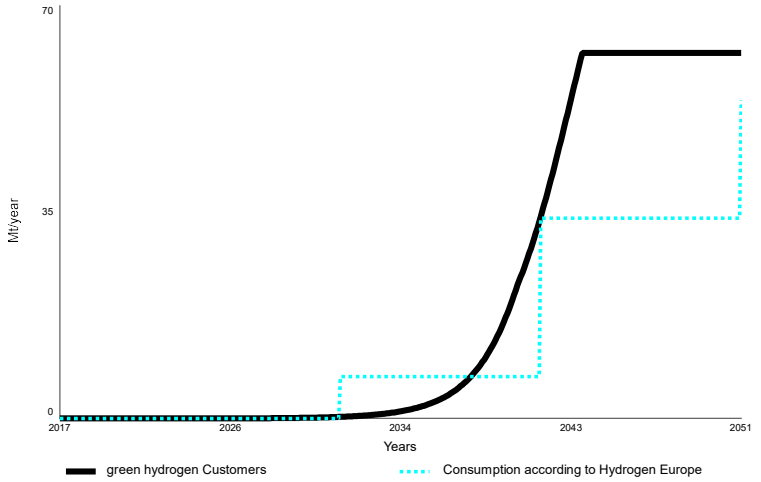
- FP funding and number of projects over time
- Share of public/private co-publications
- Project duration
- Intellectual Property Products (IPRs – publications, methods, processes, patents) - **calibration**
- Pipeline ratios (e.g., contribution of IPRs to capital goods and drug development technology) computed from all related projects
- BERD by industry orientation (re-investment into hydrogen R&D)
- Sub-domain focus of the FP within hydrogen (monitoring flash)
- EIB loans (disbursements, interest and repayments)
- EU procurement of vaccines ($, units)
- Historical and planned European Hydrogen Bank subsidies
- Hydrogen cost curves from EU reference scenario - **calibration**

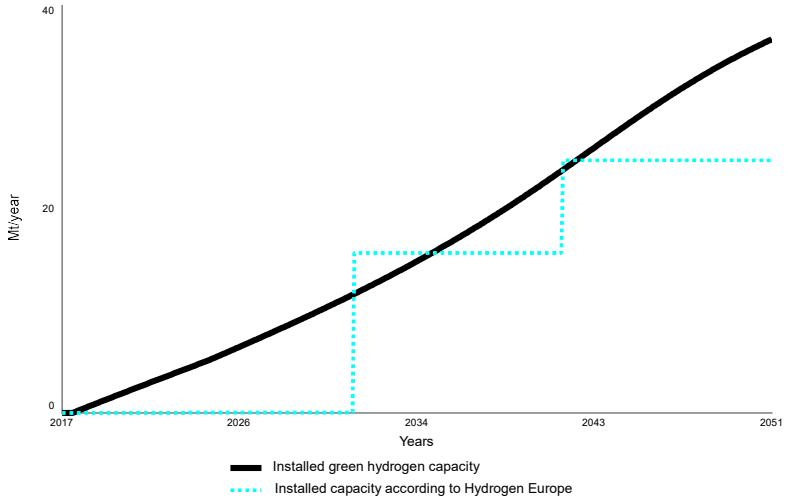
Corporate

- Financial data from 5 pharma companies that have financial ties with the EU (margin, cash generation, reinvestment rates into R&D)
- Some of the R&D pipeline success rates and delays (others had to be calibrated)
- mRNA drugs released over time - **calibration**
- Historical and projected green hydrogen capacity and adoption (Hydrogen Europe) - **calibration**

Calibration
(and fit to future projections)

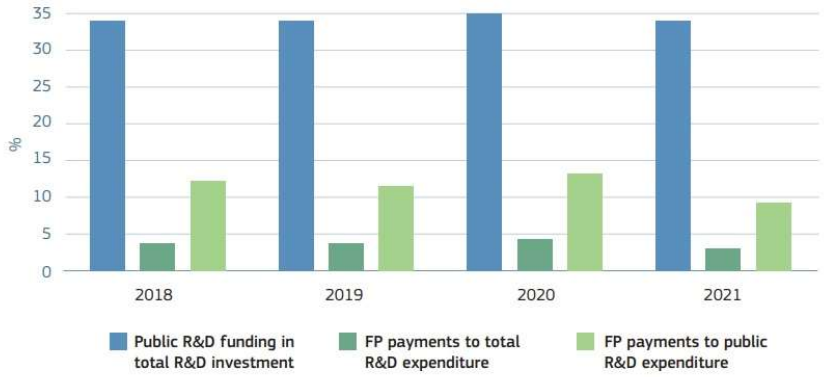






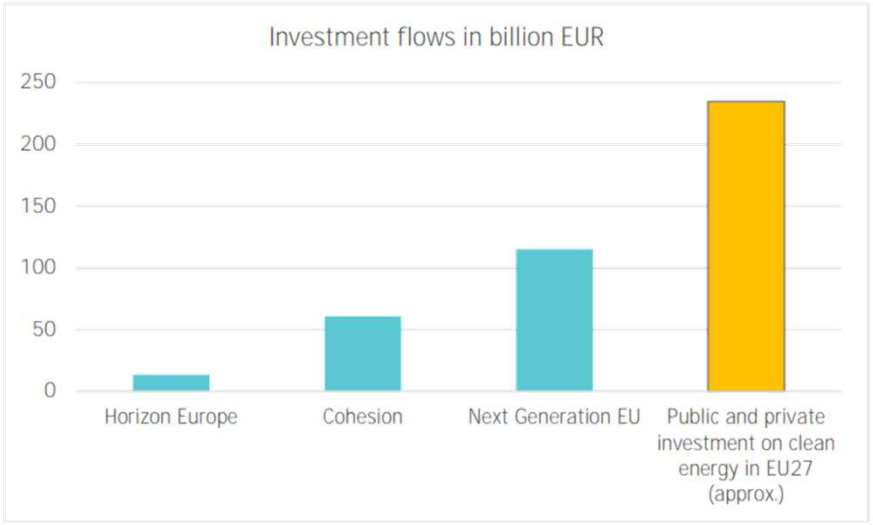
Considering the relatively small financial effort compared to overall R&D expenditure, and considering that the FP focuses on upstream research, it would be reasonable to assume it doesn't move the needle of clean energy adoption in Europe…

Figure 2.1-7 The contribution of the Framework Programme for R&I as a percentage of total and public R&D expenditure, 2018-2021



Science, research and innovation performance of the EU 2024
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit's own elaboration based on Eurostat.

From DG R&I (2024)



Sources: Estimated from IEA (2023) by assuming the share of EU27 investment in the world total is equal to its share of world GDP. EU budget figures from European Commission (2024), annualised by dividing grand total by the duration of the multiannual funding framework.

Figure 2 - EU support (overall) and public and private investment on clean energy in EU27 member states (approx.), 2023, in billion EUR

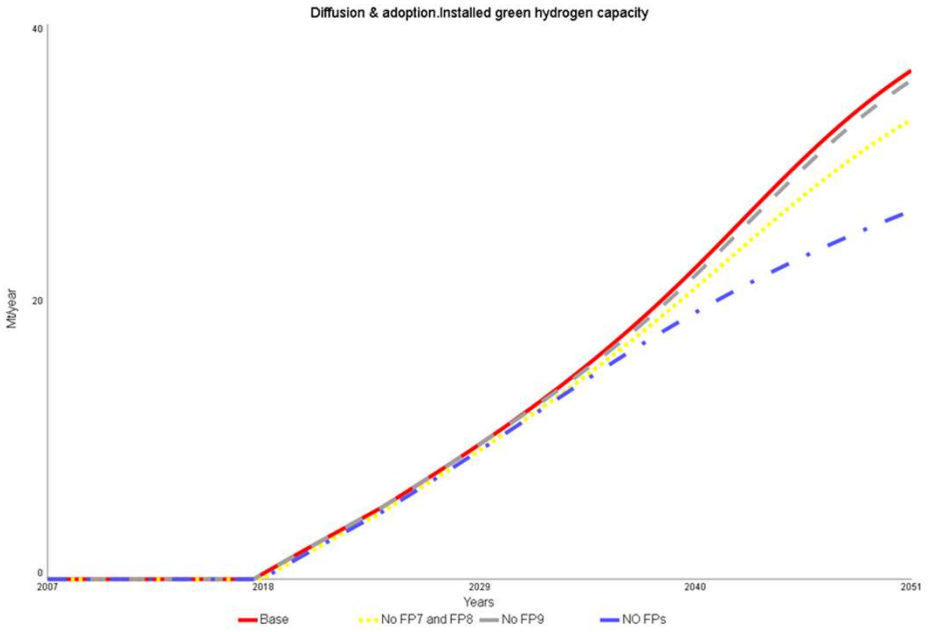
From Pontikakis et al. (2024)

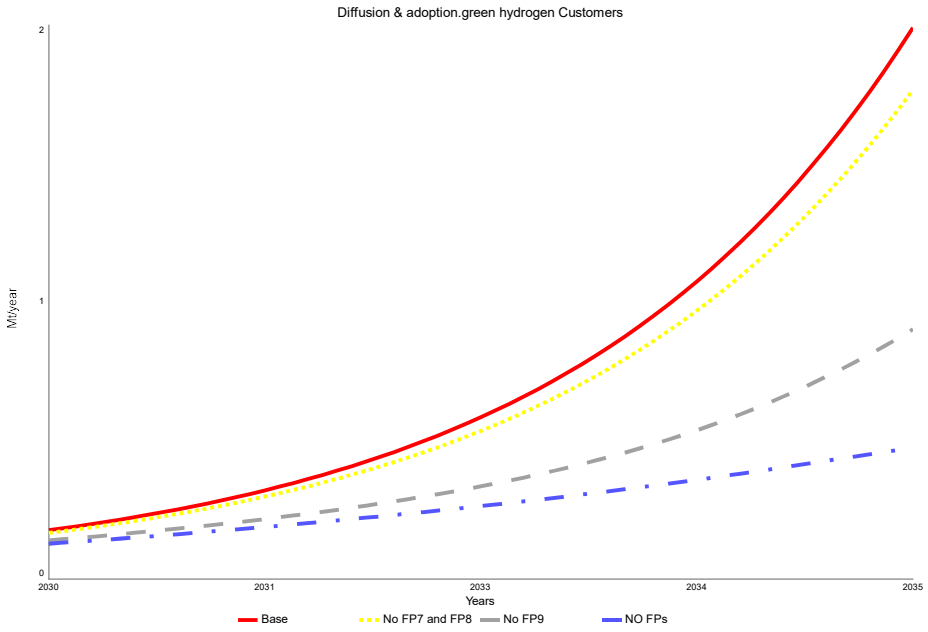
… however, that is not what our simulations show for the green hydrogen domain

We identified two different systemic roles for the FP:

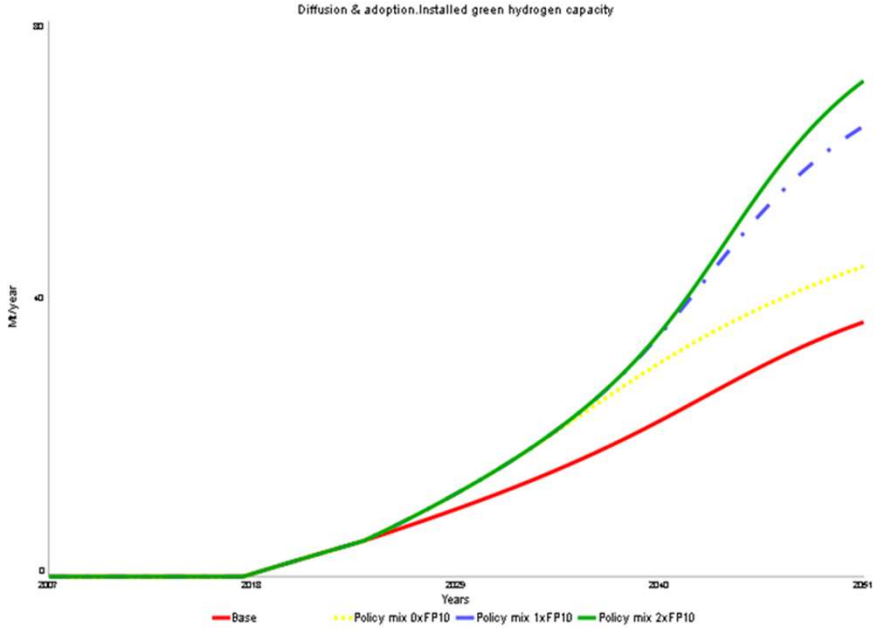
1. **Foundational role:** the upstream contribution of the FP in the R&I process is key to ensure adoption
2. **Synergistic role:** in the context of broader policy-induced transformation, the FP magnifies the positive outcomes and impacts of other measures

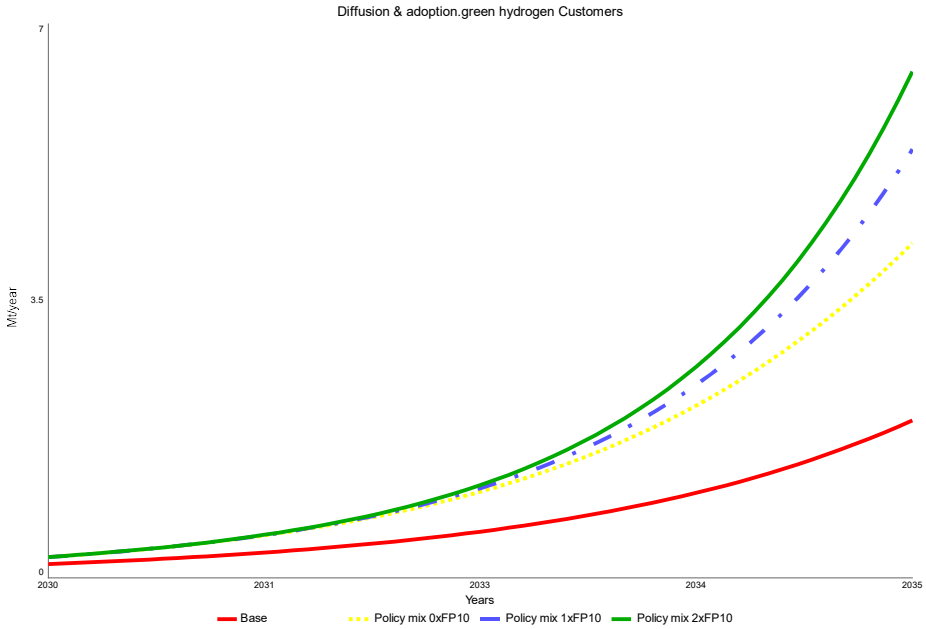
Foundational role: the FP creates conditions for technologies to be adopted





Synergistic role: the FP helps broader policy packages to move the tech adoption needle





BUT…

1. When we expand model boundaries, we also create the need for datasets that don’t exist

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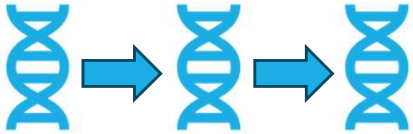
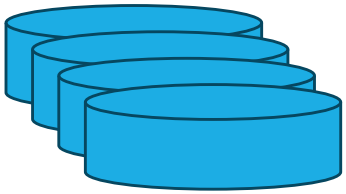


Pharma companies disclose the development stage of each drug they're developing and what disease(s) they tackle

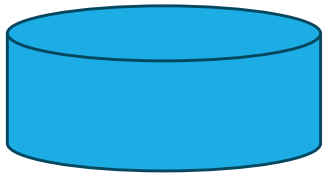
There isn't an equivalent dataset in the green hydrogen domain

BUT…

1. When we expand model boundaries, we also create the need for datasets that don't exist



Among the Intellectual Property Rights (IPRs) reported as outputs of FP projects, there are some instances of 'products'

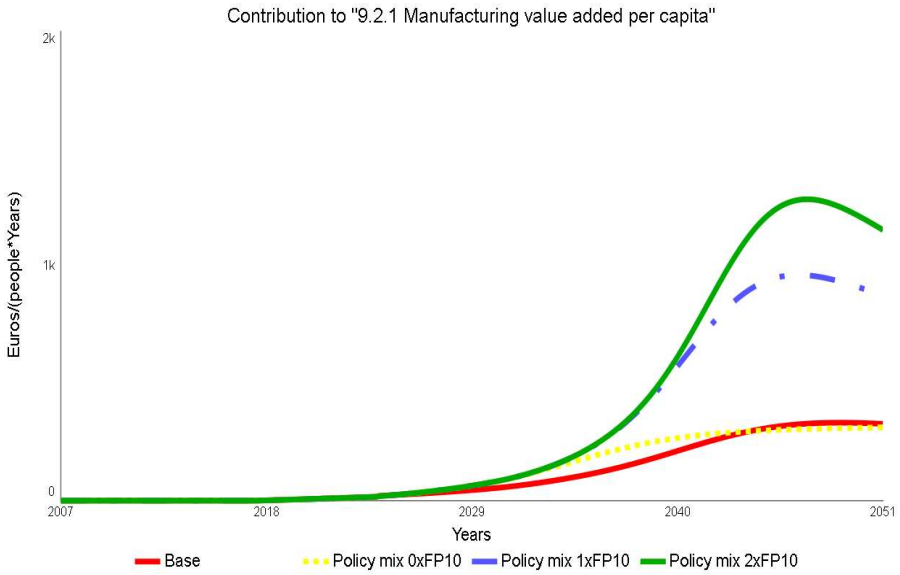


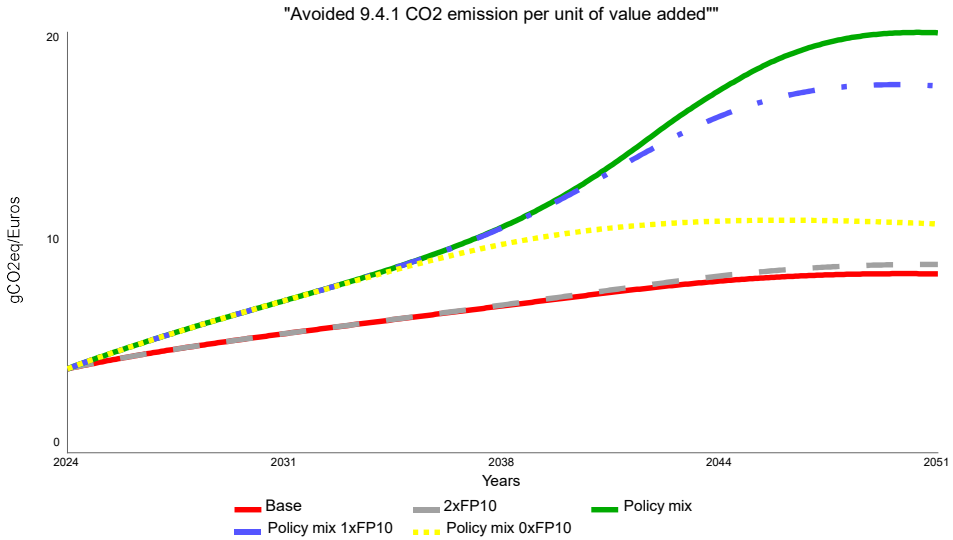
However, there is an ontological difference between this and the use of the word 'product' by industry players

BUT…

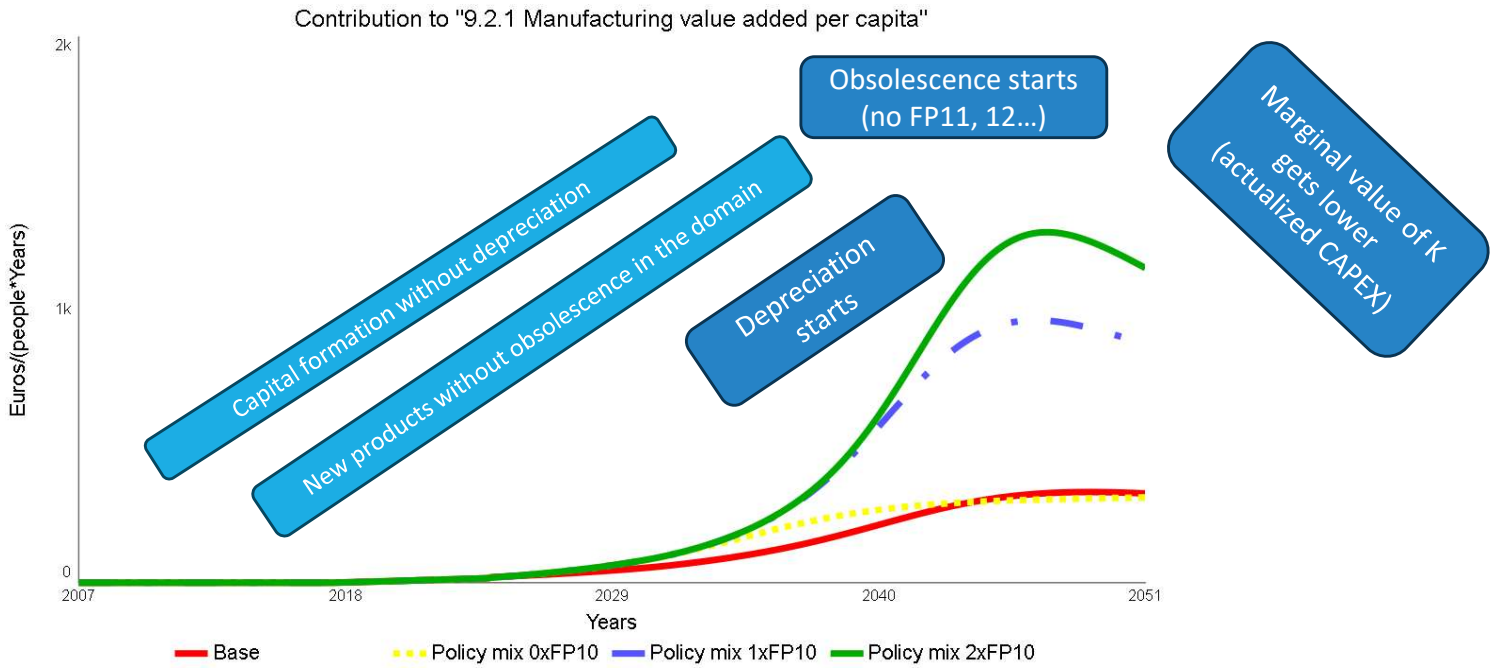
1. When we expand model boundaries, we also create the need for datasets that don't exist
2. To really understand impact pathways as measured by SDGs and other frameworks, we need a multi-scale modelling approach
   - Contrary to the original nature of these indicators, what we manage to measure is often the relative contribution of these very specific technological domains
   - Contrary to the original nature of these indicators, we don't capture national policy

SDG indicators





SDG indicators



Key policy messages

The FP synergises with other policy mechanisms in creating competitiveness and sustainable development

Funding decision depends on maturity of value chain components and research landscape: for mRNA downstream public research, for green hydrogen core tech private research

Major impact of regulations, cost of capital and collaboration

Deployment (including pioneer installed capacity) is also innovation, so deployment support is also innovation policy

Thank you

European Commission