WHY Open Day

11th of June 2021 | online

Predicting the Impact of Household Behavior Intervention on Environmental Pollution

EU GREEN WEEK 2021 PARTNER EVENT

ZERO POLLUTION #EUGreenWeek

for healthier people and planet

PANEL DISCUSSION

THE WHY TOOLKIT

WHY OPEN DAY

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#EuGreenWeek

EU GREEN WEEK PARTNER EVENT

#whyh2020 ONLINE

European Commission | 11. 06. 2021 10:00-13:00 CET

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WHY

Creation of a Toolkit to include behavioural aspects on Energy System Models: Results from the Stakeholders Consultation

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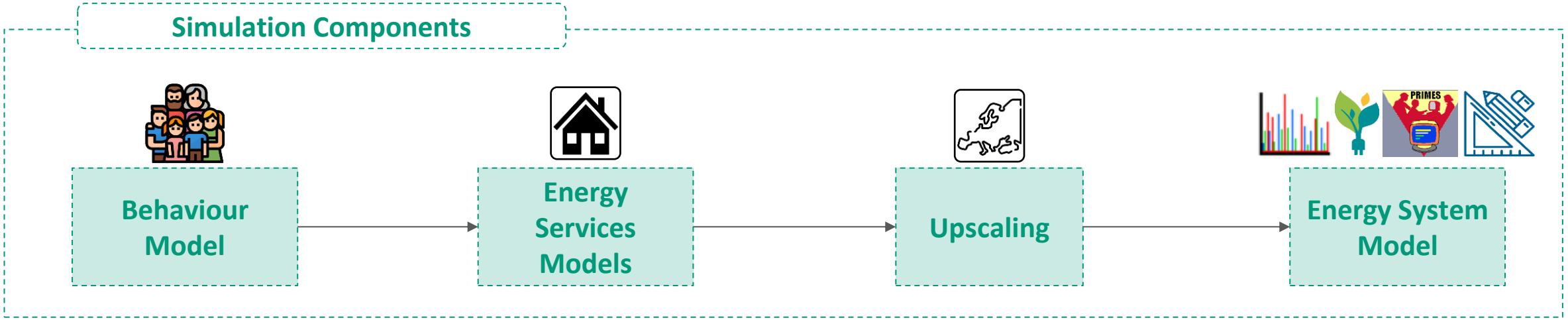
Concept of the WHY-Toolkit



Stakeholder Consultation - defining the parameters for the WHY-Toolkit

Stakeholders identified

- 14 Policy Modelling experts
- 16 Energy System Modelers
- 33 End-results users

Actions

- 3 Focus Groups
- 5 Surveys
- 19 Interviews

Stakeholder Consultation - Initial requirements for the WHY-Toolkit identified

Constraints	Models	Interventions	Results
● Different Countries ● Transparency ● Spatial resolution: Building ● Temporal Resolution: 15 minutes ● Robustness of the results: Credibility and Sensibility ● Visual interface and ease configuration ● Modular Structure ● Standalone Software ● Open Science ● Use Python	● Consumer's reaction to new technologies and new business models ● Active Consumers ● Sector coupling: EV, power2heat, power2gas, cogeneration ● Demand Side Management & Flexibility markets ● Decentralized generation and storage ● Price signals ● Digitalisation	● Include ○ EU-wide directives (EED, EPBD, circular economy, etc.) ○ Member state actions (NECP) ○ City level policies (SEAP) ● Energy and carbon taxation ● Subsidies ● New financial products and business models ● Support in planning building codes ● Information campaigns ● Black-out in a microgrid ● New or redesigned tariffs ● Reassess 2030 & 2050 decarbonisation and long-term global energy scenarios	● Include energy KPI: ○ final energy consumption, ○ primary energy mix, ○ energy services use ● Include social KPIs: ○ behavioral changes and investments carried out, ○ energy affordability for households, ○ energy access index, energy ○ technology poverty ● Carry on an ethical impact analysis ● Cluster by user groups ● RAW data or interactive diagrams ● Provide traditional load forecasts

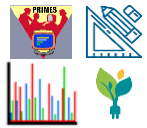
General approach of the WHY-Architecture

1. Identify the different Energy Behaviour Profiles
2. Create two maps: Energy Behaviour Profiles ⟺ Socio-Economic Profile
3. Define an intervention scenario for the year
4. For each Energy Behaviour Profile,

   a. use a causal model to decide the energy investment

   b. simulate the behaviour to create a distribution of its energy load profile

5. Use the distributions to upscale and plug the results in the Energy System Model



6. Feedback the results, advance a year and repeat from 3

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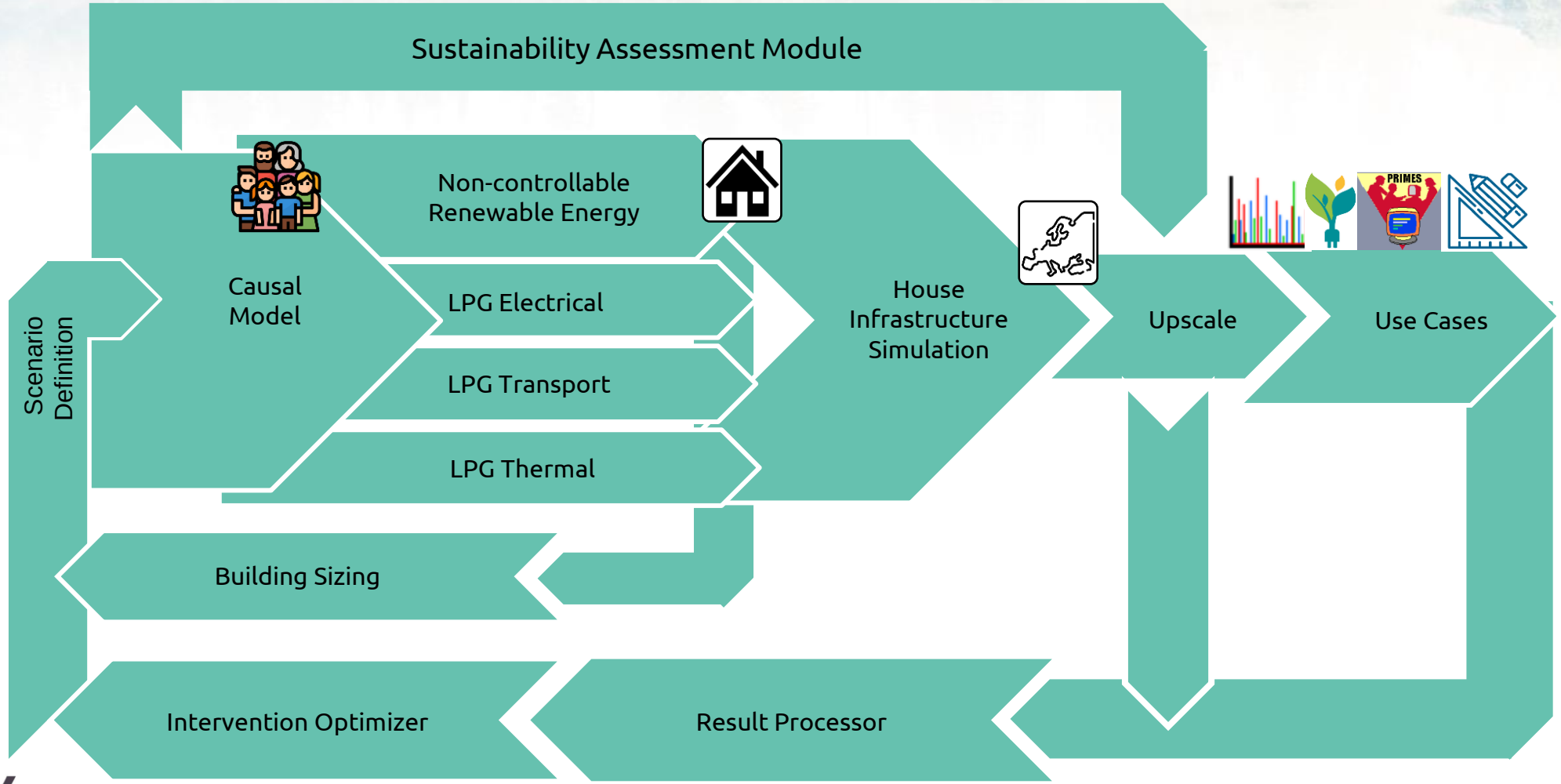
The WHY-Toolkit-Architecture



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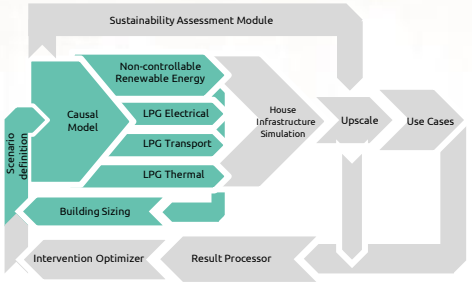
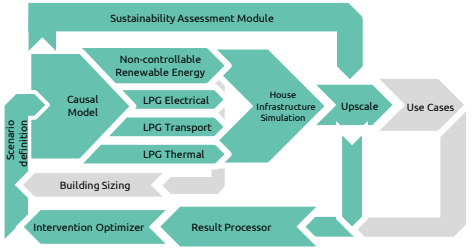
Run Modes of the WHY-Toolkit

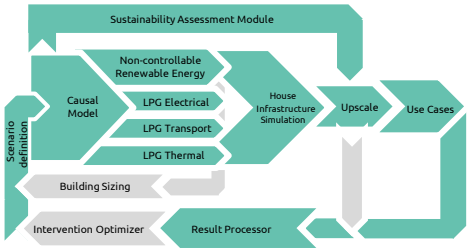
- **Building Sizing Loop:**
  - Optimize the size of all components at the household (generation, storage, insulation, power2X, etc.) according to:
    - the user preferences (including their energy behaviour)
    - the interventions and macro-economic set the scenario



- **Intervention Optimizer Loop:**
  - Optimize the parameters of the interventions (subsidies, taxes, limits, etc.)



- **Use Case Loop:**
  - Assess the impact that a set of interventions have on the Energy System
- **Counterfactual Loop:**
  - Create a “business as usual” scenario for the proof of concept



How many different behaviours towards electricity are at households?

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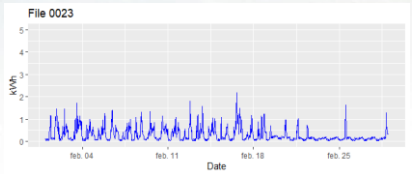
Introduction

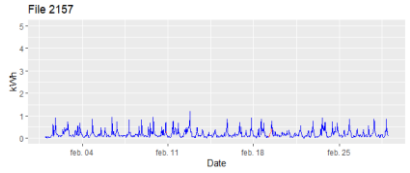
- Energy System Models (ESMs) for the analysis of long-term scenarios
  - Supply side: useful results
  - Demand side: lack of accuracy for proper characterisation
- Arbitrary behavior of households
  - Synthetic profiles do not capture all possible cases

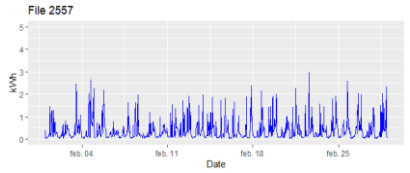
Objectives

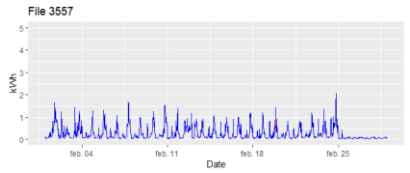
- Build a set of profiles that define the electrical behavior of households
- Describe the household *persona* behind each profile

Methodology







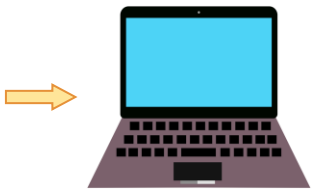


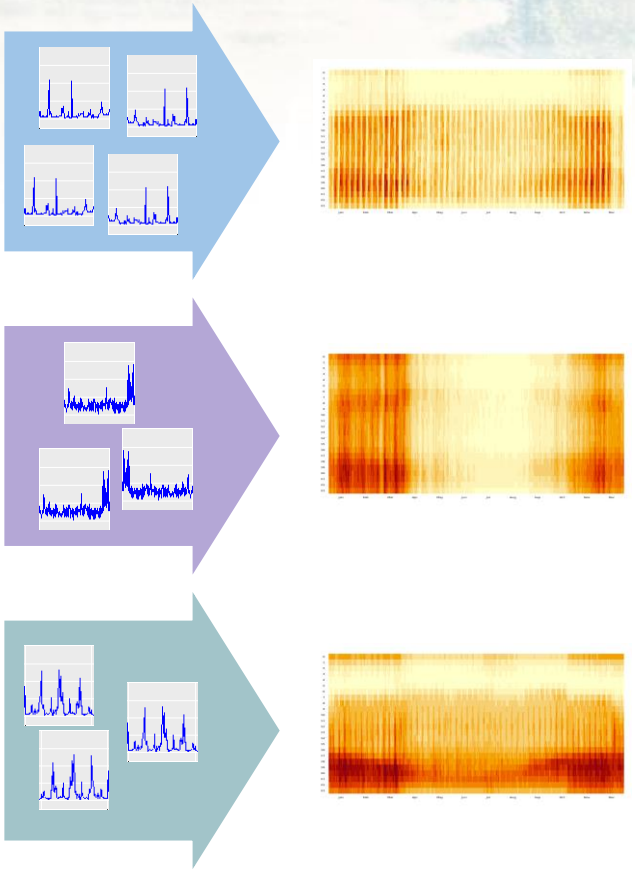
A	B	C	D
3	-2	7	4

A	B	C	D
-3	0	-1	3

A	B	C	D
1	2	5	6

A	B	C	D
-4	-1	0	1





households | load profiles | feature extraction | analysis | segmentation

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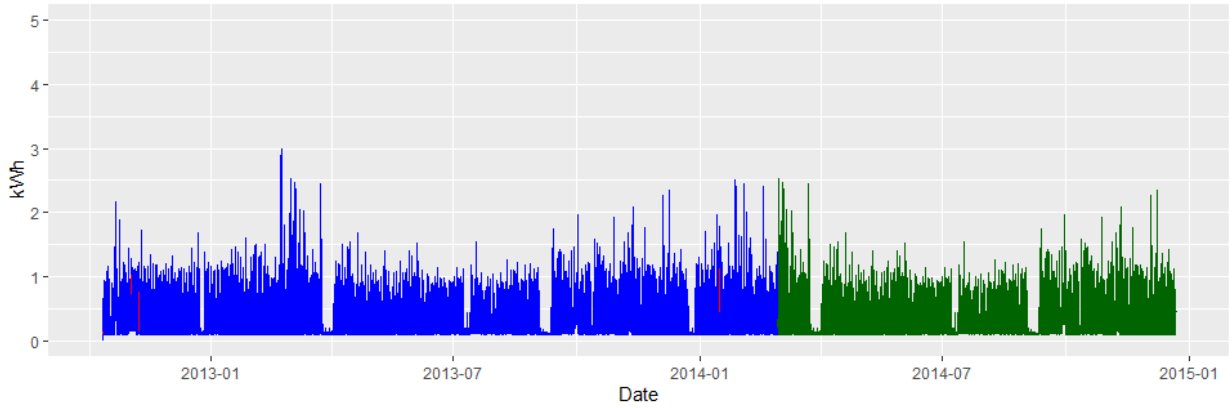
Datasets

Name	Time series	Spatial resolution	TS length	Dates	Current state
ADRES	30	Households in Upper Austria	14 days	NA	Discarded (not enough data)
Energie Steiermark	100	Households in Austria	< 1 year	2020	Raw (more data needed)
EnerNOC	100	Commercial/industrial in US	1 year	2012	Partially processed (to be used later)
ENLITEN	~1400	Appliances in Exeter (UK)	> 2 years	2013-2016	Discarded (only appliances)
GOIENER	(19108) 11799	Energy retail clients from across Spain	1-4 years	2018-2021	Fully processed
ISSDA	(6435) 6088	Households/commercial in Ireland	> 1 year	2008-2010	Fully processed
Kaggle	1449	Buildings (commercial/industrial)	1 year	2016	Partially processed (to be used later)
La Corriente	(720) 0	Energy retail clients from across Spain	< 1 year	2020-2021	Fully processed (more data needed)
Levion	99	Submetering at households in Austria	> 1 year	2019-2020	Raw (to be used later)
Low Carbon London	(5449) 5269	Households in Greater London (UK)	~1.5 years	2012-2014	Fully processed
Megara	(851) 320	Energy retail clients from across Spain	1-2 years	2019-2021	Fully processed
NEEA	(200) 64	Load profiles in Western US	> 1 year	2019-2020	Fully processed
NewTRENDS					To be received
PerModAC	74	Households in Germany	1 year	synthetic data	Partially processed (to be used later)
Portugal (UCI)	351	Load profiles in Portugal	> 1 year	2012-2014	Fully processed
REFIT	20	Households in Loughborough (UK)	~2 years	2013-2015	Partially processed (to be used later)
REScoopVPP					To be received
OPSD heating	384	Building heat pumps (Europe)	> 5 years	2008-2013	Discarded (only heat pumps)
OPSD households	68	Households in southern Germany	> 4.5 years	2014-2019	Raw (to be used later)
UCI ML repository	1	Household near Paris (FR)	~ 4 years	2006-2010	Raw (to be used later)

Datasets: preprocessing

- **Imputation** of NA values using nearest samples (interpolation & LOCF)
- **Extension** of time series shorter that 800 days (LOCF)
  - Base series: 364 complete days (week day matching)
- At the moment, only data prior to COVID lockdowns



Results: features table

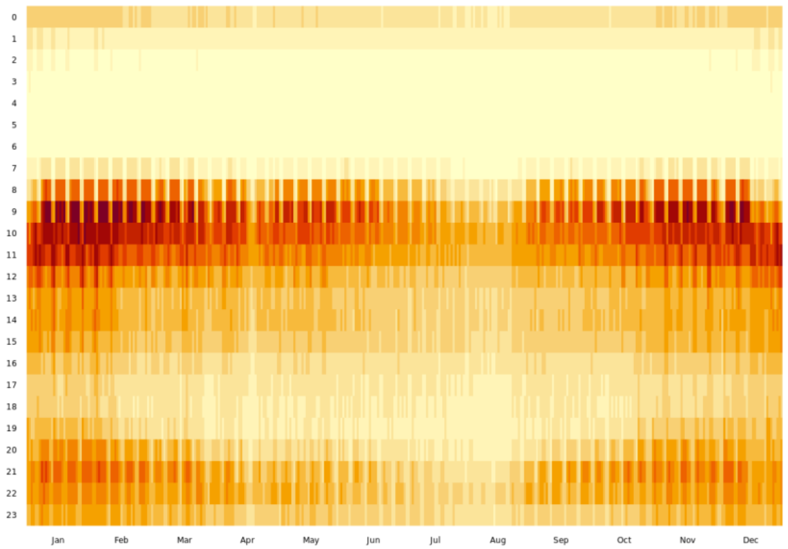
- Over 700 features computed per time series (more are planned to be added)
- 4 subsets of features to cluster the data:
  - 25 seasonal aggregates (by 4-hour group & season, by weekday/weekend)
  - 5 peaks and off-peaks (by hour, by month, by weekday/weekend)
  - 8 seasonal strengths & autocorrelations (+ mean, + entropy)
  - *Catch-22* features*

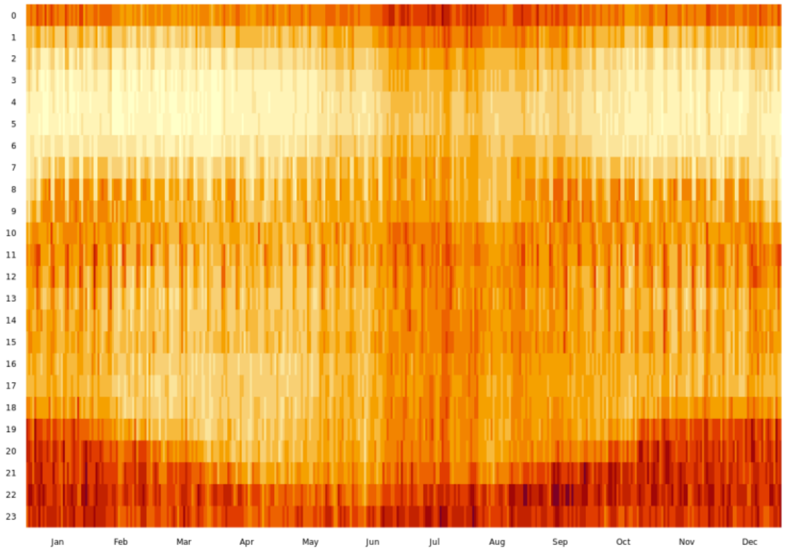
* *catch22: CAnonical Time-series CHaracteristics*, Carl H. Lubba et al. (2019)

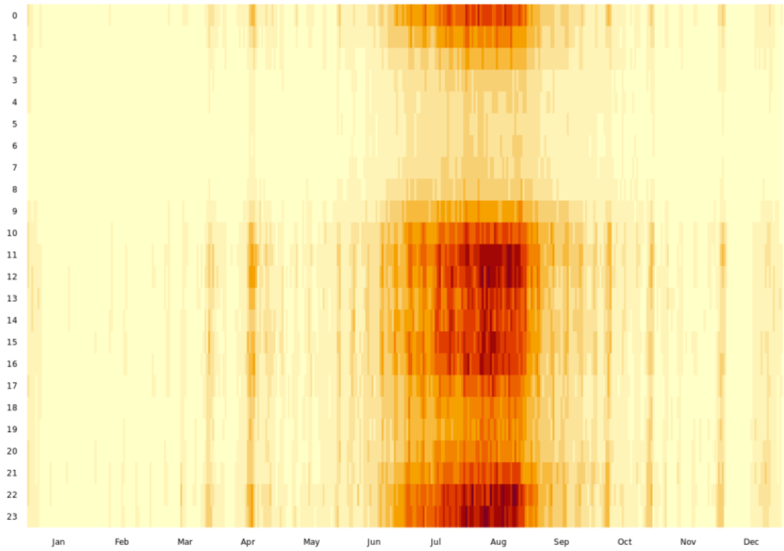
Results: clusterization

- 9 clustering methods tested: only *k*-means and SOM provide good results
- 7 cluster validation metrics to select the number of clusters
- 4 groups of features tested
- Initially 24 clusters per dataset (to be modified in some datasets)

Results: electrical behavior examples







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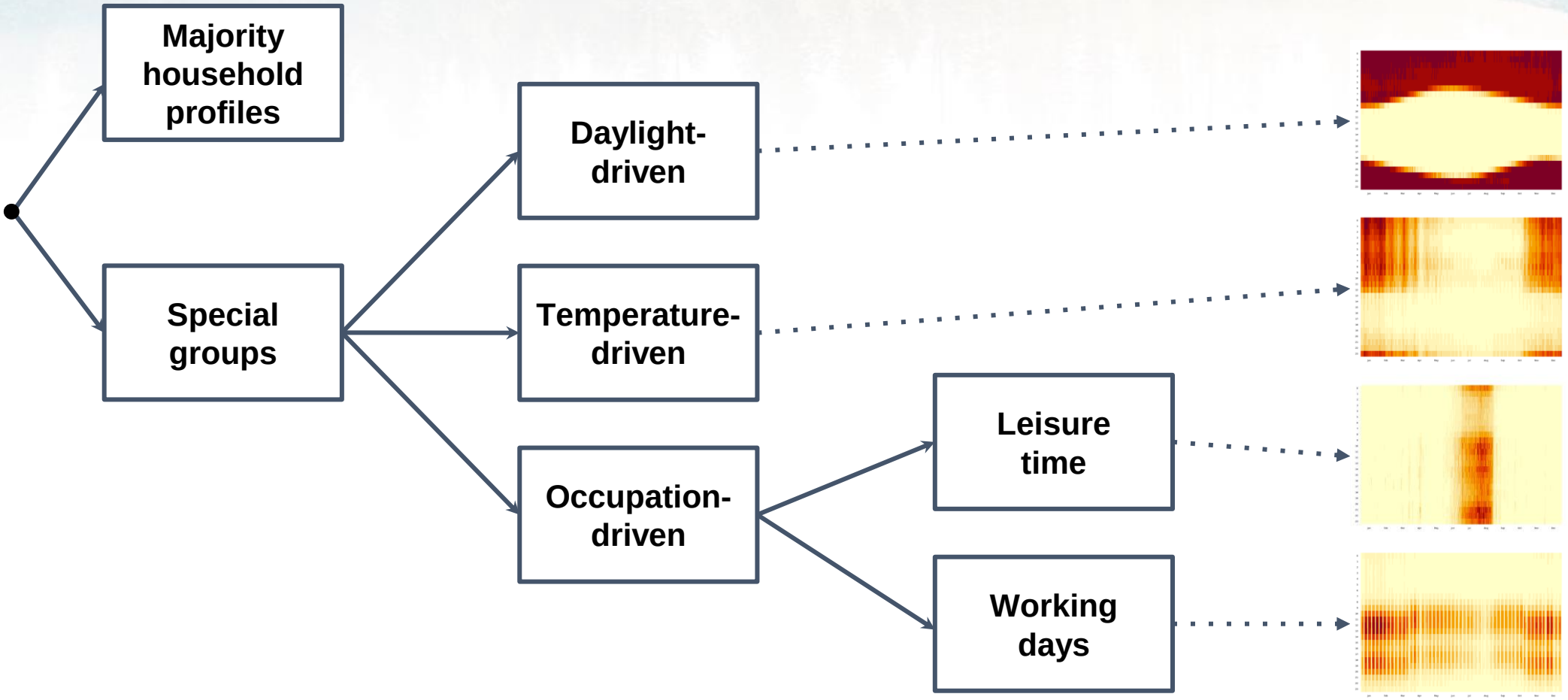
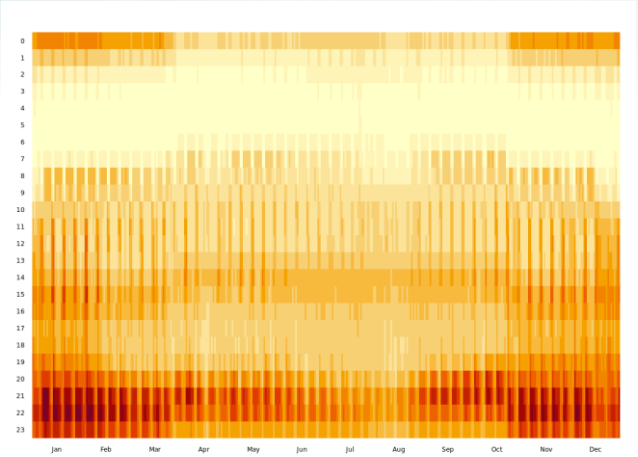
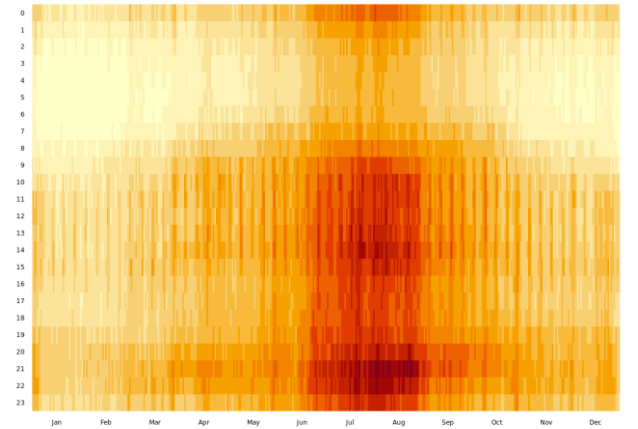
Results: electrical behaviour taxonomy



Results: electrical behaviour personae



- Working close to home during weekdays
- Lunch and dinner at home
- Dining in on weeknight
- Going out on weekend nights, then staying up late at home (afterparty?)
- Resting at home on Sundays
- Holidays at home



- They don’t follow a routine
- The consumption is much higher in summer (air-conditioning?)
- They spend very little time at home in winter
- They have lunch and diner at home

Next Steps

- Enrich the features table with weather correlations and socioeconomic information where possible
- Compare the electrical behaviors between countries
- Compare the electrical behavior before and during COVID lockdowns and between countries

Why do people invest time and money in the energy transition?

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Introduction

- A large part of the energy transition lays on the shoulders of households
- Households, in general, are characterized by not taking rational decisions. Thus, the *homo-economicus, Rational man or Resource man* is not the archetype to follow. Hence, household behaviour are unsuitable for traditional models [Rational Choice Theory]
- The investment decisions to make towards the energy transition is no different. Hence, a different approach from a different angle is needed.
- Artificial Intelligence methods have achieve good results on modeling behaviour but are not robusts under intervention [the interventions modify the Data Generating Process]

Objective of the task

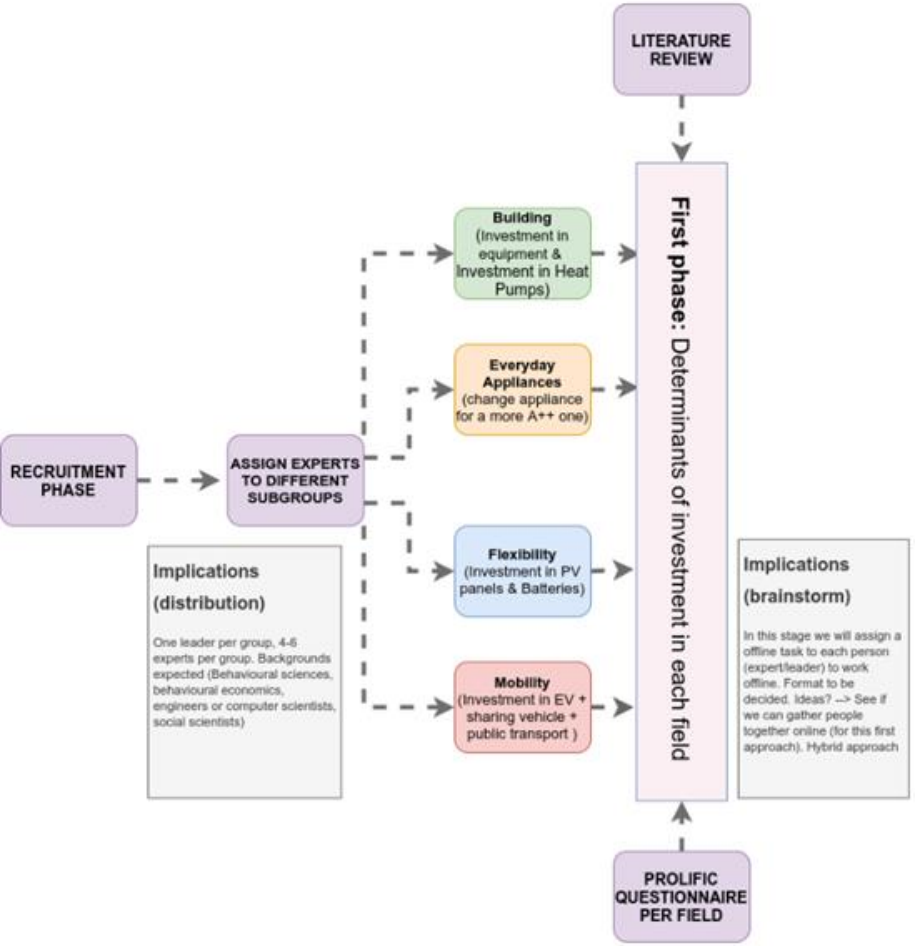
Build a model of:

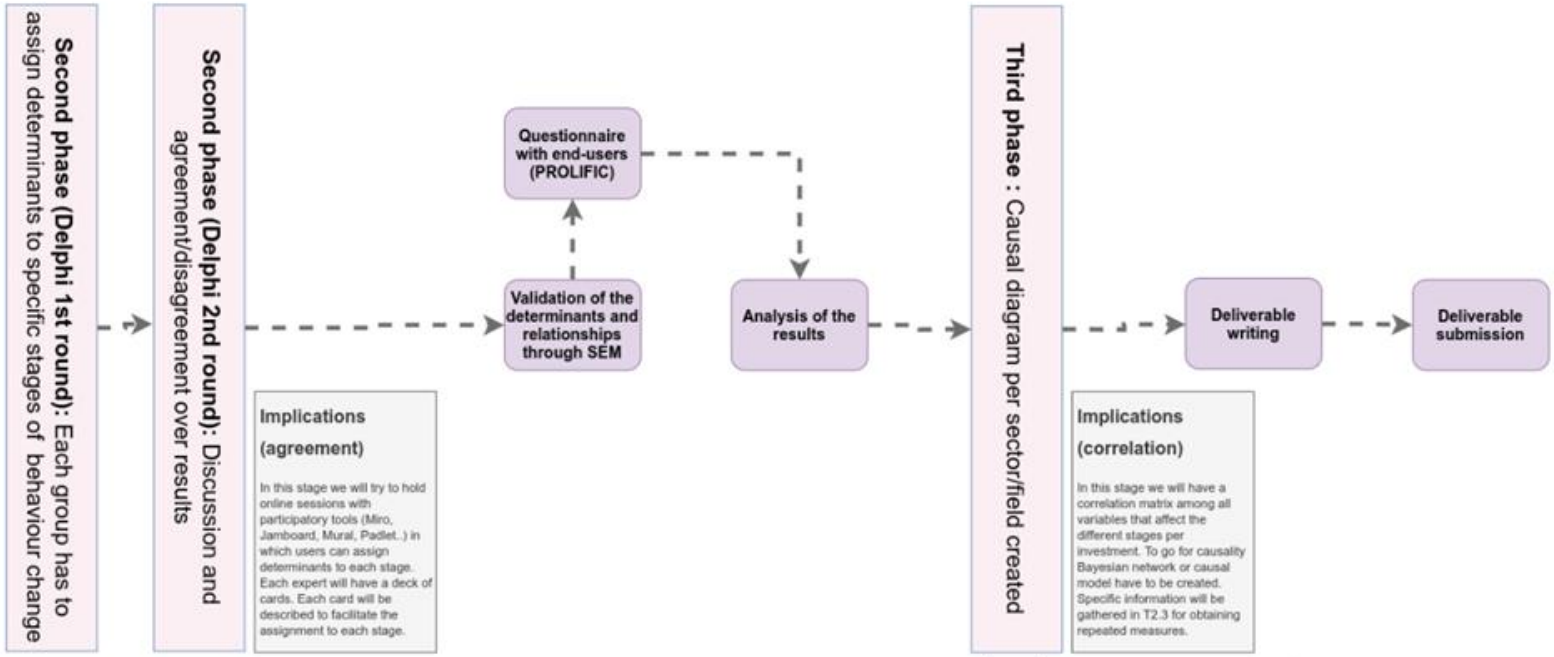
- individual households investment decisions on
- technology or behaviours
- related to the energy transition
- that is robusts to interventions

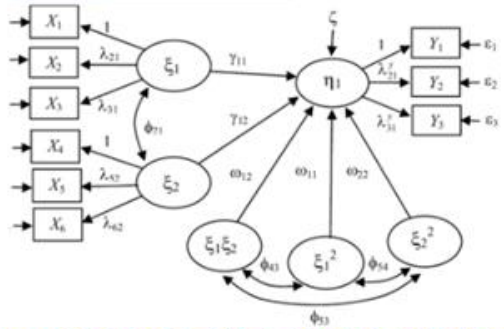
Overview of the Methodology

- Fuzzy Delphi Method
- Speculative Scenarios
- Role-Playing and Just-in-Time Surveys

Overview of the Methodology







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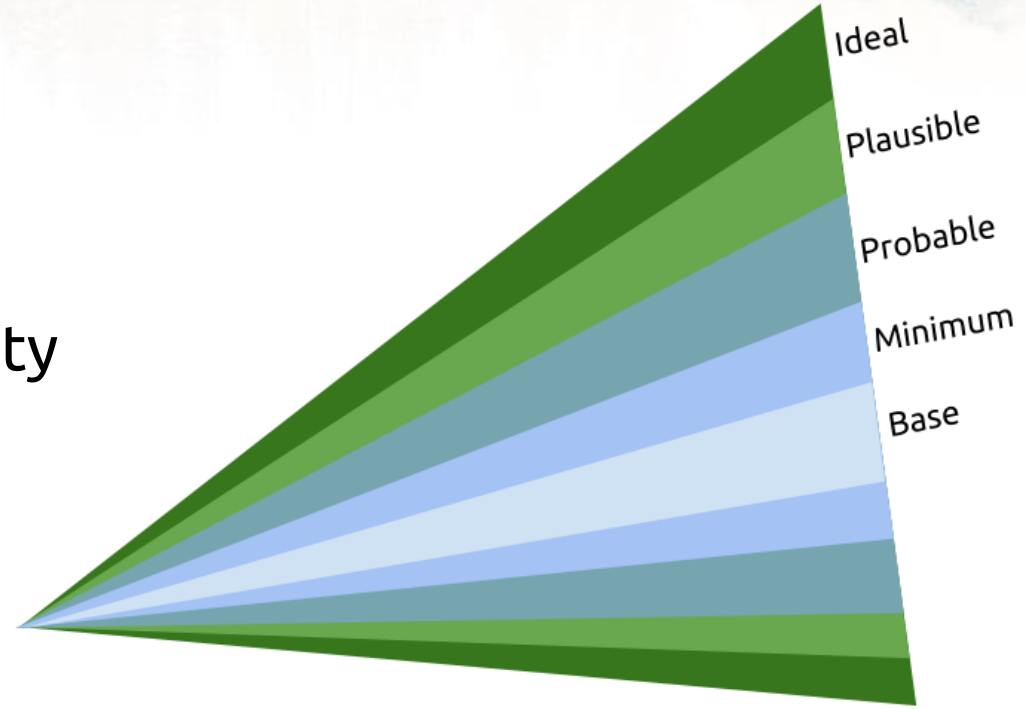
Phase 0: creation of speculative scenarios

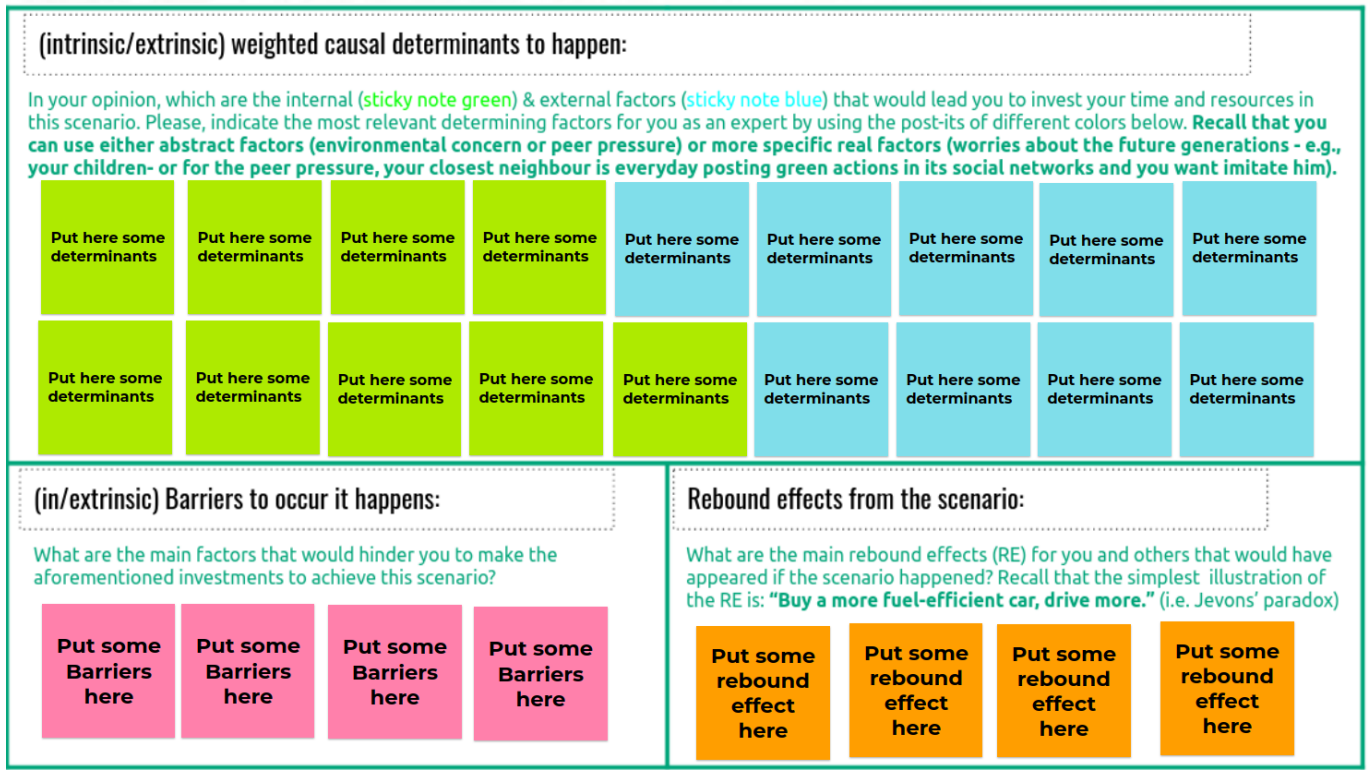
Divide et impera:

- **split the energy transition in 4 aspects:**
  - Buildings, Appliances, Flexibility and Mobility
- further split each aspect if **4 speculative scenarios** each one covering **different technologies and behaviours**:
  - Minimum, Probably, Possible and Ideal



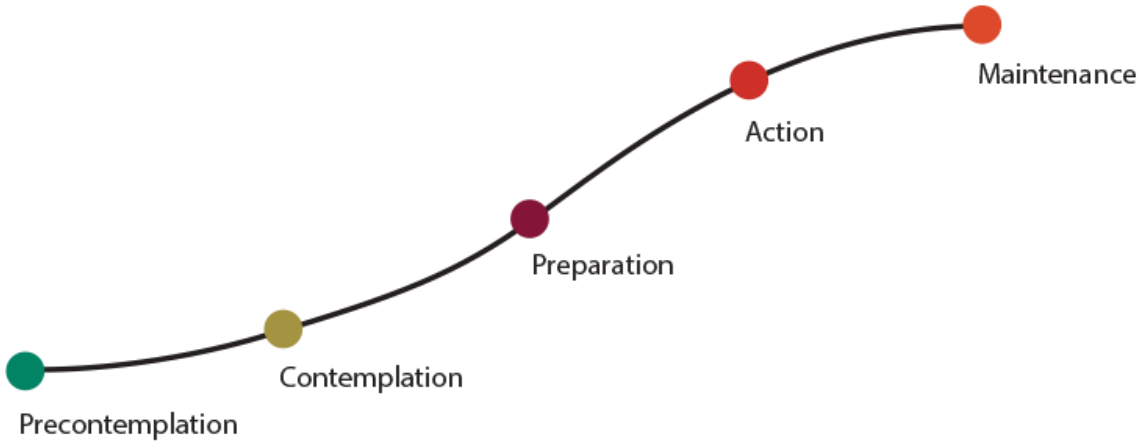
Phase 1: Determinants

- Obtain the **intrinsic and extrinsic determinants** related to each one of the 16 scenarios.
- **Social Learning Theory** [Bandura] **for clustering the determinants:**
  - Cognitive factors
  - Environmental factors
  - Behavioral factors
- Defined the **barriers and rebound effects** that are present in each scenario.

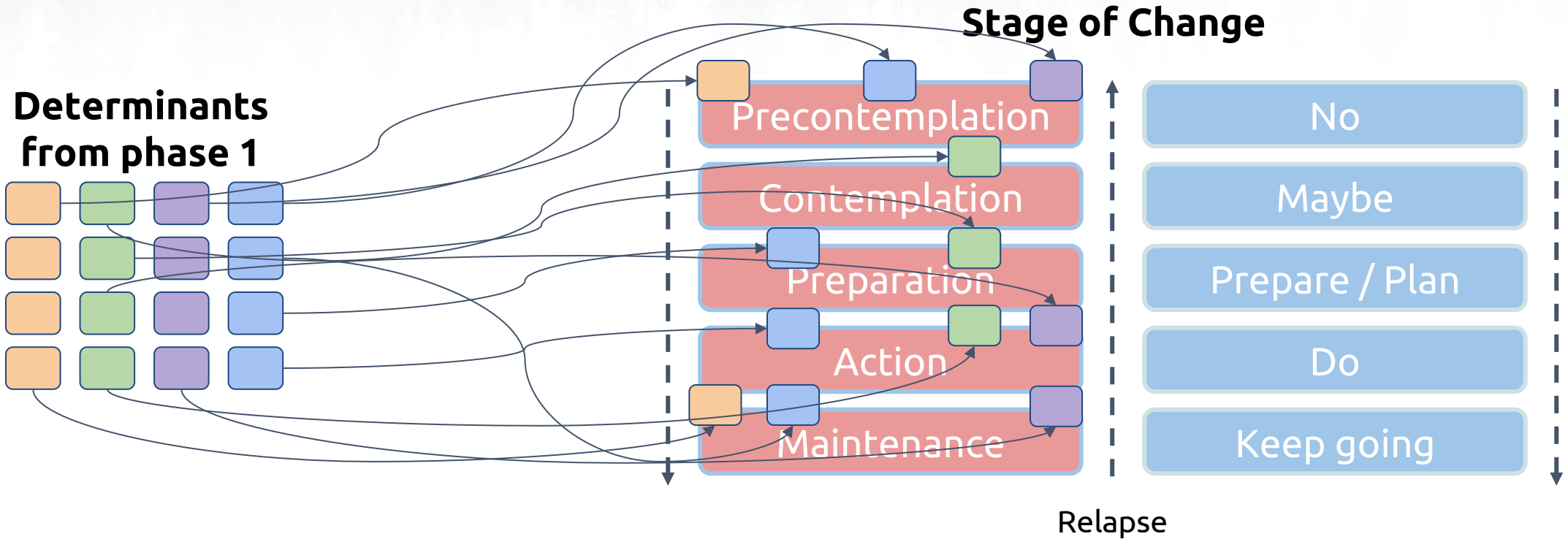


Phase 2: Transtheoretical Model

- **Behavioural model** from Prochaska and DiClemente in the late 1970s resulting from assessing the results of studies that compare smokers that quit on their own with ones that go to therapy
- The basic idea is that you **carry on an action** when you are ready to do so and **there is a process to reach** that point affected by different constructs
- **5 stages** are included in the model:
  - precontemplation, contemplation, preparation, action, maintenance
- The objective is to **map determinants and barriers to stages** of the model

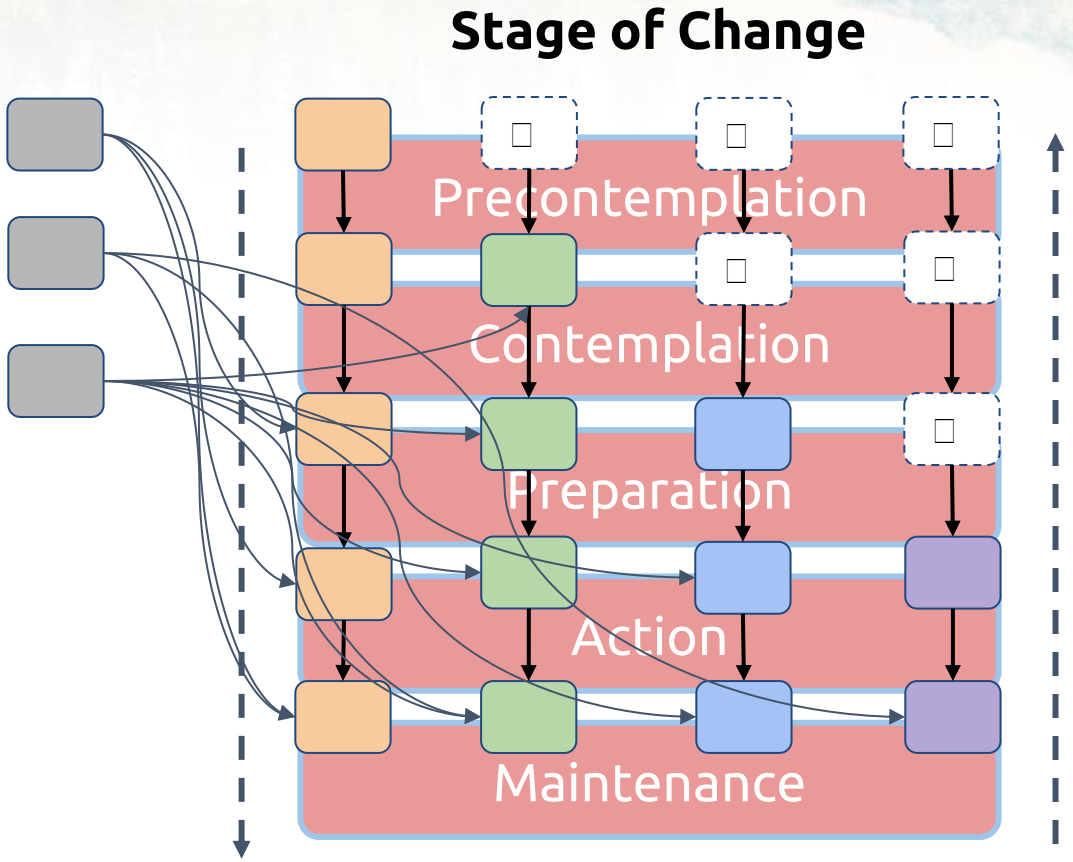


Phase 2: Transtheoretical Model



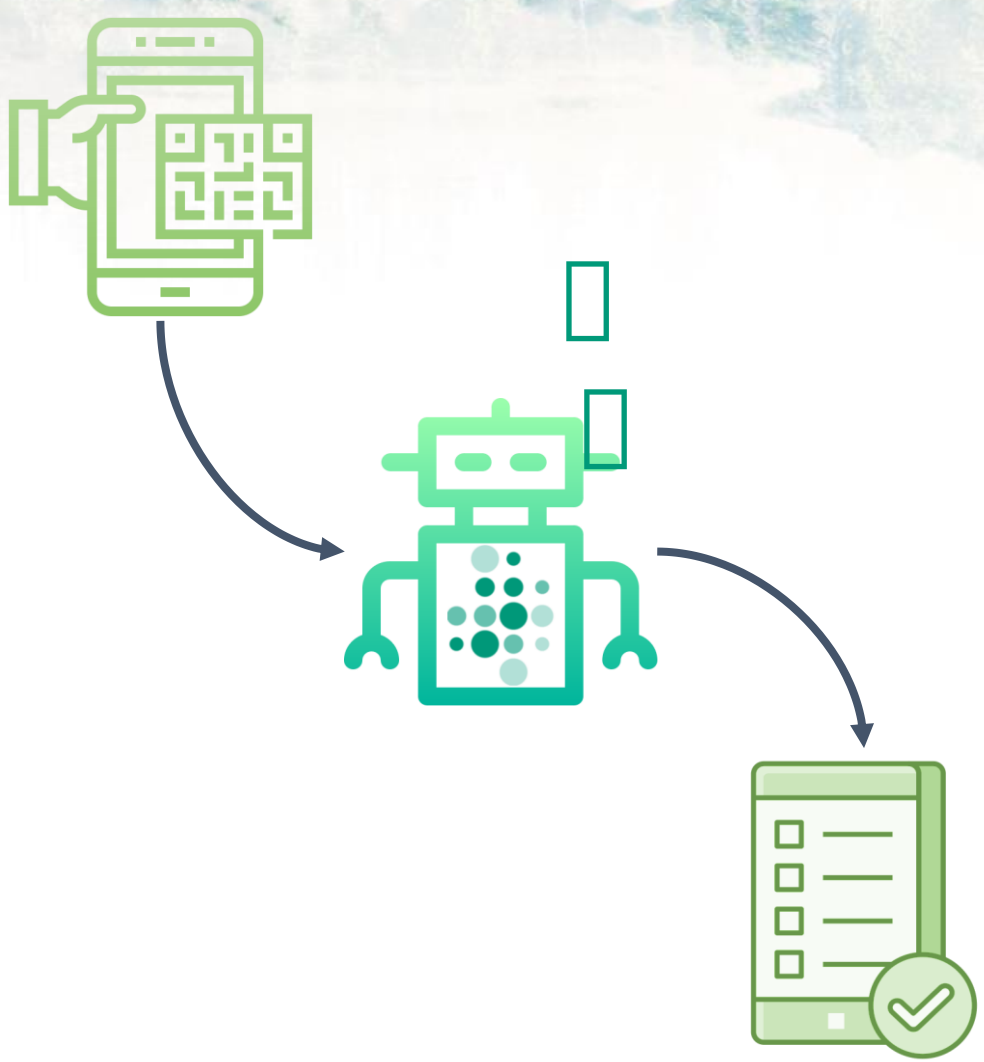
Phase 3: Causal Diagram

- The objective is to **explain why a household progress** from one stage to another
- The **difference between determinants** in each stage seems to be the key
- Also we are interested in knowing which determinants are more important to make someone **advance** from one stage to the next one: **triggers and thresholds.**

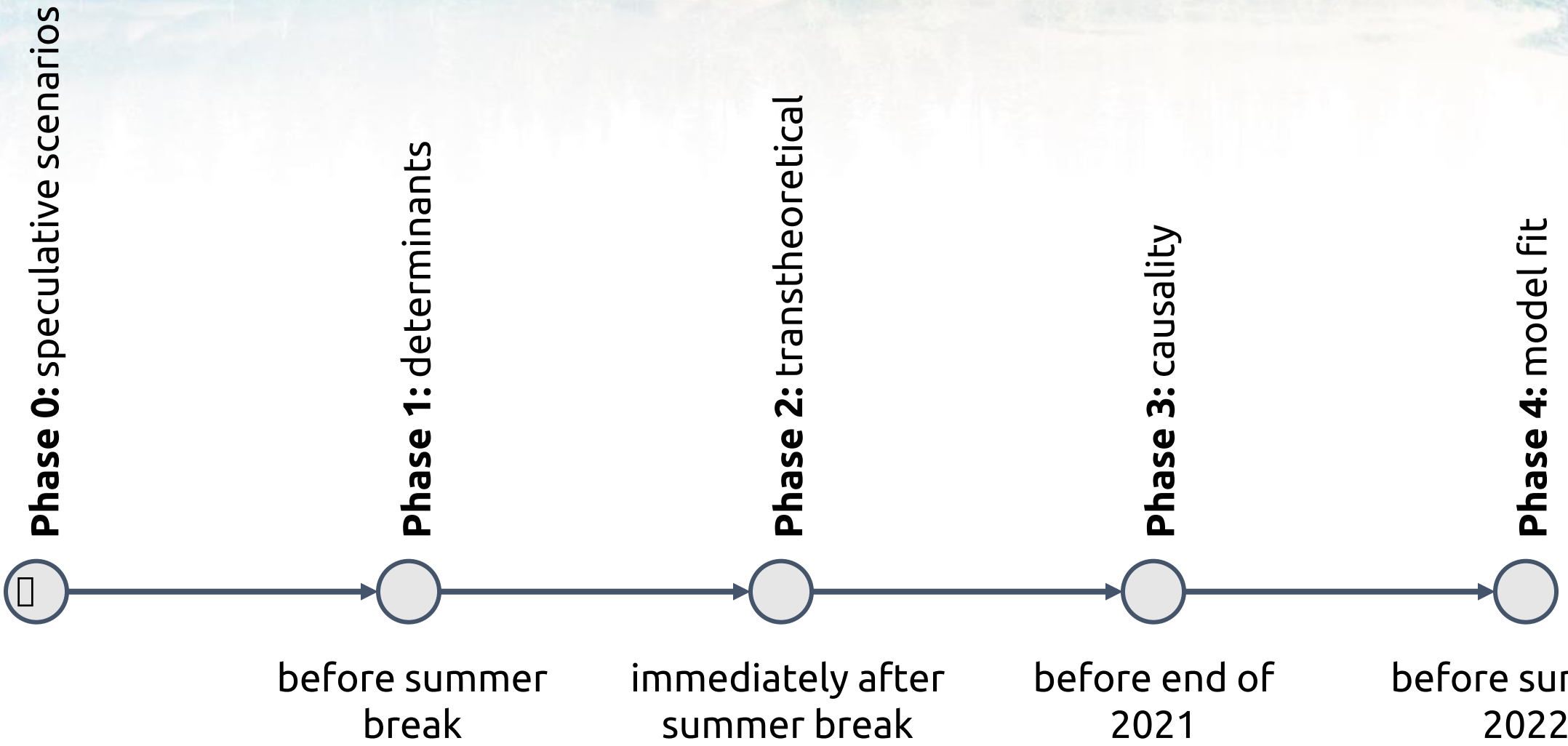


Phase 4: Causal Model

- The objective is to get the data needed to fit the causal model
- Data fusion techniques from different sources
- Traditional surveys and focus groups
- Just-in-time role-play-based surveys



Timeline


Phase 0: speculative scenarios
Phase 1: determinants
Phase 2: transtheoretical
Phase 3: causality
Phase 4: model fit
before summer break
immediately after summer break
before end of 2021
before summer 2022

Panel of Experts

Volunteers are welcome

- **Following the 6i Strategy:**
  - International, Interdisciplinary, Intersectorial, Impact, Innovation, Inclusion.
- **7 roles per group:**
  - Facilitator, Helper, Technical, Societal, Economic and Behaviour experts and different representant of the Civil Society.

SCAN ME

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or

completing this form

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THAT'S A WRAP!

THANK YOU FOR JOINING US

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WHY The WHY project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 891943.

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