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EUCALC

Explore sustainable European futures

Expert Consultation Workshop on Scenarios for Decarbonising European Buildings

D2.7

July/2018

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Short Description

This report summarises the structure, the major findings, and the lessons learned of a well-facilitated expert consultation workshop on the decarbonisation of the European building stock carried out in June 2018 in Brussels.

The main aim of the workshop was to get input and feedback from experts of the sector on the first draft of the Buildings' module of the planned EU Calculator.

The workshop opened with an overview of the EUCalc project while further emphasis was given on the Buildings module of the calculator. Two keynotes (from the European Commission and from the Industry sector) gave insights on their view on decarbonising the European building stock.

This document further includes main points of discussion and inputs arising from an interactive dialogue between the stakeholders, who were divided in four working groups, and were aiming to give their opinion on the suggested levers and levels of the Buildings modules.

The comments from the workshop participants and the output of the discussions during the workshop will be reviewed, analysed. Feasible and target-aimed inputs will be considered in the further design and implementation of the building module. Feedback on the overall EU Calculator will be feed into the internal project discussion on the Calculator design

Quality check	
Name of reviewer	**Date**
Ivana Rogulj (SEE Change Net)	**30.06.2018**
Christiane Walter (PIK)	**10.08.2018**
Katja Firus	**23.08.2018**

Statement of originality:

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

EUCalc policy of personal data protection in regard to the workshop

EUCalc defined the procedures in order to reply to ethical requirements (Deliverable 12.1: Ethics requirements – procedures and criteria to identify research participants in EUCalc – H – Requirements No. 1). All procedures in relation to the co-design process, in particular the stakeholder mapping, the implementation and the follow-up of the workshops follow these procedures. The informed consent procedure in relation to the workshops is based on predefined "Stakeholder mapping" (D9.2) and "Method for implementation of EUCalc co-design process" (D9.4). The originals of the signed consent forms are stored at the coordinators' premises without possibility of access of externals. Scans of the informed consent forms are stored on the internal EUCalc file storing system.

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List of abbreviations

GHG - Greenhouse gas emissions

NGO – Non-profit organisation

HVAC – Heating Ventilation and Air Conditioning

CHP – Combined heat and power

LED – Light Emitting Diode

EPC – Energy Performance Certificate for buildings according to the EBPD

EPBD – Energy Performance in Buildings Directive of the EU

1 Introduction

The EUCalc project aims to deliver a comprehensive framework for research, business and decision making that will enable an appraisal of synergies and trade–offs for decarbonisation pathways at European and member state level. The pathways are based on an innovative modelling approach rooted between complex energy systems and emission models; it introduces a multi-sector approach that is developed in a co-design process with scientific and societal actors.

Different sectors like transport, buildings, industry, agriculture, power generation, energy usage, and lifestyles are explored in EUCalc. EUCalc will provide a Transition Pathways Explorer for politicians at European and member state level that can be used as a planning tool for the technological and societal challenges linked with inertia and lock-in effects. The tool is meant to be widely used for policy and decision making and it will involve an extended number of decision makers from policy, business, and stakeholders through expert consultations.

This report describes the expert consultation workshop on scenarios for decarbonising European buildings related to the buildings module of the calculator. This half day workshop was carried out in Brussels on the 4th of June 2018 and was part of the Sustainable Energy Week. This workshop is one in a row of expert consultations that have been organised for the different sectors. It followed the common structure and facilitation defined in D9.4.

Twenty stakeholders representing private and public sector, academia, associations, and the European Commission were gathered and exchanged views and opinions related to the decarbonisation of the European building stock.

Two keynote speakers representing the Commission and the Industry presented their perspective on scenarios for decarbonising European Buildings: Alex Bierer, Policy Officer of DG Energy unit for Energy Efficiency, shared Commission’s view, while Céline Carré, President of the European Alliance of companies for energy efficiency in buildings (EuroACE) shared the Industry’s perspective.

Objectives of the expert consultation

The main objective of the workshop is to present the current state of the modelling work of EUCalc and to validate and critically discuss the followed methodology of the buildings module. The ultimate goal is to the select the most crucial emission-driving levers within the buildings sector and define how ambitious their levels are. The results will be taken into consideration in the EU Calculator, as far as these are coherent with other modules and inputs.

For the discussion we have identified the following framing aspects with respect to the project goals:

- Investigate the main trade-offs and tipping points within energy in buildings that form important assumptions used within the buildings module;
- Assess the impact of national differences, e.g. building stock, fuel mix, policy framework, and economic condition;
- Identify potential barriers, preventing the implementation of the suggested measures and suggest ways of overcoming these barriers;
- Discuss interactions between the building sector and other sectors.

2 About the European Calculator

The debate on decarbonizing Europe evolved from being a concern of separated national governments to also encompass a cross-border heterogeneity of economic sectors, businesses, regional decision makers and individuals. Simulation tools supporting policy making were mostly shaped by focussed scientific debates and missed out to engage with the new diversity of actors willing to drive transformation.

To bridge this gap, we developed the EU Calculator model and its public outlet, the Transition Pathways Explorer. This tool addresses European and national policymakers, businesses, NGOs, and other actors of society. Its goal is to equip these users with a mean to create their own low-carbon transformation pathways on the European and member state scale and compare them to other integrated pathways. The results will enable EU policy makers to support the energy, emissions and resources debate on a low carbon transition.

The underlying methodology roots between pure energy simulation and integrated impact assessment and harmonizes across all sectors to link 1) behaviour, 2) products, 3) material & resources, 4) energy, and 5) emissions. It also integrates trade-offs like the impact of eating habits on land-use or buildings renovation on material demand.

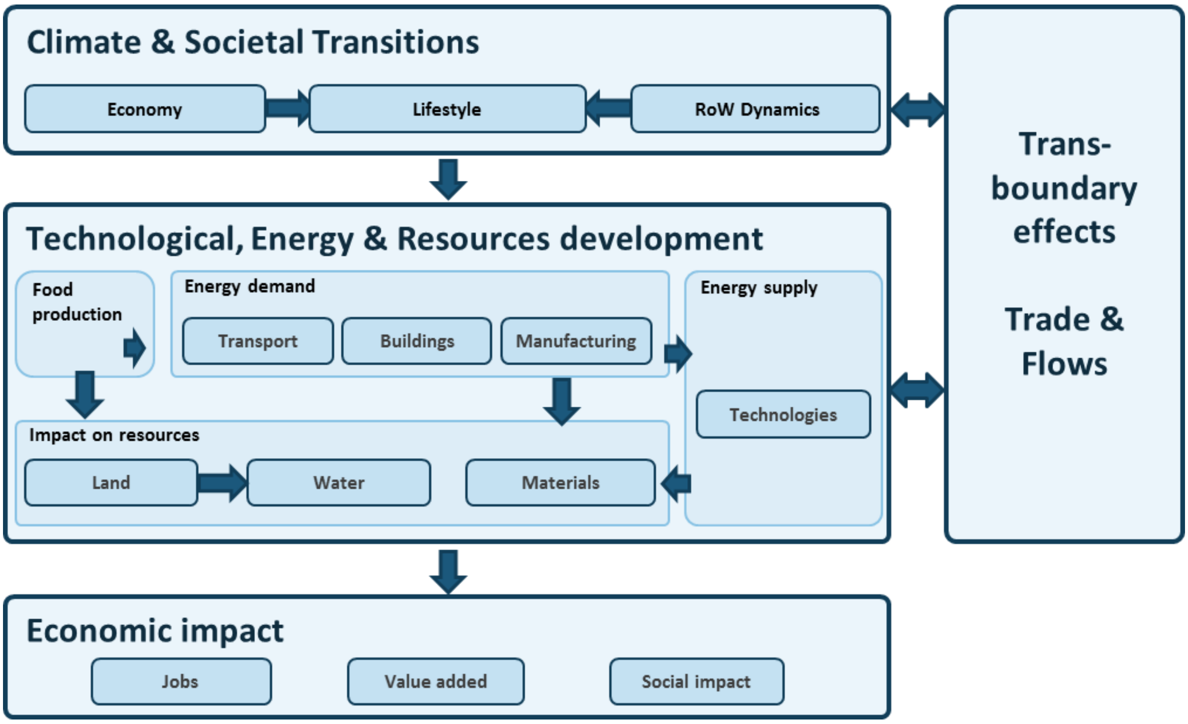

Figure 1 – Modular structure of the EU-Calc model

To share model outputs with a wider audience, we are developing the Transition Pathways Explorer, an online, open source tool providing instant results from the EU Calculator model runs. Co-designed with scientific, business and societal actors, the modelling approach defines the options that will be available to the user later for creating their own transition pathway. The model retains an intermediate level of complexity while providing a high level of transparency.

The European Calculator model consists of several interconnected modules (Figure 1). More information is included in the EUCalc project's website.

3 Modelling approach in the buildings module

The scope of the buildings module of the EU calculator includes residential and non-residential buildings (Figure 2). It seeks to calculate the energy need, delivered energy, primary energy demand, and direct CO_2-emissions for space heating and cooling, hot water, lighting, and appliances. The overview of the buildings module below shows the calculation intra-year per country. It frames the scope of the model and highlights the disaggregation of the calculation by energy use (green boxes).

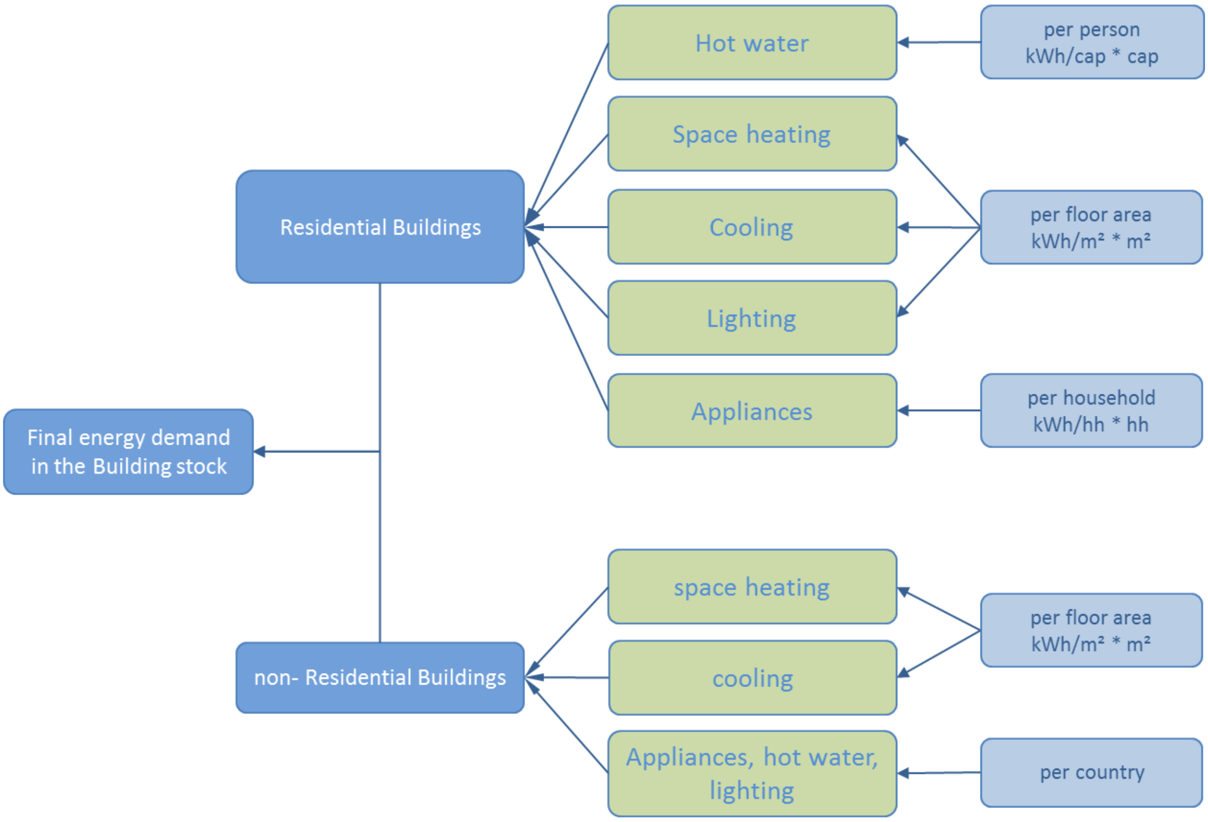

Figure 2: Overview of the annual calculation logic behind the Buildings module

The calculations within the module covers the operational phase of buildings. Shifting building materials from mainly steel and concrete to mostly wood for construction and energy renovation will also be covered in the analysis.

The data used for the model runs are summarised in the deliverable D2.4.

4 Definition of levers & levels

This Building workshop aimed at selecting the most crucial emission-driving levers within the buildings sector and define how ambitious their levels are. Within this analysis, a lever is a driver for reducing GHG-emissions. The magnitude of this reduction is expressed in the ambition levels 1 to 4.

4.1 Levers

As most important drivers for reducing GHG-emissions in the building sector, the identified levers are described in the following table. These levers are derived from the review of the GHG emission driving processes and the resulting design of the building module as depicted in the flow chart on the EUCalc webpage[1]. The final definition of the Levers and level will be documented in the deliverable D2.5.

Table 1 – Levers to discuss for the buildings module

	Lever	**Brief description**	**Content**
1.	**Living space demand per person**	This lever controls the average living space per person.	The living space demand per person affects the energy consumption. The more floor area is heated in total the higher the energy demand. Reducing the average size of dwellings for example by sharing kitchens and common areas will impact emission levels.
2.	**Building insulation**	This lever controls the average heat loss which is reduced by insulation and affects the energy need per floor area.	Heating and cooling accounts for around 30% of all the energy demand of buildings. The amount of energy needed to heat or cool buildings can be reduced significantly by improving external walls, floors, roofs, ceilings, windows and doors so that the building is better insulated. This means that less heat energy can escape from the inside of the building during cold weather, and less heat energy from outside can get in if you are cooling it[2]
3.	**Indoor temperature and hot water demand**	This lever controls the average room temperature during warm and cold times of the year, and also controls the hot water demand per person per year.	Heating and cooling represent a big proportion of the energy demand of buildings. The energy demand will increase when indoor temperatures significantly deviate from outdoor temperatures.
4.	**Material use**	This lever controls the material used to construct or insulate a building and manufacture the HVAC systems.	The carbon emissions and energy input associated with products such as steel, wood or insulation can be reduced by 3 ways: (i) reduction of required material during manufacturing, which can be done through improvements in the design, (ii) switching to less carbon-intensive materials and (iii) using more recycled material to reduce energy & emissions.

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[1] http://www.european-calculator.eu/building-transport/wp2-buildings/

[2] http://tool.globalcalculator.org/gc-lever-description-v23.html?id=13/en

5.	**Heating and cooling (ventilation) system efficiency**	This lever controls the average energy loss in heating, cooling and ventilation systems.	HVAC systems have recently become more energy efficient. Increase in the energy efficiency lowers the emissions impact.
6.	**District heating share**	This lever controls the level of heating energy demand covered by district heating.	District heating can facilitate decarbonisation buildings in dense urban areas even with decreasing heat density. Buildings in dense urban areas are particularly hard to fully release from their energy need partly due to historic or special restrictions.
7.	**Heating technology and fuel switch**	This lever controls the mix of technologies used for spare heating, space cooling, hot water, cooking and lighting.	A variety of different technologies are used in buildings for space heating, water heating and cooking. These technologies can have very different efficiencies and emissions associated with them. Today, the most common forms of heating in urban areas are combined heat and power (CHP), district heating, and gas boilers. In rural areas, solid fuel boilers are most common. In the future, new technologies could be used which have much lower emissions, for example heat pumps (which use electricity to move latent heat energy from the outside of the building to the inside) and solar hot water systems. This lever allows you to change the proportion of buildings using these new forms, and therefore to reduce emissions. Similarly, this lever also increases the proportion of cooling systems that use more efficient and lower carbon technology. The technologies for space cooling within the model are air conditioning, chillers and solar cooling.
8.	**Appliances, cooking, lighting efficiency**	This lever controls the average rate of energy use for appliances, cooking and lighting.	A variety of different technologies are used in buildings for cooking, lighting and appliances. This lever allows you to use more electricity in cooking (rather than gas, oil or traditional biomass), and to introduce more efficient lighting options like LED bulbs.
9.	**Appliances, cooking, lighting behaviour and use**	This lever controls the average number of appliances per urban and rural household. It also controls average cooking and lighting demand.	The appliances modelled for this lever are refrigerators, dishwashers, clothes washers, clothes dryers and TVs. Miscellaneous appliances like laptops and DVD players are modelled separately. It also controls the number of light-bulbs per household, and energy demand for cooking.

4.2 Levels of ambition

The extent of the GHG-emission reduction within the described levers is embodied in the ambition levels 1 to 4.

The definitions of the four levels tailored for the buildings module are given in Table 2.

Table 2 – Levels of ambition for the Buildings Module

Level 1	**Level 2**	**Level 3**	**Level 4**
This level contains projections that are aligned and coherent with the observed trends.	This level is an intermediate scenario, more ambitious than the trend but not reaching the full potential of available solutions.	This level is considered very ambitious but realistic, given the current technology evolutions and the best practices observed in some geographical areas.	This level is considered as transformational and requires additional breakthrough and efforts such as a very fast market uptake of deep measures, an extended deployment of infrastructures, major technological advances, or strong societal changes, etc.

During the Building workshop we verified the definition of the four EU(+Switzerland)-wide levels of ambition for all levers of the building sector.

4.3 Target concepts to disaggregate ambition levels

For the implementation of the EU-wide levels of ambition to the countries, we use the Science-based target concepts to disaggregate ambition levels at the country level. This approach is applied throughout the whole project, where for each lever the suitable option is chosen.

The Science-based target uses two concepts to describe the targets evolution: the convergence or the compression (see Figure 3 and Figure 4).

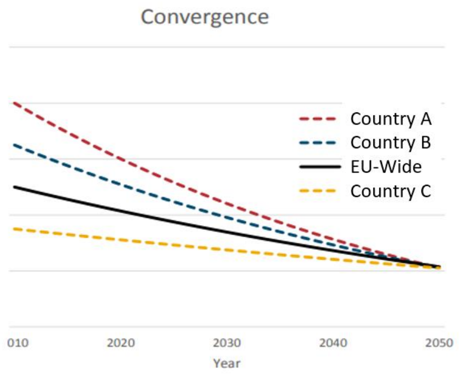

Figure 3 – Convergence concept [Science Based Target, 2015]

Convergence:

- The *absolute* 2050 ambition is the same for all countries (e.g. x kwh energy need/m² for single family homes in 2050 in all countries)
- This results in some countries having to do greater efforts than others, depending on their 2015 situation

The convergence is better suited when country-specific parameters have little to no influence on the long-term evolution of the lever value. This is usually accepted for technological levers such as energy efficiency of a given technology for example.

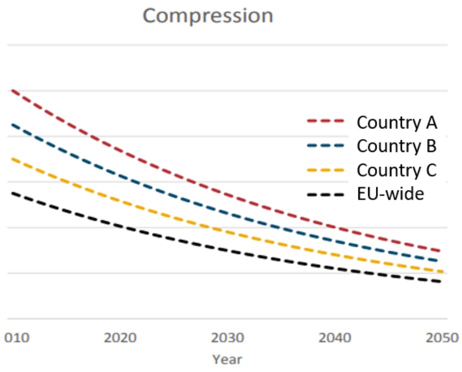

Figure 4 – Compression concept [Science Based Target, 2015]

Compression:

- The *relative* 2050 ambition is the same for all countries (e.g. -30% kWh electricity/year for one appliance by 2050 vs 2015 in each country)
- This results in all countries having to do the same relative efforts based on their 2015 situation

It was decided within the consortium that the compression is better suited when local or country-specific parameters have an important influence on the long-term evolution of the lever value. This could be the case for transport demand, for example, for which urbanization rate, population density or local topography can have an influence.

We also use a hybrid calculation which sets goals per country based on a weighted average of convergence and compression results. The weights of the hybrid calculation that are used are specified for each lever in the following sections.

5 Questions asked to experts

As written in Capter 1.1, the aim of the Buildings workshop was to get feedback from experts of different fields (e.g. private, public, NGOs) on the levels and levers defined for the Buildings sector for the EUCalc model. One week prior to the workshop, pre-read material of the building's module of the European Calculator was sent to the invited participants. This material included information about the project, the buildings module, the major discussion points their required input and the consent form of the workshop (Sections 2, 3, 4, Appendix). The questions to the stakeholders also provided in the pre-read document, are listed below:

Scope of analysis

- Is our scope of analysis complete? Or should we add further technologies or drivers?

Levers

- Do you agree with the selection of the most important levers? Do you think our choice of lever is coherent and comprehensive?
- Are there any other important levers missing on the list, i.e. unlisted/ unrecognized drivers of building energy demand? Are there irrelevant levers you think we should remove from the list?
- Are the levers correctly described? How would you re-define them?

Ambition levels

- Do you agree with the levels of ambition in each of the levers? How would you calculate them?
- How would you improve the definition of the levels of ambition? Which indicators or parameters would you use?

Future scenarios

- Which are the future trends in the building sector? Does the model allow enough flexibility to take them into account? Where could we expect some major disruption in the building sector? Is there an innovative solution that you think would make a positive change?
- How fast will innovation take place? What is the pace of technological and behavioural change?

For a more effective contribution from all stakeholders, they were divided in 4 groups. Groups 1 and 3 discussed the same levers while groups 2 and 4 shared another set of levers. All levers are described in-detail in Table 1.

Group 1 & 3

Groups 1 and 3 discussed the following levers:

- Living space demand per person (1)
- Indoor temperature/ hot water demand / cooling demand (3)
- Heating and cooling system efficiency (5)
- District heating share (6)
- Heating technology and fuel switch (7)

The numbers in bracket refer to the numbered lever shown in Table 1.

The stakeholders of groups 1 & 3 were also provided with the following guiding questions, levels of ambitions of selected levers (Table 3) and a diagram showing the distribution of technologies used for urban heating across the different levels (Figure 5).

Guiding Questions:

- ❖ Is the market uptake of cooling technology in Mediterranean countries continuing a fast trend?
- ❖ What are extremes in living space demand and how are they linked to urbanization?
- ❖ How fast will innovative technologies take up? Especially renewable technologies for district heating such as heat pumps and solar thermal?
- ❖ Do you believe in a significant role of district heating in the future? Which technology will be dominant in the future to generate renewable heat for district heating?
- ❖ Shall the heating fuel mix be separate from the electricity fuel mix lever? That means, shall the user choose individually or is the user overwhelmed with too many decisions?

Table 3: Levels of ambition of selected levers for discussion for groups 1 & 3

Lever		Level 1	Level 2	Level 3	Level 4
1.	Living space demand per person	55 m^2	45 m^2	40 m^2	39 m^2
3.	Indoor temperature and hot water demand	20^{0}C in winter, 24^{0}C in summer	19^{0}C in winter, 25^{0}C in summer	18^{0}C in winter, 26^{0}C in summer	17^{0}C in winter, 27^{0}C in summer
5.	Heating & cooling efficiency				
	solid boilers	50%	65%	80%	90%
	liquid boilers	75%	80%	90%	96%
	gas boilers	80%	100%	150%	200%
	heat pumps	200%	300%	400%	500%
	electricity heater	100%	100%	100%	100%
	solar	50%	60%	70%	80%
	Micro chp	50%	60%	65%	70%
	District heating	56%	70%	80%	90%

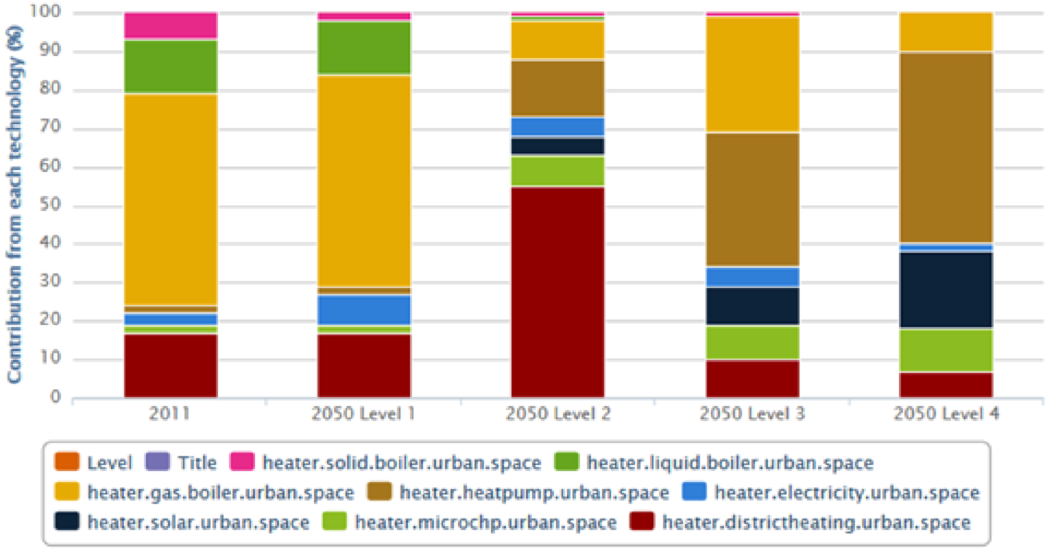

Figure 5: Technologies used for urban heating

Group 2 & 4

The levers given to groups 2 and 4 for discussion were the following:

- Building insulation (2)
- Material use (4)
- Lighting, cooking & appliance efficiency (8)
- Lighting, cooking & appliance behaviour and use (9)

The numbers in bracket refers to the numbered lever shown in Table 1.

The stakeholders of groups 2 & 4 were also provided with the following guiding questions, levels of ambitions of selected levers (

Table 4) and two diagrams showing the distribution of lighting and cooking technologies across the different levels (

Figure 6).

Guiding questions:

- What renovation depth and rate are feasible in the stock considering its historic structure and the countries’ economic power?
- What is a feasible timeline for a shift from cement and steel to wood?
- What share of population would be addressed by the energy and money saving opportunities of a sharing society? For example, do all future apartments need their own kitchen?
- What trends do you see for lighting and appliances regarding the efficiency of the technologies?
- In the development of quantity versus efficiency what will be the resulting trend for Europe?

Table 4: Levels of ambition of selected levers for discussion for groups 2 & 4

Lever		Level 1	Level 2	Level 3	Level 4
2.	Building insulation Through better insulation, thermal performance of urban residential buildings improves by	29%	47%	64%.	76%.
9.	Appliance and lighting efficiency Refridgerator Dishwasher Clothwasher Clothdryher TV	82% 79% 80% 88% 97%	68% 71% 68% 79% 83%	61% 63% 60% 70% 77%	52% 50% 52% 62% 70%
8.	Lighting, cooking and appliance use	6.3 large appliances (refrigerator, clothes washer and dryer, dishwasher and TV) and 5.0 small appliances (e.g. laptop, DVD player).	5.5 large appliances (refrigerator, clothes washer and dryer, dishwasher and TV) and 4.2 small appliances (e.g. laptop, DVD player).	4.9 large appliances (refrigerator, clothes washer and dryer, dishwasher and TV) and 3.6 small appliances (e.g. laptop, DVD player).	4.1 large appliances (refrigerator, clothes washer and dryer, dishwasher and TV) and 3.0 small appliances (e.g. laptop, DVD player).

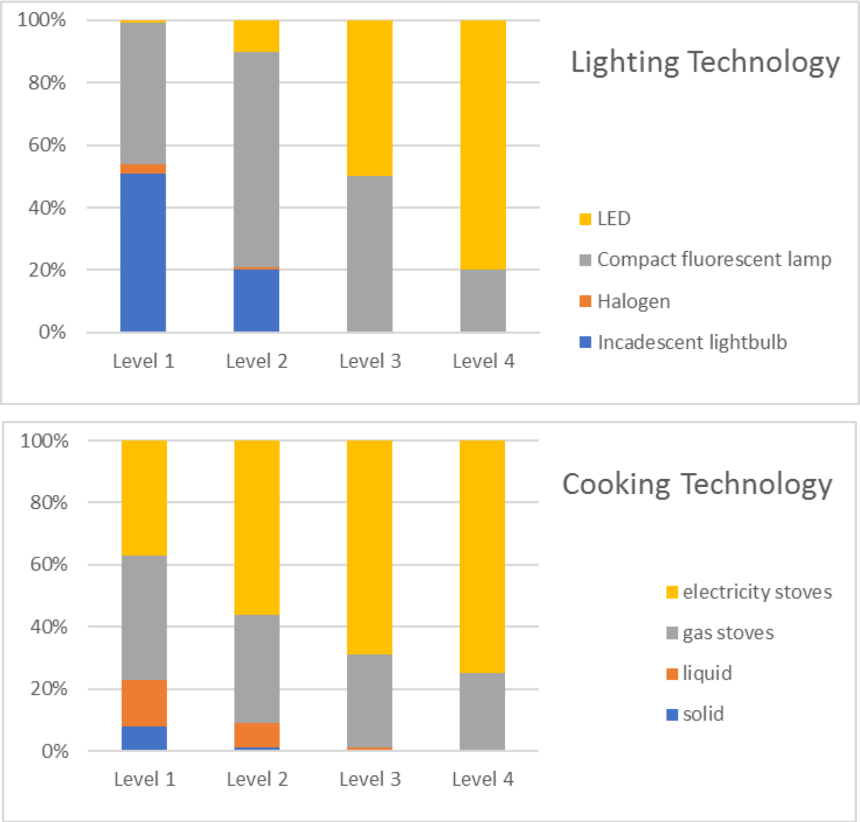

Figure 6: lighting (top) and cooking (bottom) technology distribution on the 4 levels

6 Recommendations from stakeholders

Lively discussions took place in all groups. The groups build their own ideas on the topics presented and then exchanged their while switching the board and presenting their findings to each other. Finally, one representative of the group summarized and elaborated the combined finding to all participants.

6.1 Levers

The major points related to levers raised by the stakeholders are summarised below:

- The scope of the covered consumption elements that contribute to the energy demand originating in buildings was challenged:
    - Adding of swimming pools, saunas, Jacuzzis (impact e.g. in the tourism sector, but also in private houses); these could be linked to building typology
    - Include elevators in buildings
    - Include refrigerators in supermarkets

➢ How we take this point into account: The consideration of these consuming elements will be determined based on their relevance and potential future relevance for the total GHG emissions.

- The share of secondary and holiday residences which are only used part of the year and not necessarily within the heating season, but within summer where they are potentially cooled
- Consideration of partial heating improves the calculation
- Separation of hot water in different temperature levels
- Possibility of autonomous communities could be also examined

Further below are some points related to specific levers:

Level 1: Living space demand per person

- Secondary residences should be also described on level 1.
- Shared spaces: raise of living space demand per person.
- There should be a link of living spaces, urbanisation density, cultural differences, and price.

Lever 2: Building insulation

- The overall lever description is ok. The title is a bit misleading as it is directing linked ONLY to insulation. Below are some suggestions for improvement:

  'Building thermal properties' or 'Building Envelope' and/or 'Performance' 'efficiency' or 'building envelope performance'.
- In addition, it was suggested to distinguish between renovation rate and depth (level of ambition of a single retrofit). The combination makes it appear as a black box.
- The stakeholders were interested in our validation process for the energy demand calculation. How does the model validate the predictions of the calculations? The calculations should be made available in order to check if they are correct.

- ➢ Answer: As in the global calculator the description of the lever building insulation will be a mix of renovation rate and renovation depth. Nevertheless, we will consider a separation with respect to the total number of levers allowed and the benefit of a separation.

Lever 3: Indoor temperature and hot water demand

- It is difficult to understand what this lever tries to measure.
- Comfort is not well described, and there is a missing driver (could cover driver #3).
- Comfort should not be defined based solely based on indoor temperature. The indoor temperature by itself is the wrong parameter to examine levels.
- The levels of comfort need to be reconsidered. There are strange extremes in level 4.
- The question was raised if the EUCalc also projects energy consumption decrease?

Lever 4: Material use & lifetime of construction and heating, cooling and ventilation systems

- The description overall is ok but should be expanded beyond building materials.
- Some ideas for expanding this lever would be to include: 'reuse', 'circularity', 'life cycle assessment'.

Lever 5: Heating and cooling (ventilation) system efficiency

- Why is it 'more efficient' to use electricity vs gas? This should be explained.
- Stress the efficiency, but say also what is included. Is it technology improvement or update?
- Certain fuel choices can be removed (e.g. soil fuel…)
- A percentage of how it is related to efficiency should be introduced.
- The following points/questions can be considered to improve this lever:
  - How to measure control system (BACs)?
  - How to forecast cooling increase?
  - Regional CDD (Cooling Degree Days)
  - Relation to envelope –NZEBs, PASSIVHAUS
  - Need to measure SYSTEM LEVEL
  - Role of district H/C system depends on its efficiency

Lever 8: Appliances, cooking, lighting

- This lever is about the number of appliances, but it could also cover average hours of operation.
- Appliance & lighting efficiency use reductions are less easy to assess than the share of insulated floor space and its increase over time
- Levers 8 and 9 (Appliance, cooking & lighting behaviour and use) could be merged.

Further general discussion took place and will feed into the definition of levers:

Switch in the Lifestyle towards services

People are moving from owning equipment and performing actions themselves to buying the service. How many people eat out for at least one meal a day. How many use laundry services? Do all apartments need kitchens in the future? Will this reduce the amount of floor space, appliances, and energy needed in the households?
A question beyond the levers is: How will the outsourcing of such emissions be accounted for?

Switch in the Lifestyle towards sharing society

People are currently sharing bikes, cars, and apartments in all European countries. In Sweden people of one building share a pool of washing machines. These washing machines are used more often and thus they will be fully used up in a shorter time, thus have a shorter lifetime and get replaced sooner by a hopefully more efficient technology. The sharing behaviour thus has an impact on the number of appliances bought, they are being used more efficiently, but replaced earlier and thus on average might be more efficient.

Role of efficiency in buildings for grid optimization

Do we consider the role of buildings and their efficiency for grid optimization? The amount and timing of the exchange of electricity between the building and the grid will affect the optimization of the grid. Buildings consume electricity, produce electricity and can potentially shift electricity loads to fulfil a storage function (Demand side management). For the future, this role of buildings will be increasingly important, as the electricity sector is largely changing, and fluctuating renewables need to be integrated.

Further Questions

- Interaction/relation between levers need to be laid out transparently – the documentation of the levers will include the approach taken to integrate interaction between the levers.
- Do we assume unlimited recycling? In reality, for buildings a large share of the used material may not be recyclable. – Will be discussed further at the industry workshop.
- Is the energy used for construction included? – we will look into the relevance of this energy share.
- The lifetime of the measures may change – the advanced retrofit options will have a longer lifetime.

6.2 Levels

Conditions and implications of choosing an ambition level

It is not easy to decide on the definition of the ambition level or later for the user if the conditions and implications are unknown. This leads to a certain black-box charm: what do the choices imply? What infrastructure is needed as a condition for choosing a certain lever level? Can we link the lever levels to EPC's[3] or eco-design standards? What implication does the choice of a certain ambition level have on

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[3] EPC – Energy Performance Certificate for buildings

- Cost;
- the conditions?

Summarizing quite a few of these questions, it is not easy to understand the trade-offs of choosing the different ambition levels.

- ➢ How we take this point into account: This remark may be quite essential for the attractiveness and the future use of the EU Calculator and will therefore be highlighted in the discussion about the general design.

A specific request was to describe costs, policy decisions and incentives.

- ➢ How we take this point into account: The European calculator will provide cost, however the effect of moving the levers can be achieved with several policies in the different national frameworks.

Another important condition is the owner structure which affects the decision-making process for selecting energy efficiency measures in buildings. For example, the incentives that lead to the investment depend on the owner of the building. For rented buildings a split incentive would facilitate the decision-making process of both acting parties involved: the owner and the user.

Two more abstract question were raised with respect to levers. Firstly, as we are combining some levers for scenario building, we were asked if we supporting multi-variable decision making? And secondly, we were asked to make clear what the baseline is.

- ➢ How we take this point into account: These questions will be taken into the general design and documentation discussions for the EUCalc team.

Consideration of hybrid and passive technologies

We were asked if we consider: Solid fuel fired heat pumps, Gas fired heat pumps, Waste fired heat pumps, Passive solar cooling and heating.

How do we handle implicit regulation, meaning that the initiative of some countries policies to ban conventional fuels by 20XX will affect the fuel and technology choices and the pressure to find renewable solutions and be able to spread them?

It was suggested to consider

- adding a lever to go passive;
- ventilation and renewable energies need to be considered;
- the integration of different possibilities for thermal comfort ;
- windows / shading

Balancing sufficiency measures and comfort and health benefits

When we talked about the indoor temperature range, arguments came up that with a too low indoor temperature in winter the comfort and health benefits would not only decrease but problems would appear. Hence, there is a limit to sufficiency measures in that respect and we need to research and stick to the recommended temperature range.

Below further items raised by the stakeholders on the 4 levels of ambition:

- For some of the levers the specialists had no way of judging if the numbers are suitable;
- On the indoor temperature lever, level 4 of 17ºC, is not realistic;
- There should be a link between the efficiency of systems & the efficiency of the building/component;
- On district heating, where does heat come from and why 50% in level 2;
- There should be a link with political instruments such as incentives (quality/timing) and building passports;
- What is the baseline/ scale (building or national stock or EU)? (Also in level 9) for the heat loss (or gain) reduction;
- It is not clear if level 1 is referring to the current situation or to 2050;
- The percentages are quite specific for the ambition levels;
- In the ambition levels, more details are needed (e.g. add projected costs or some example scenarios on different scale/references);
- Implications should be explicitly made;
- Predictions for level 4 would be welcomed;
- Take into account current directives and make references;
- The compression approach is better for the lever 2 because demand in every country varies;
- With the 2015 baseline, level 4 ambitions are unachievable;
- The 76% on thermal performance of buildings is not realistic;
- Steel to wood transition depends on steel use and is ranging between member states and building types;
- On the question related to the share of population addressed by the energy and money saving opportunities, this depends on cultural and behavioural changes as well as economic incentives and constraints. There should be an awareness raising (marketing) to increase the social acceptance. Also, there is the question on how behavioural changes should be calculated;
- Different level of detail is required in the different levers and levels;
- If all energy comes from renewable energy, then levels do not have any impact on GHG for temperature/ water demand lever;
- Do we consider all factors for comfort? Measuring the energy demand more in detail would help to understand it.
- On the foreseen trends of energy efficiency for lighting and appliances, the building design with natural lighting and ventilation is ignored;
- The levels for heat pump depend on the starting point;
- In the convergence approach there should be a link to efficiency systems, while in the compression approach there should be a link to heating demand;
- The convergence approach is better for the lever of lighting and appliances, however, overall, the compression approach is the preferable one. It will be politically easier to be disseminated, as the countries have different economic and climate conditions and a convergence to the same value may be too ambitious for all of them to achieve.

7 Contribution from invited speakers

Alex Bierer, Policy Officer at DG Energy unit for Energy Efficiency gave the perspective of the European Commission on the decarbonisation of the European building stock. He emphasised the need to accelerate the renovation rate of buildings and facilitate and promote the renovation of the private sector as well. Member States should strengthen aggregators on the demand side to face less restrictions and get encouraged to put effort on the renovation of buildings. He further highlighted that the EU building legislative framework supports a holistic approach towards energy efficiency.

Céline Carré, President of the European Alliance of companies for energy efficiency in buildings (EuroACE) and member of the European Alliance to save energy (EU-ASE), gave the industry perspective on the decarbonisation of the European Building stock. Some of the major highlights of her presentation are summarised below:

- The reduction for buildings is 88% to 91% (37% -53% around2030) means an essential role for energy efficiency and renewables;
- Energy demand in buildings could increase globally by 50% in 2050. But the sector offers the largest cost-effective GHG mitigation;
- Industry CAN deliver, technically speaking. Whether it WILL deliver depends on how quickly it can scale-up. Investment today depends on the visibility to 2030/2050;
- Long term-planning is key for transforming the sector. Also: It takes time to work differently!;
- Some start early, but many more are catching up. Roadmaps need good data and good scenarios (modelling);
- Besides climate and energy, major trends will transform the building sector. Modelling the decarbonisation requires to take a close look at them;
- Modelling is important for describing the present situation and realistically representation of the drivers for change. It helps to reduce the assumptions about the unknown future. Making choices leads to simplifying e.g. ignoring/magnifying trends;
- Can we still assume that 'frontrunners' renovate their homes with a view to restrain comfort, simply encouraged by their climate conviction?

Her main conclusions were that modelling can best support decision making by good data, transparent assumptions, revisiting assumptions (e.g. discount rates), capturing trends (e.g. multiple benefits), envisaging complexity, recognising changes and impact of policy, ensuring consistency between modelling assumptions, societal & economic reality. Also, modelling should not ignore trends, including those pushed by policy and openness in early stage is an essential success factor for designing policy.

Other points raised after the presentations from the keynote speakers included the following:

- It would be interesting to cross-check if results from modelling in the past were correct, however this would be a complex procedure;

- The connection to jobs would be good to include as well, also to make arguments on the importance of measures; if they create jobs, then they will be more accepted;
- The sector contribution to the Paris goals are of importance;
- We should consider the way of integrating emerging trends to help the big stories.

8 Conclusions

In the workshop we inspired a vivid discussion. We have the impression that the participants were successfully introduced into the complexity of the model as well as the detail and the multitude of the data. Although the expectation to get an improvement on single data was to high, we did receive feedback that will help us to scope and define the lever in a more suitable and comprehensible way. In addition, we received some feedback on the general design for the EUCalculator that will help us to make its appearance more useful to the user group.

We will take the feedback and the impulses we received into internal discussion and design processes and evaluate their feasibility for implementation.

9 Appendix

9.1 Workshop Agenda

Scenarios for Decarbonising European Buildings

Date: Monday, June 4th, 2018, from 12:00pm to 17:00pm

Venue : CEN-CENELEC Meeting Centre, Rue De La Science 23, 1040, Brussels, Belgium

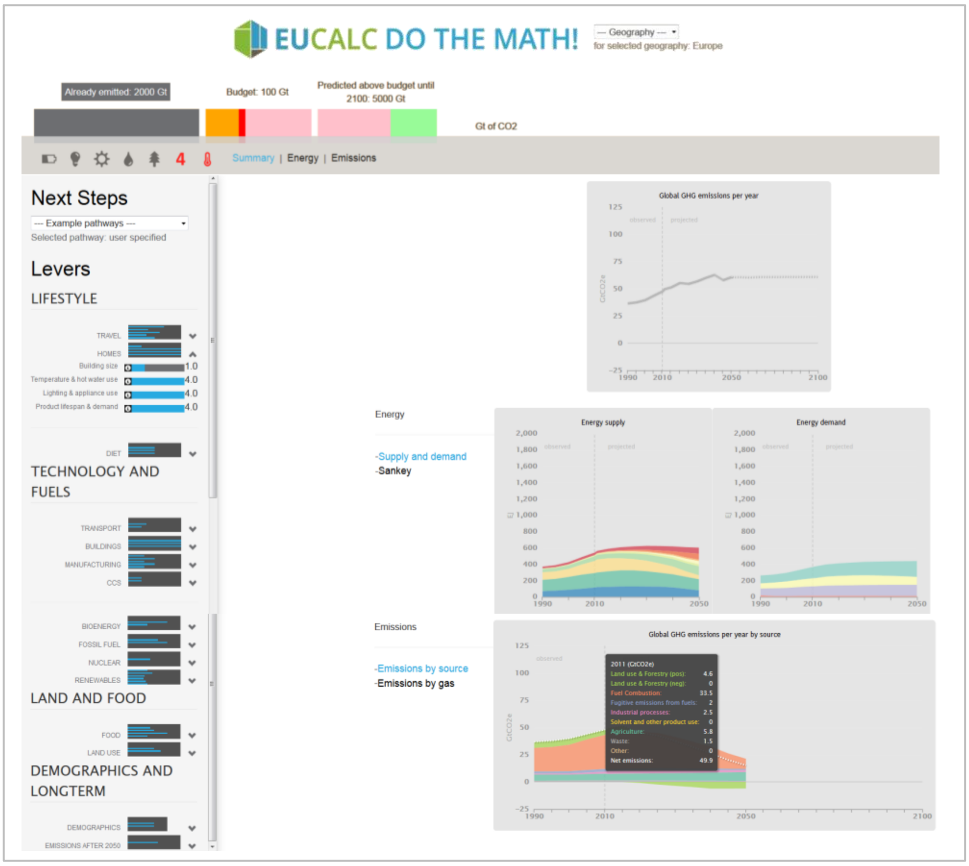
Time	Activity
12:00-12:45	***Lunch*** *(CEN-CENELEC cafeteria, ground floor)*
12:45-13:00	***Registration*** *(in front of Tesla rooms)*
13:00-13:20	***Opening & Welcome*** **Oliver Rapf** Executive Director BPIE, **Jonathan Buhl** Facilitator 4sing
13:20-13:35	***Presentation of the EUCalc project*** **Judit Kockat** Project Manager BPIE
13:35-13:50	***Scenarios for Decarbonising European Buildings: The Commission's perspective*** **Keynote speaker: Axel Bierer** Policy Officer, DG Energy unit for Energy Efficiency
13:50-14:05	***Scenarios for Decarbonising European Buildings: Industry perspective*** **Keynote speaker: Céline Carré** President of the European Alliance of companies for energy efficiency in buildings (EuroACE), member of EU-ASE
14:05-14:20	***Q & A***
14:20-14:50	***Introduction of the Building module of EUCalc*** **Judit Kockat** Project Manager BPIE
14:50-15:10	***Coffee break***
15:10-16:45	***Interactive dialogue*** **Jonathan Buhl** Facilitator 4sing
16:45-17:00	***Summary and Conclusions***

9.2 Participants list

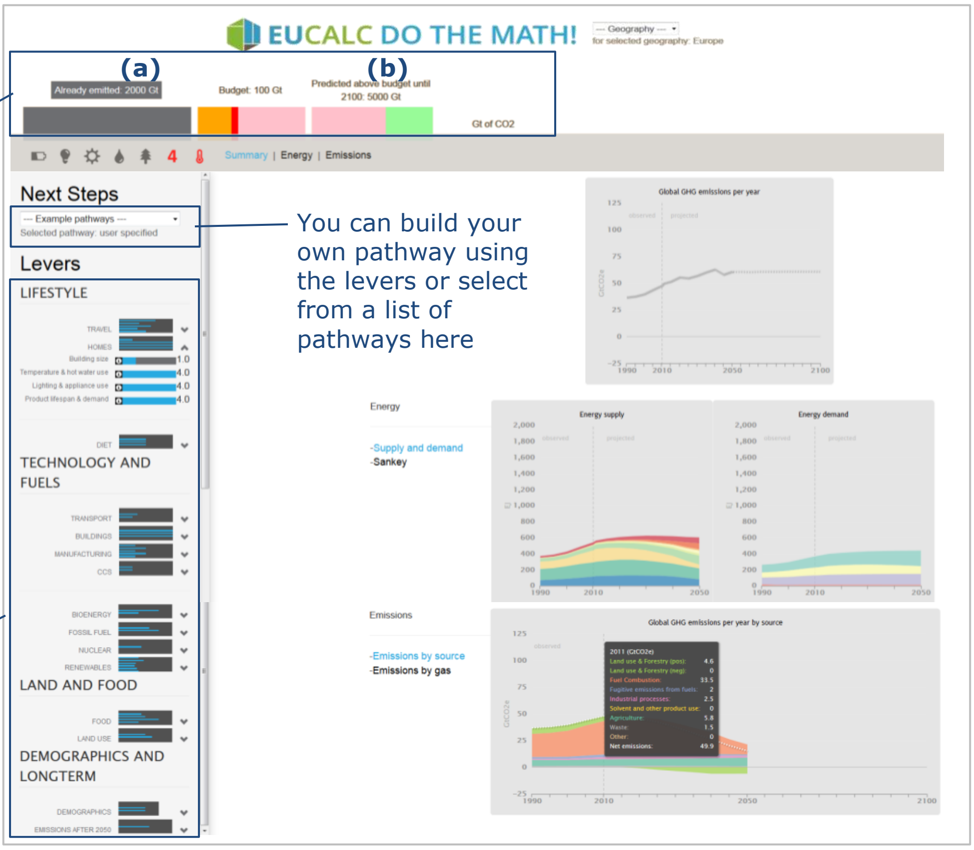
First Name	Last Name	Organization
Jonna	Byskata	UTC
Thaleia	Konstantinou	Tu Delft
Miklós	Gyalai-Korpos	PPIS
Kjell	Bettgenhaeuser	Ecofys
Paul	Drummond	UCL
Adam	Pinney	EBC-Construction
Roland	Ullmann	Siemens
Niki	Gaitani	NTNU
Merita	Govori	EEAS
Sibylle	Braungardt	Öko-Institut
Panagiotis	Sarellas	Temes
Helge	Schramm	Danfoss
Katharina	Bouchaar	ESC Sustainability
Bohdan	Kadlec	Praha EU
Katja	Firus	T-6 Ecosystems
Ulrike	Lunacek	European Parliament
Jonathan	Buhl	4sing
Axel	Bierer	European Commission
Celine	Carre	Euroace
Irena	Gabrielaitiene	European Commission
Chiara	Spinelli	Saint-Gobain
ARB	Govori	NGA
Oliver	Rapf	BPIE
Judit	Kockat	BPIE
Vivian	Dorizas	BPIE

9.3 How will the European Calculator work

Interactive web interface



Graphs show you cumulated GHG-emissions
(a) for the past,
(b) for the projection
period until 2050
(c) for the effect

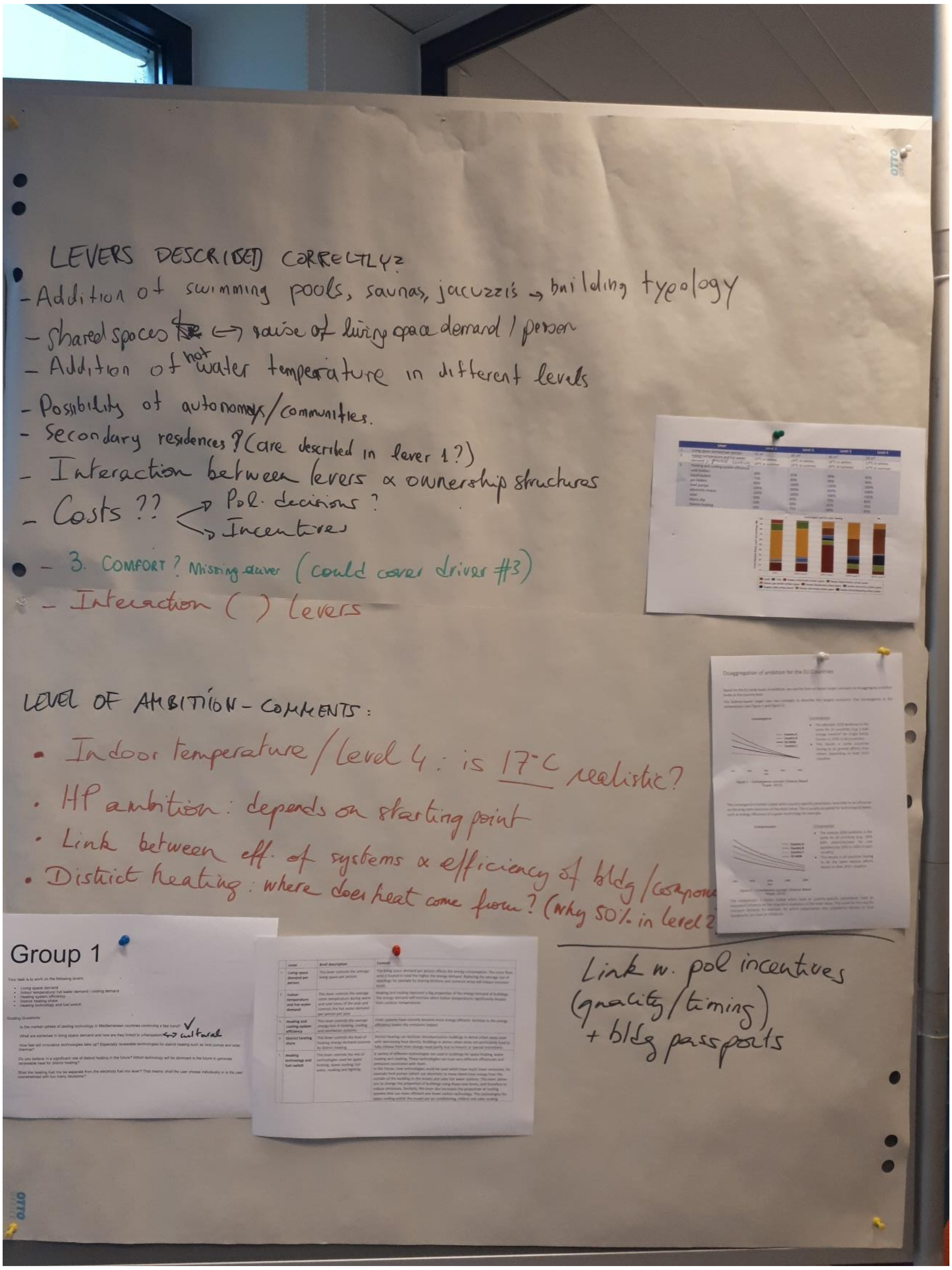


You can build your own pathway using the levers or select from a list of pathways here

15 areas with more than 30 levers to let you vary the way we live in the future.

9.4 Pictures from the notes of the working groups

Group 1:



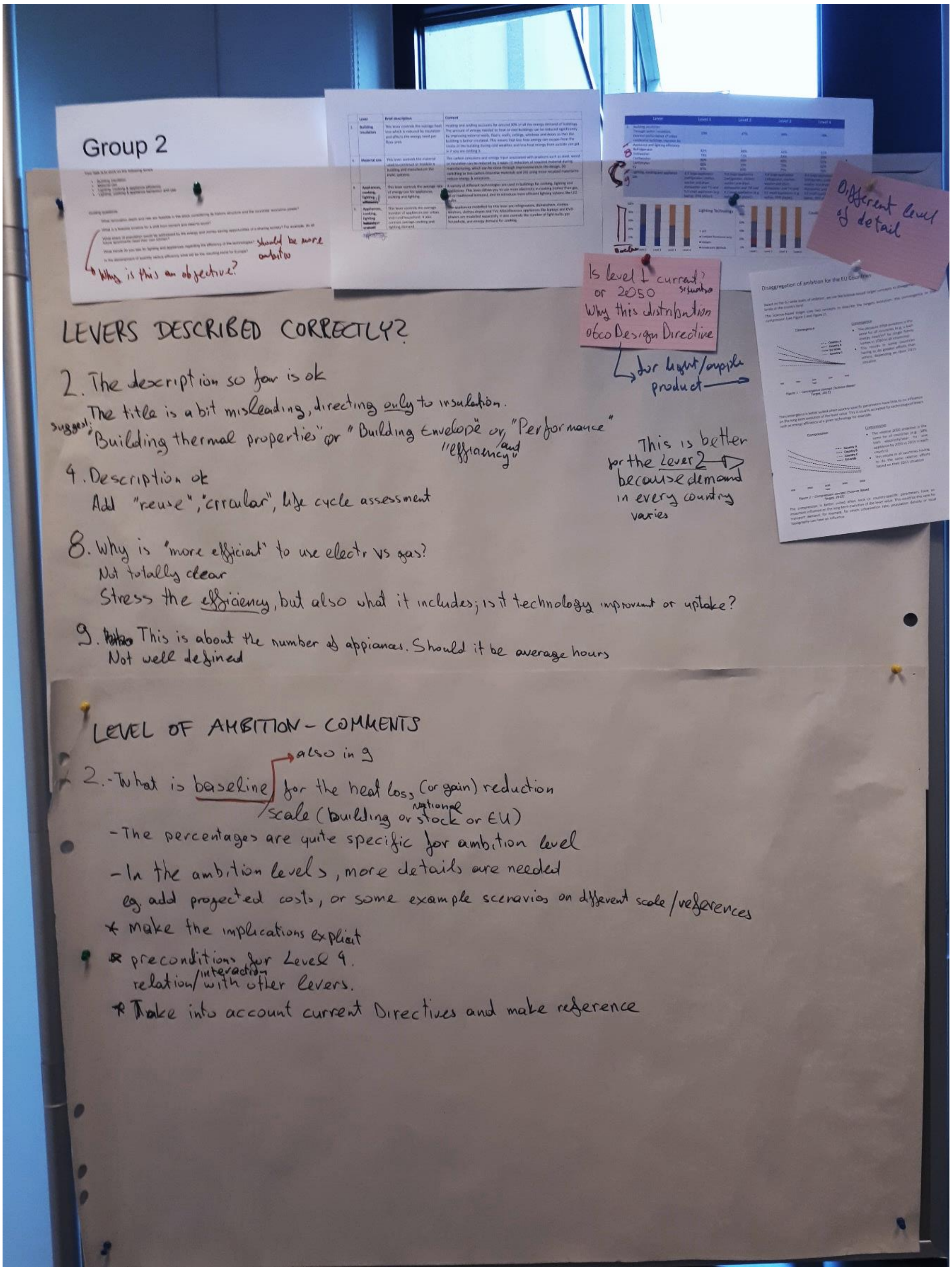
LEVERS DESCRIBED CORRECTLY?
- Addition of swimming pools, saunas, jacuzzi's → building typology
- shared spaces ~~[illegible]~~ ↔ raise of living space demand / person
- Addition of hot water temperature in different levels
- Possibility of autonomy/communities.
- Secondary residences? (are described in lever 1?)
- Interaction between levers & ownership structures
- Costs ?? → Pol. decisions ? → Incentives
- 3. COMFORT ? Missing driver (could cover driver #3)
- Interaction ( ) levers

LEVEL OF AMBITION – COMMENTS:
- Indoor temperature / Level 4: is 17°C realistic?
- HP ambition: depends on starting point
- Link between eff. of systems & efficiency of bldg / compon
- District heating: where does heat come from? (why 50% in level 2

Link w. pol incentives (quality / timing) + bldg passports

Group 1

Group2:



Group 2

should be more ambitio

Why is this an objective?

Different level of detail

Is level 1 current situation or 2050

Why this distribution

Eco Design Directive

for light/apple product

LEVERS DESCRIBED CORRECTLY?

2. The description so far is ok
The title is a bit misleading, directing only to insulation.
suggest: "Building thermal properties" or "Building Envelope" or "Performance and "efficiency""

This is better for the Lever 2 because demand in every country varies

4. Description ok
Add "reuse", "circular", life cycle assessment

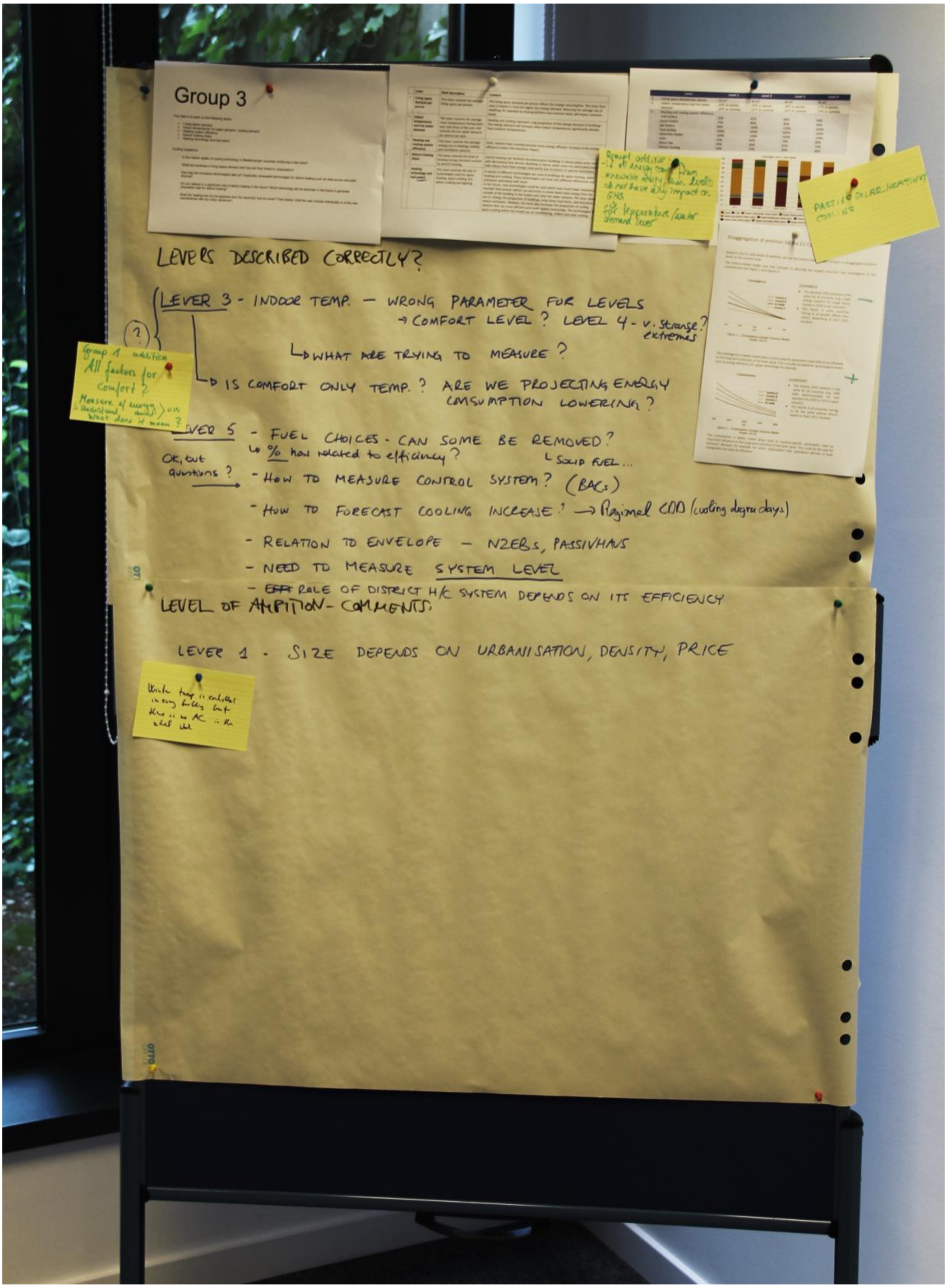
8. Why is "more efficient" to use electr vs gas?
Not totally clear
Stress the efficiency, but also what it includes; is it technology improvement or uptake?

9. This is about the number of appiances. Should it be average hours
Not well defined

LEVEL OF AMBITION - COMMENTS

2. - What is baseline for the heat loss (or gain) reduction
also in 9
scale (building or national stock or EU)
- The percentages are quite specific for ambition level
- In the ambition levels, more details are needed
eg. add projected costs, or some example scenarios on different scale/references
* make the implications explicit
* preconditions for Level 4.
relation/interaction with other levers.
* Take into account current Directives and make reference

Group 3:



Group 3

Group 1 addition
- is all energy come from renewable energy, then levels do not have any impact on GHG
for temperature / water demand lever

PASSIVE SOLAR HEATING
COOLING

LEVERS DESCRIBED CORRECTLY?

LEVER 3 - INDOOR TEMP. — WRONG PARAMETER FOR LEVELS
→ COMFORT LEVEL? LEVEL 4 - v. strange? extremes

↳ WHAT ARE TRYING TO MEASURE?

↳ IS COMFORT ONLY TEMP.? ARE WE PROJECTING ENERGY CONSUMPTION LOWERING?

Group 1 addition
All factors for comfort?
Measure of energy & Understand demand > use
What does it mean?

LEVER 5 - FUEL CHOICES - CAN SOME BE REMOVED?
↳ % how related to efficiency? ∟ SOLID FUEL...

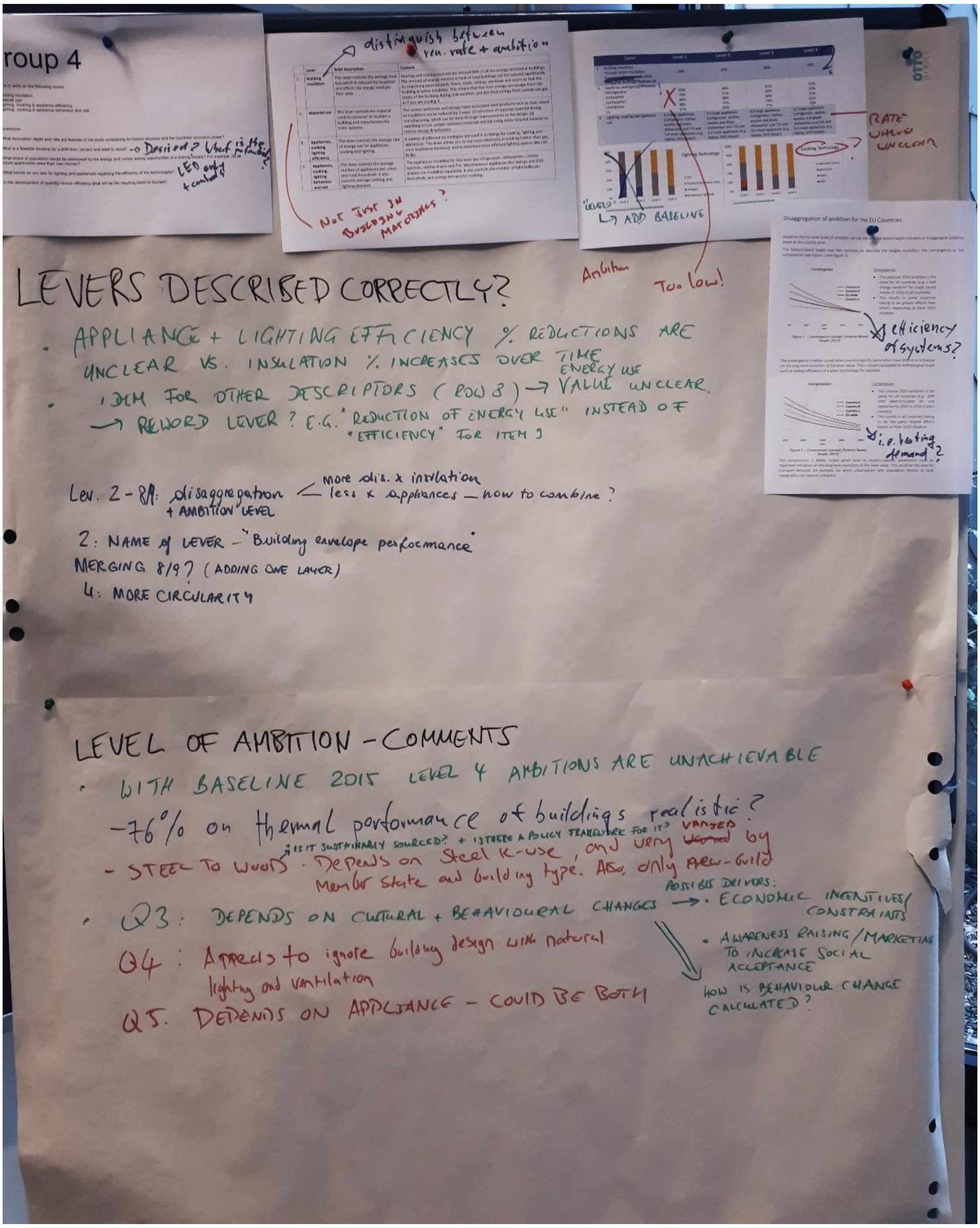
Ok, but questions? →

- HOW TO MEASURE CONTROL SYSTEM? (BACs)
- HOW TO FORECAST COOLING INCREASE? → Regional CDD (cooling degree days)
- RELATION TO ENVELOPE — N2EBs, PASSIVHAUS
- NEED TO MEASURE SYSTEM LEVEL
- ~~EFF~~ ROLE OF DISTRICT H/C SYSTEM DEPENDS ON ITS EFFICIENCY

LEVEL OF AMBITION - COMMENTS:

LEVER 1 - SIZE DEPENDS ON URBANISATION, DENSITY, PRICE

Group 4:



LEVERS DESCRIBED CORRECTLY?

- APPLIANCE + LIGHTING EFFICIENCY % REDUCTIONS ARE UNCLEAR VS. INSULATION % INCREASES OVER TIME
- IDEM FOR OTHER DESCRIPTORS (ROW 8) → ENERGY USE VALUE UNCLEAR. → REWORD LEVER? E.G. "REDUCTION OF ENERGY USE" INSTEAD OF "EFFICIENCY" FOR ITEM 9

Lev. 2-8A: disaggregation + AMBITION LEVEL < more dis. x insulation / less x appliances — how to combine?

2: NAME of LEVER – "Building envelope performance"

MERGING 8/9? (ADDING ONE LAYER)

4: MORE CIRCULARITY

LEVEL OF AMBITION - COMMENTS

- WITH BASELINE 2015 LEVEL 4 AMBITIONS ARE UNACHIEVABLE

-76% on thermal performance of buildings realistic?

- STEEL TO WOOD (IS IT SUSTAINABLY SOURCED? + IS THERE A POLICY FRAMEWORK FOR IT?) - Depends on Steel K-use, and very ~~varied~~ VARIED by Member State and building type. Also, only new-build

- Q3: DEPENDS ON CULTURAL + BEHAVIOURAL CHANGES → POSSIBLE DRIVERS:
  - ECONOMIC INCENTIVES/CONSTRAINTS
  - AWARENESS RAISING/MARKETING TO INCREASE SOCIAL ACCEPTANCE

HOW IS BEHAVIOUR CHANGE CALCULATED?

Q4: Appears to ignore building design with natural lighting and ventilation

Q5. DEPENDS ON APPLIANCE - COULD BE BOTH

9.5 Information Sheet

In advance of attending the workshop we would like to outline our joint understanding of how the workshop will be conducted and how information from it will be used. We take these issues seriously so please take time to read and understand the following. Please let us know in case of any concern. We will ask you to sign a copy of the consent form (overleaf) at the workshop.

I consent to be participant in the Expert Consultation Workshop on Scenarios for Decarbonising European Buildings, to co-design a novel climate, energy and resources model under the framework of the EUCalc project, in Brussels, on June 4th, 2018 based on the principles outlined below.

During this workshop, a group of app. 25 frontline experts from public, private, civil society sectors and academia, will come together to share their perspectives and discuss main social impacts and indicators of climate change mitigation in Europe. The workshop programme (attached) is designed to stimulate interactive knowledge exchange and we welcome your active participation and contribution to this group effort.

The EUCalc project team assures you that we will only record information that is necessary to address the central purpose of our research. While your name and organisation will be acknowledged on the list of participants, your inputs and contribution will not be attributed and will only appear in de-identified form in the publications/reports arising from this research. Anonymity of your input will at all times be safeguarded, except where you have consented or specified otherwise. This principle will be applied effectively on social media sites such as Twitter. Pictures taken at the workshop may be used inside project reports and could be used for the project website (http://www.european-calculator.eu/) and project presentations.

I understand that if at any time during the Workshop I feel unable or unwilling to continue, I am free to leave without negative consequences. That is, my participation in this Workshop is completely voluntary, and I may withdraw from this project at any time.

Co-design is one of the central components of the EUCalc project and we thank you for your willingness to participate. As a benefit of participating we would like to highlight an opportunity to be involved in a significant piece of research, to make connections with other prominent experts and to shape the EUCalc. The EUCalc team is also committed to the continued collaboration and exchange with workshop participants including opportunities for subsequent feedback and access to early releases of the EUCalc. On the other hand, collected information will be stored internally and managed by the EUCalc partners under strict rules defined to safeguard anonymity of your inputs and alleviate any potential participation burdens such as harm for misuse of your identifiable information.

I have been informed that if I have any questions seeking further clarification or assurances about the ethical issues relating to the project, I am free to contact Judit Kockat: judit.kockat@bpie.eu **or Paraskevi Vivian Dorizas:** vivian.dorizas@bpie.eu

9.6 Informed Consent Form

EU CALC - Pathways for a sustainable Europe
Expert workshop on Buildings
Date: June 4th 2018
Venue: CEN-CENELEC Meeting Centre, Rue De La Science 23, 1040, Brussels, Belgium

I ……………………………………………………………………………………… agree to participate in Expert workshop on Buildings.

The purpose of the Workshop has been explained to me in writing.

I am participating voluntarily and understand that I can withdraw from the research project, without repercussions, at any time, before it starts or while I am participating.

I am satisfied that the assurances of responsible and strict data governance, given by the *European Calculator projec*t, will be upheld.

I understand that my name and organisational affiliation will appear as a workshop participant but that anonymity of participants' contributions will be ensured at each research stage in the project, unless otherwise agreed.

I agree that pictures taken at the workshop may be used inside project reports and could be used for the project website (http://www.european-calculator.eu/) and project presentations.

A copy of the information sheet and (this) signed consent form will be given to the signee.

Signed……………………………………………………………………………………….

Date……………………………………………………………………………………….

Note: The consortium would like to assure you that any personal data or information you provide will be kept strictly confidential and will be securely stored and retained for the lifetime of the project and deleted thereafter. In gathering our data, we will only record information that is necessary to address the central purpose of our research, and ensure contributions are not attributed to any specific participant. Furthermore, should you agree to participate in this workshop, and subsequently feel unable or unwilling to continue, you are free to leave without negative consequences. That is, your participation is completely voluntary, and you may withdraw from this project at any time.

9.7 Letter to the stakeholders

Expert Consultation Workshop on Scenarios for Decarbonising European Buildings

Monday, June 4th, 2018, from 12:00pm to 17:00pm

CEN-CENELEC Meeting Centre, Rue De La Science 23, 1040, Brussels, Belgium

Pre-read document for the workshop

Dear **Participant**,

The team of the European Calculator (EUCalc) project by developing a new state-of-the-art model, with origins in the modelling philosophy of the Global Calculator, will create an online tool for analysing trade-offs and pathways towards a sustainable and low-carbon European future. With this tool, EUCalc aims to provide decision makers with an accessible energy modelling solution to quantify the sectorial energy demand, greenhouse gas (GHG) emissions trajectories and social implications of lifestyles and energy technology choices in Europe.

This workshop is devoted to the Buildings' module of the European Calculator and will investigate the corresponding levels of ambition and effort that reflect the full range of what experts believe could be possible by 2050.

In this document you will find important information including: ***the agenda, the structure of the European Calculator, the building's module, the major discussion points and the informed consent form (!) -complemented with logistics information.***

We look forward to welcoming you in Brussels and having a fruitful debate. Your presence on the expert workshop will provide us with valuable contribution on scenarios for decarbonising European Buildings.

Judit Kockat, Project Manager BPIE
Paraskevi Vivian Dorizas, Project Manager BPI