MEASURING PRODUCTIVITY IMPACT-MULTIPLE IMPACT PERSPECTIVE

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01.06.2017

eceee Summer Study-2017, Presqu'île de Giens, France

STUDY OUTLINE

- Background and introduction
- Building sector energy efficiency measure-HVAC system with proper building envelope
- Productivity indicators from building sector energy efficiency measure
- Quantification challenges

MULTIPLE IMPACTS

- Many studies have shown that energy efficiency policies can yield a wider set of additional benefits for the economy and society apart from energy saving and CO2 reduction.
- Additional effects could be job creation, GDP growth, enhanced productivity, increase of energy security, positive impacts on health, as well as improvement of ecosystems.
- MI captures all positive and negative additional effects of EE measure.
- Co-benefits implies there is a main benefit but additional effects may be bigger than 'main' benefit.

WHY MIS ARE IGNORED

- Most of the sustainable energy policy related decision is taken based on only considering energy savings and its implementation cost and completely ignoring multiple impacts.
- Many of these benefits are non-marketable, indirect and which makes quantification process more difficult.
- Many of the impacts overlaps with each other.
- Lack of mature methodology to quantify these additional impacts.
- Double counting.

OBJECTIVES

- Provide a consistent methodological framework to quantify multiple impacts of energy efficiency.

1) Identify the links between productivity impact and energy efficiency measures.
2) Clearly define productivity impact in the context of multiple impacts of improved energy efficiency measures such as HVAC system with proper building envelopes.
3) Calculate different indicators of productivity impact accordingly.

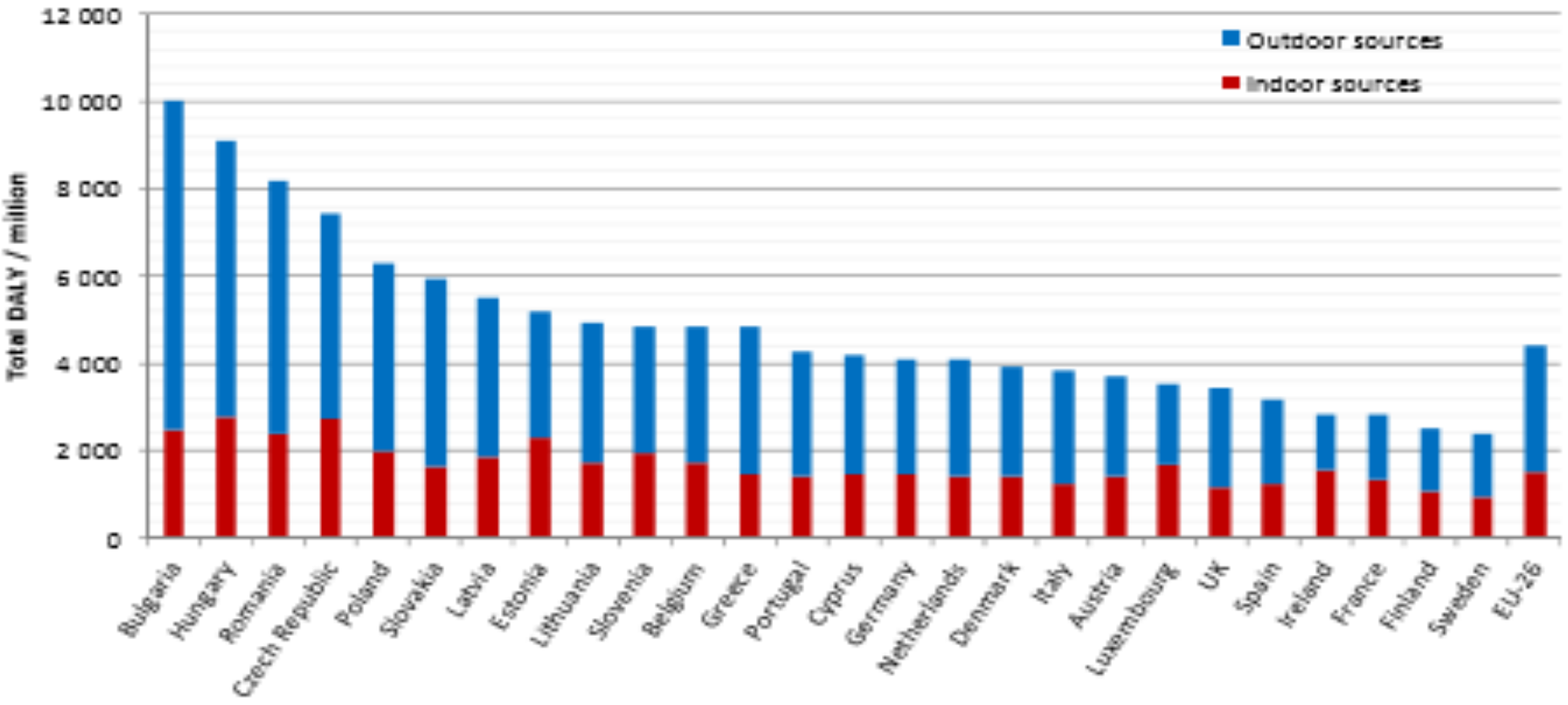
PRODUCTIVITY IMPACT

- Two key types of productivity are single factor productivity (ratio between output and a single input) and multi-factor productivity (ratio between output and more than one inputs).

- Labour productivity can be measured as the ratio between outputs produced within an economy in a year and total numbers of hours worked by the employees (OECD 2008).

- Health is the input factor of productivity which implies improvement in health condition also improves productivity.

TOTAL BURDEN OF DISEASE AS DALY/MILLION POPULATION FROM INDOOR EXPOSURES IN EUROPEAN COUNTRIES



Source: Hänninen & Asikainen 2013

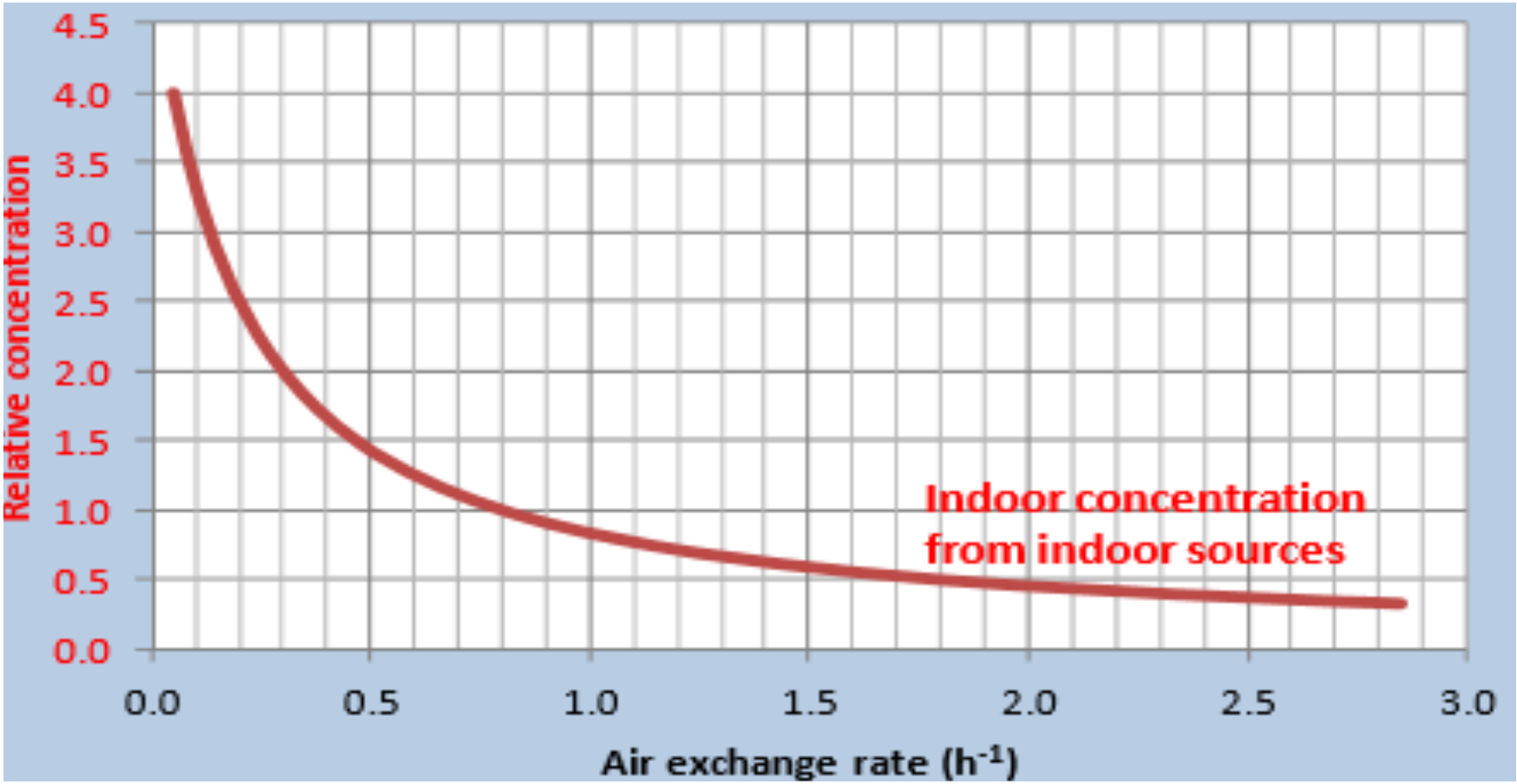
BUILDING SECTOR EE MEASURE-HVAC SYSTEM WITH PROPER BUILDING ENVELOPE

- WHO 2006 guidelines for indoor air quality identifies three issues which are affecting indoor air quality and human health. These three key issues are

1) Biological indoor air pollutants such as dampness and mould
2) Chemical indoor pollutants such as radon, carbon monoxide etc.
3) Pollutants from indoor combustion of fuels

- Studies show that sufficient mechanical ventilation is one of the key tool in order to remove humidity, carbon dioxide, bioeffluents and other pollutants from indoor air (WHO 2006) (Asikainen, et al. 2016).
- There exists an inverse relationship between indoor air pollutant concentration and rate of ventilation i.e. higher rate of ventilation lowers the corresponding indoor concentration but it never reaches to zero (Atkinson 2013).

RELATION BETWEEN AIR EXCHANGE RATE AND INDOOR AIR POLLUTANT CONCENTRATION



Source: Hänninen & Asikainen 2013

INDOOR AIR POLLUTANTS AND THEIR SOURCES

Pollutants	Source	Affected health aspect
Allergens	Indoor dust, domestic animals, and insects	Respiratory disease, skin and eye irritation
Asbestos	Fire retardant material and insulation	Lung and kidney cancer
Formaldehyde	Particleboard, insulation, furnishings	Cancer, skin and eye irritation
Micro-organisms	People, animals, plants, air conditioning systems	Cancer and heart disease
Pollens	Outdoor air, trees, grass, weeds, plants	Respiratory disease
Radon	Soil, building construction materials (concrete, stone)	Lung cancer
Fungal spores	Soil, plants, foodstuffs, internal surfaces	Respiratory disease

Source: (A. Jones 1999), (W. J. Fisk 2000), (Katsouyanni 2003) (Sundell 2004) (W. J. Fisk 2009) and own adaptation

OUTDOOR AIR POLLUTANTS AND THEIR SOURCES

Pollutants	Source	Affected health aspect
Nitrogen dioxide	Outdoor air, fuel burning, motor vehicles in garages	Respiratory and Cardiovascular disease
Particles	Tobacco smoke, combustion products	Respiratory and cardiovascular disease
Polycyclic aromatic hydrocarbons	Fuel combustion, tobacco smoke	Cancer
Sulphur dioxide	Fuel combustion	Respiratory disease
Ozone	Fuel combustion	Respiratory disease
Carbon monoxide	Fuel combustion	Headache, dizzy feeling which affects productivity

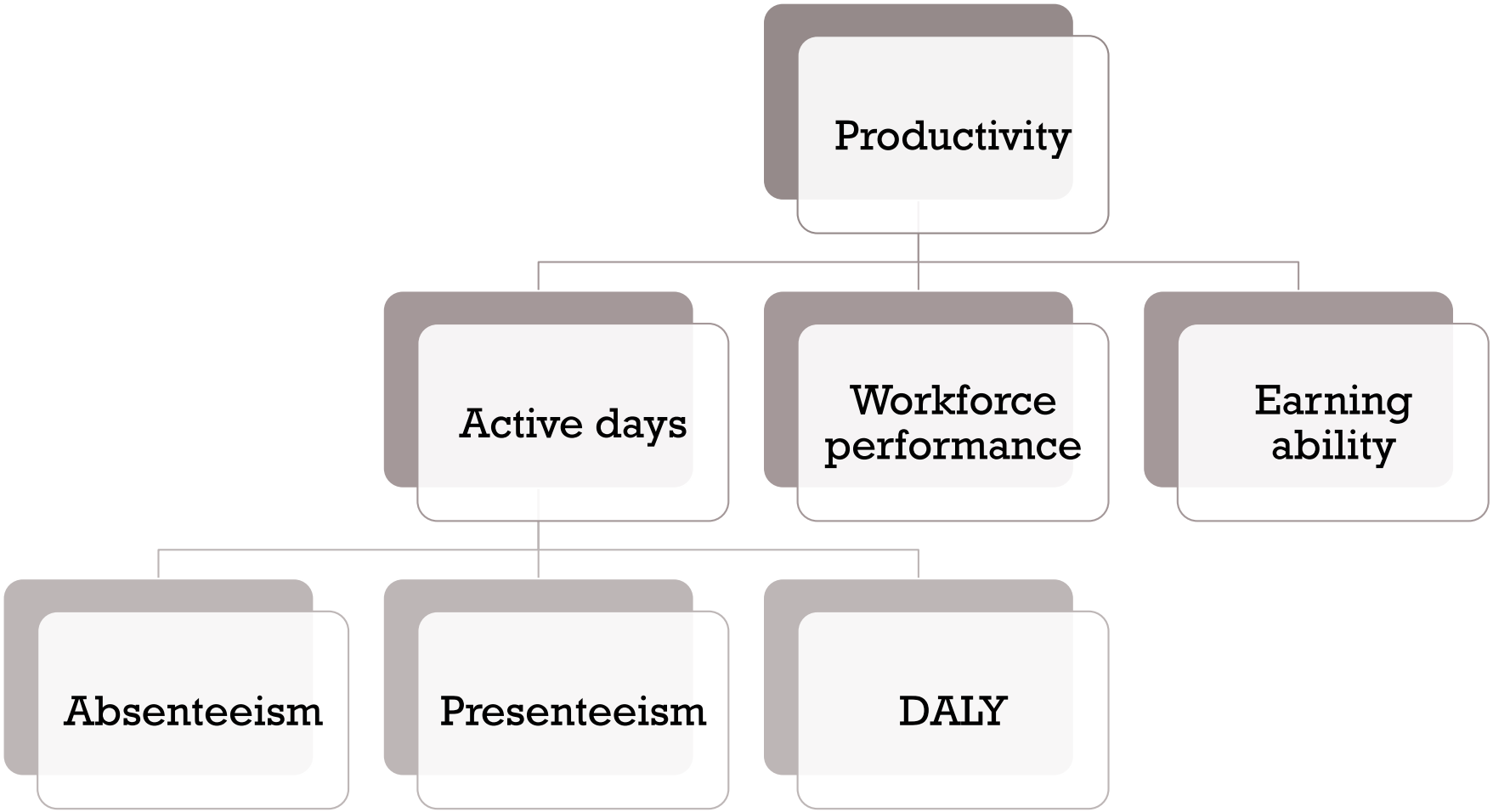
Source: (Schwartz and Morris 1995) (Jones 1999), (R. D. Brook 2004)(EPA 2015), Own elaboration

TYPES OF RETROFITTING AND BUILDINGS

- Non-retrofitted buildings
- Light retrofitted buildings
- Medium retrofitted buildings
- Deep retrofitted buildings
- Passive houses
- Nearly zero energy buildings

Productivity gain is maximum

PRODUCTIVITY INDICATORS



ACTIVE DAYS

- **Absenteeism:** Absent from work due to building related illness.

- **Presenteeism:** Presenteeism can be referred as working with illness or working despite being ill. For example, a person might work slowly than usual with respiratory diseases or make mistakes in work during his illness.

- **DALY:** Disability adjusted life years measure both mortality and morbidity.

WORKFORCE PERFORMANCE

- There are two key reasons behind workforce performance improvement;

1) Improve in indoor air quality actually help in reducing mental stress. For instance, Singh et al 2010 study shows that a worker after shifting into an energy efficient buildings can gain additional 2.02 work hours/per person (Singh, et al. 2010).
2) Thermal comfort helps a person to improve his concentration ability. (Wargocki, et al. 2000)

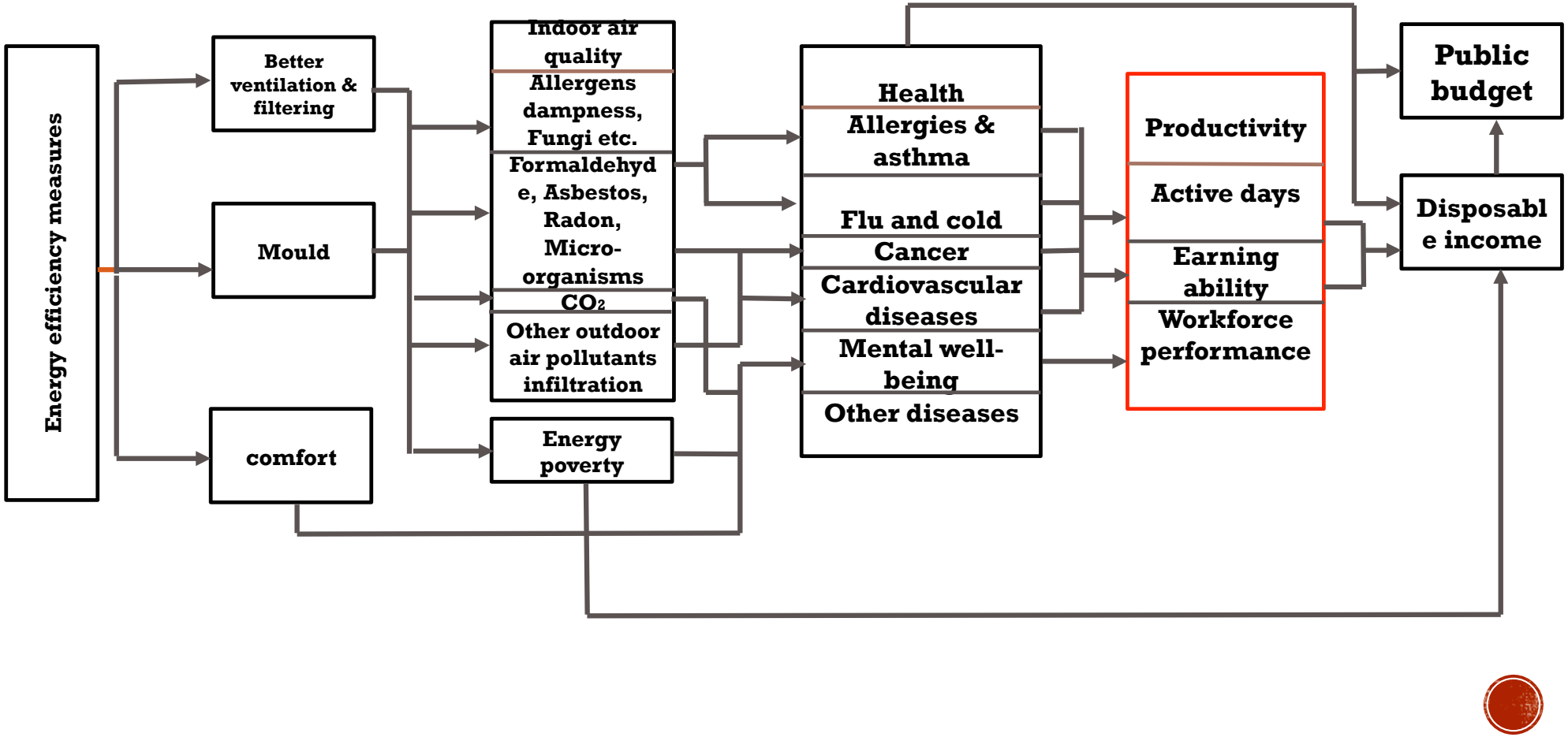
EARNING ABILITY

- Earning ability here refer to as future earning ability loss of a child and parent's present earning opportunity loss.

- This part of productivity mainly concerns with two aspects;

1) Future impact on earning ability due to loss of school days
2) Parents absenteeism and presenteeism due to take care of his sick child.

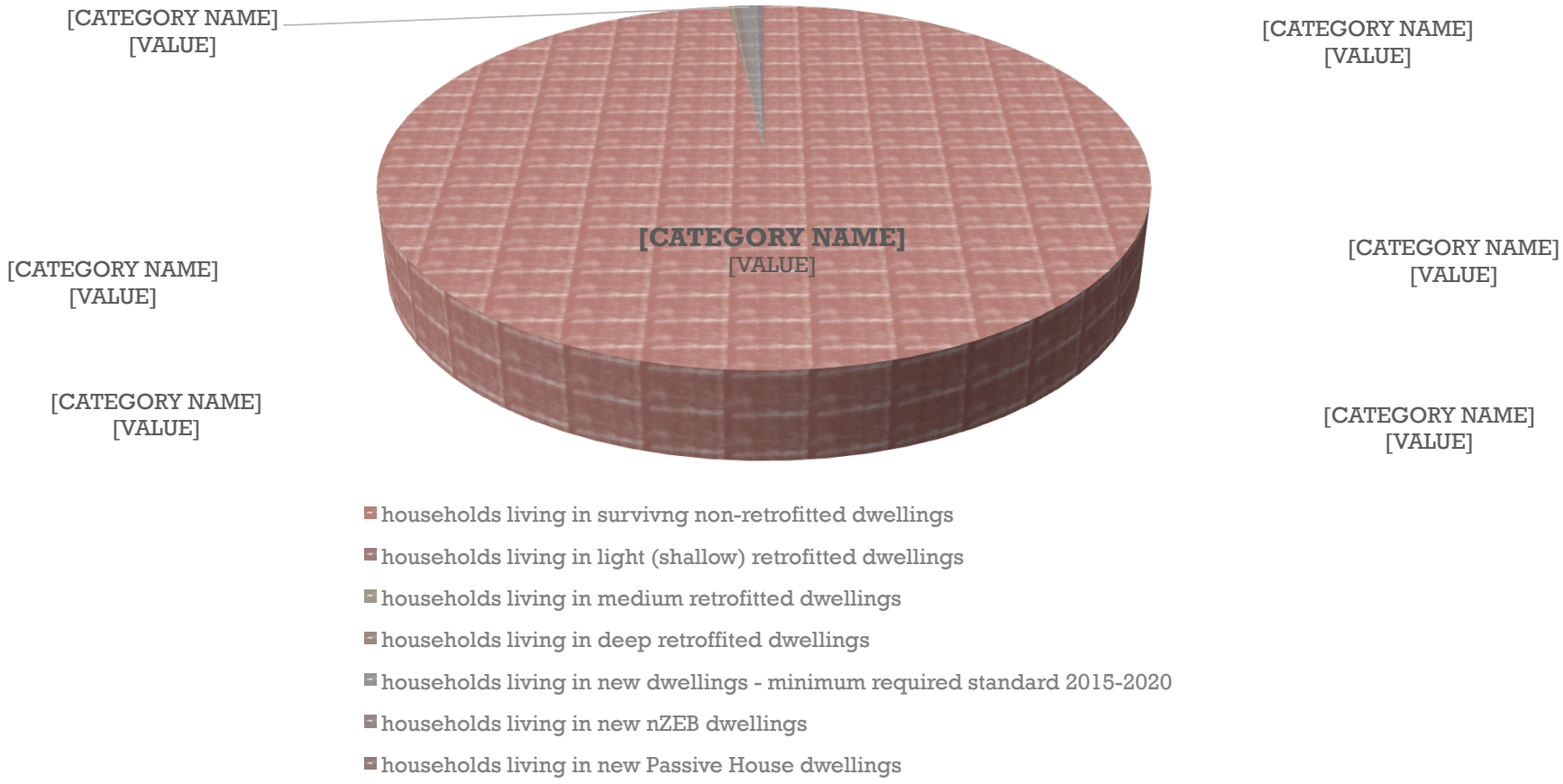
BUILDING SECTOR



PROPOSED MEASURES TO TACKLE ACCOUNTING CHALLENGES

Methodological challenges	Way-outs
Baseline, additionality and context dependency	Incorporate as much as variable possible to accurately quantify the true additional productivity impact. Consider these variables while preparing the multiple impact pathways. Also, consider impact pathways in the baseline as well as in the scenario(s) under assessment.
Distributional impact	It is important to define how productivity impact will change the pre-existing inequality and whether any welfare weight factor will be applied to adjust these factors.
Perspectives	Social perspective will be prioritized for productivity impact
Double counting	Prepare impact pathway map as extensive as possible in order to understand the various interactions among impacts.
Rebound effect	Direct and indirect rebound effect needs to be considered. However, for productivity impact, no significant rebound effect is identified.

BUILDING CONDITIONS IN HUNGARY



Thank you so much!

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DISCUSSION QUESTIONS

1. How to separate health effects from residential and tertiary buildings for an individual?
2. How to present the data?
3. Monetization possible?

ENERGY EFFICIENCY MEASURES

- Energy efficiency measures can be defined as "actions to improve the energy efficiency of existing technologies, or to replace conventional technologies with new, more efficient ones, are called measures" (Couder 2015).
- This study takes two key energy efficiency measures across two different sectors i.e. heating, ventilation, and Air-Conditioning (HVAC) system with proper building envelope and filtration for residential and commercial building sector and modal shift towards active transportation for transport sector.
- Modal shift towards active transportation is the only non-technical measure and from technical definition of energy efficiency, it should not be considered as energy efficiency measure. However, a behavioral change can also save energy and hence energy efficiency measure should consists of behavior changes along with technical changes.