Potsdam Institute for Climate Impact Research

INNOPATHS

How much energy will buildings consume in 2100?

A global perspective within a scenario framework

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Leibniz Association

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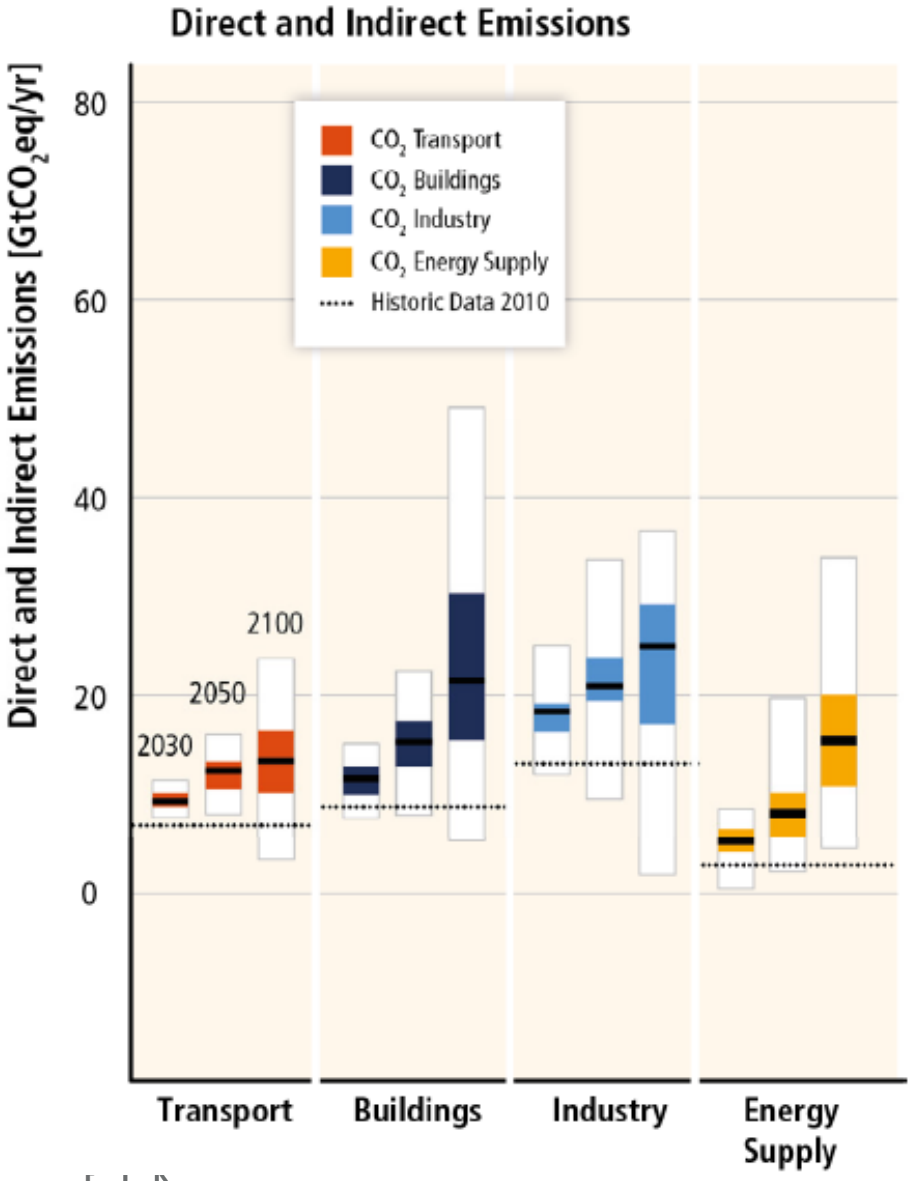
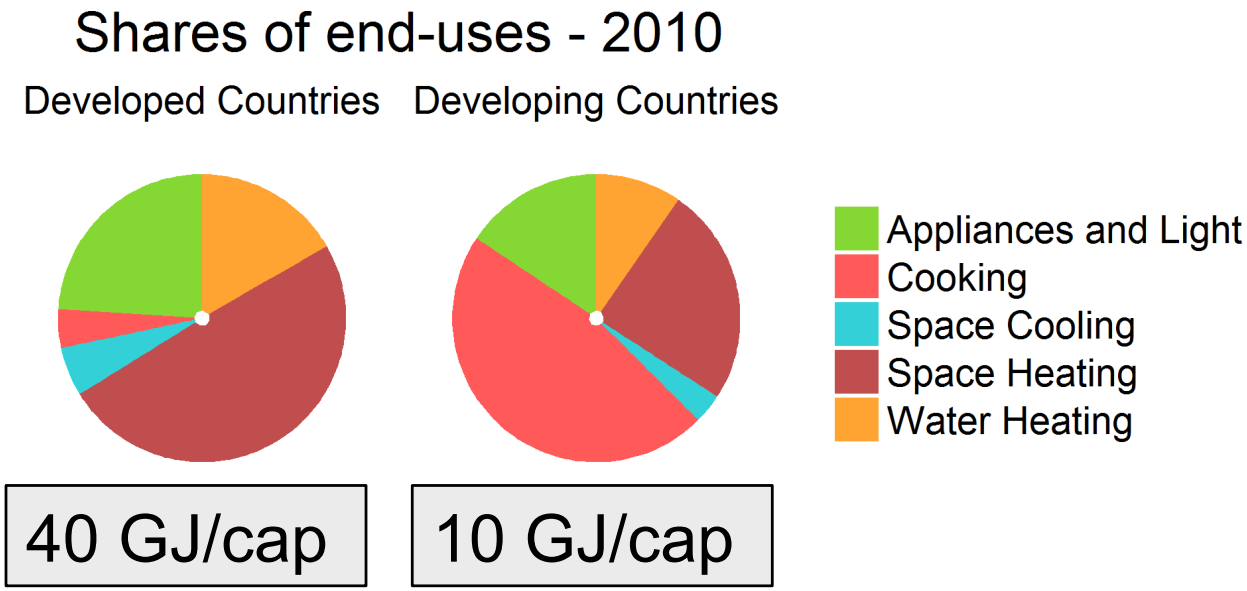
Energy demand from buildings contributes largely to GHG emissions

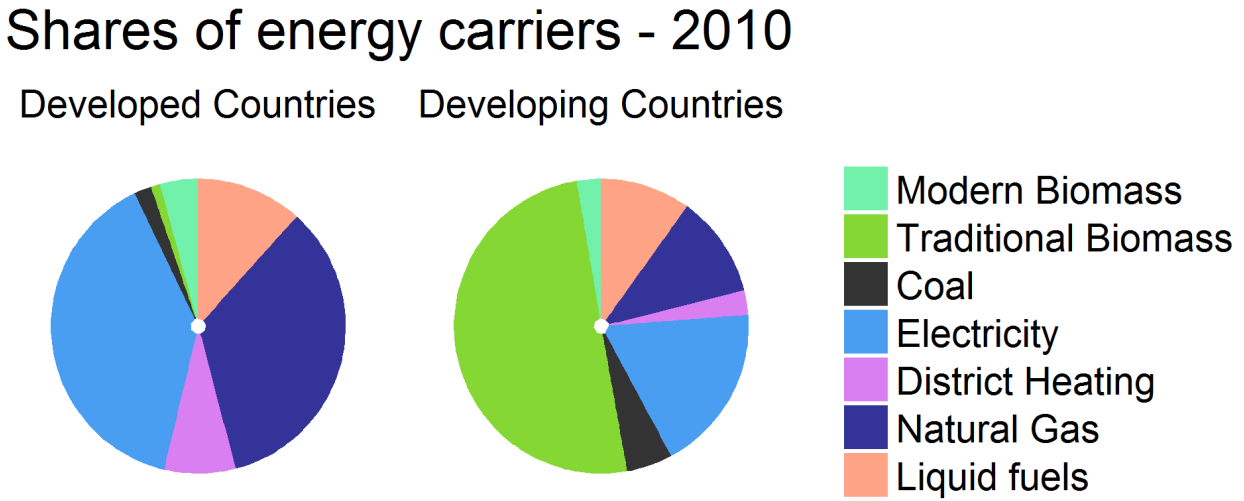


- **Approximately 75% of GHG emissions come from the energy supply/demand**
- **Buildings : 115 EJ/yr in 2010 → A third of Final Energy Consumption**

Source: AR5 WG3 Chapter 6

The difference between developed and developing regions announces deep evolutions





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Outline

Introduction

- Relevance of Energy Demand Projections

EDGE model

- Useful vs Final Energy
- Activity – Useful Energy Intensity – Final Energy Intensity
- Scenario assumptions

Results and Conclusions

- 50-200% increase by 2100
- Appliances, Light, Space Cooling
- Strong electrification
- Do the results matter?

Useful energy better represents the demand than final energy

Efficiency Losses

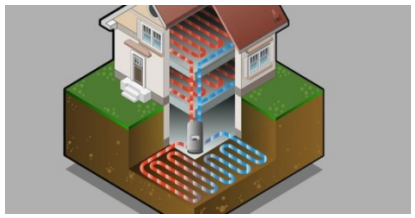
Final Energy: wood, electricity

Conversion: Stove, Heat pump

Useful Energy: radiated heat

Insulation

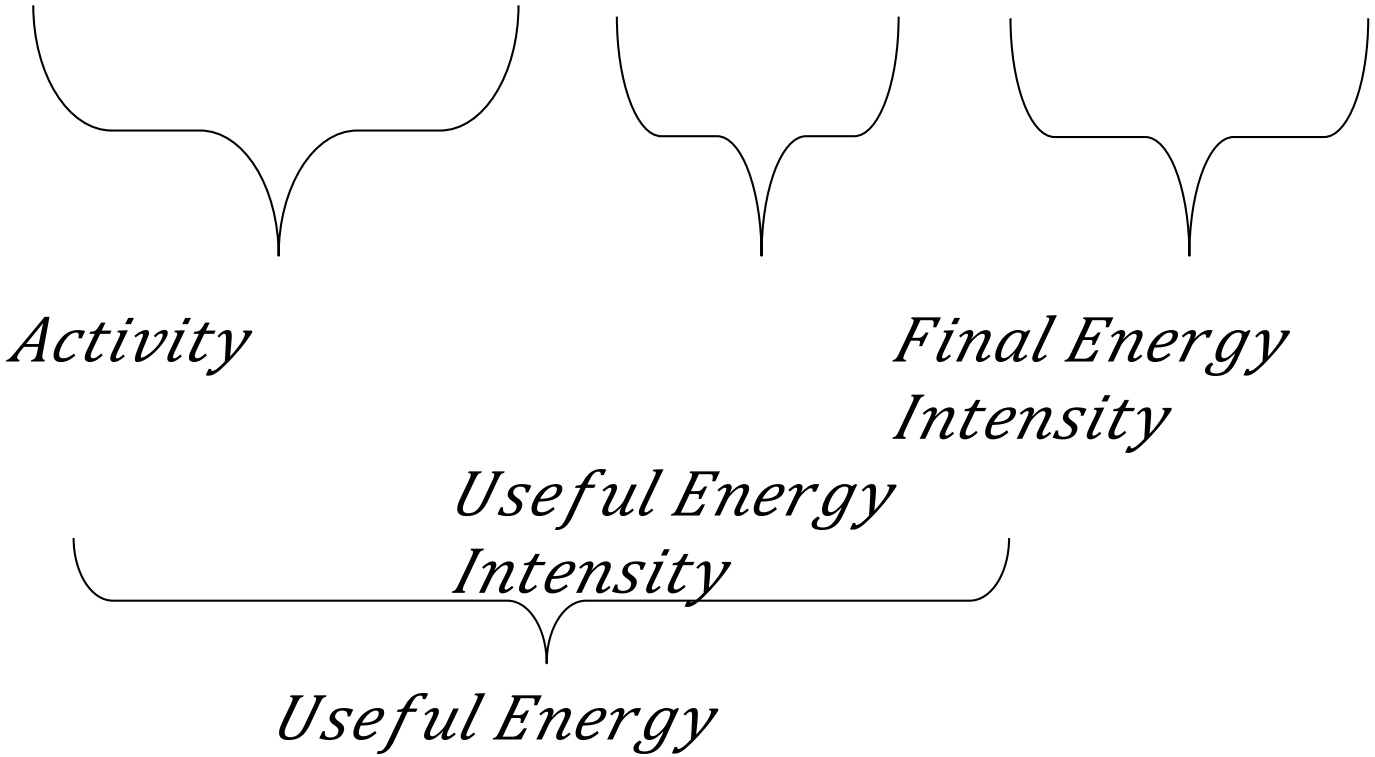
Energy service: heated space



Energy demand is modelled in three parts

Activity – Useful Energy Intensity – Final Energy Intensity

$$FE\downarrow s = A\downarrow s\,(GDP, Pop, X) \times UE\downarrow s\,/A\downarrow s\;\,(driver) \times FE\downarrow s\,/UE\downarrow s\;\,(gdpp$$

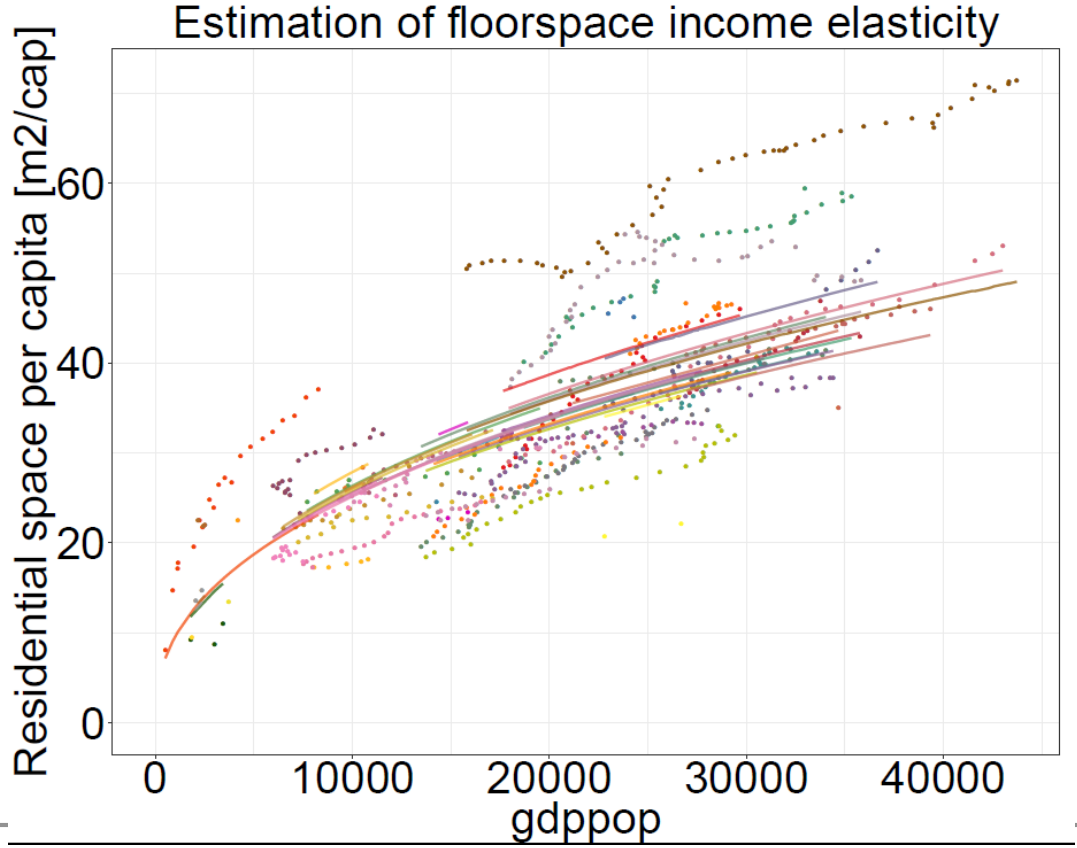


Modelling energy demand: floor space demand underlies space cooling demand

- Floorspace drives the demand for space cooling

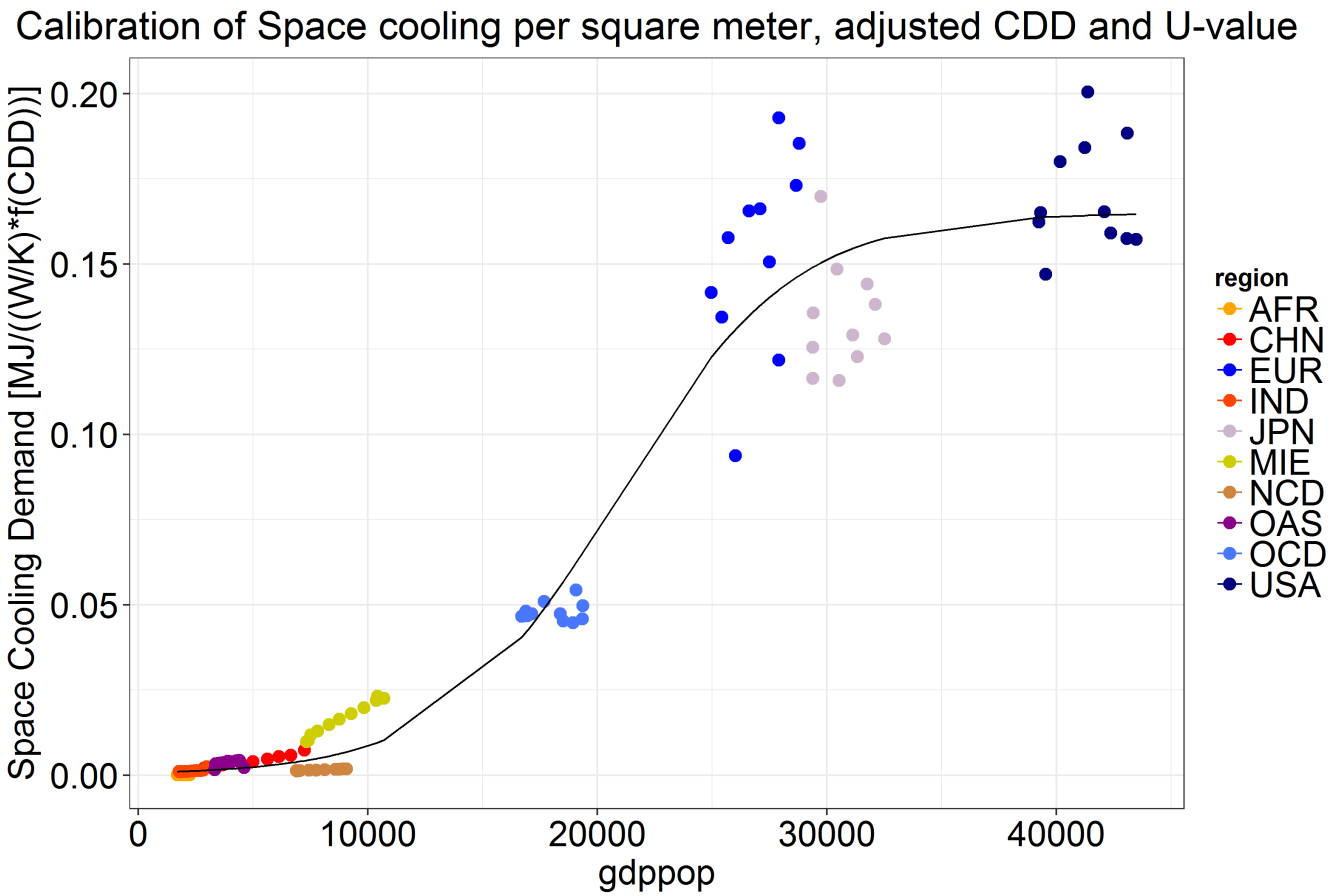
$$m\uparrow 2\ capita = \alpha Inco\uparrow \beta\ Density\uparrow \gamma$$

- In addition: impact of CDD and U-values

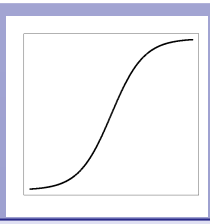
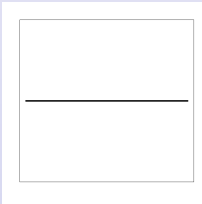
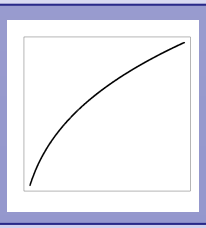
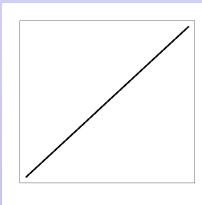
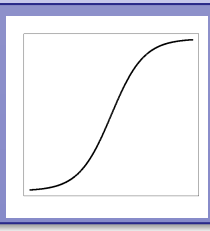


Modelling energy demand: Space Cooling as an illustration – USEFUL ENERGY INTENSITY

- Relationship between Useful energy, Cooling Degree Days (HDD), income and the U-value
- Calibration of the function with *historical Useful energy demand*



Five energy services are modelled

End-Uses	Activity	*UE/Activity*	Characteristics
Water heating (WH)	*Population*	$\phi\downarrow 1 \,/1+\exp[\phi\downarrow 2 - income/\phi\downarrow 3\ ]$	
Cooking (C)	*Population*	*constant*	
Appliances & Light (A&L)	*Population*	$\exp(Min*\log(income)+\beta/\sqrt{income}\ )$	
Space Heating (SH)	*Floorspac*e x U*value*	$\alpha+\beta\times HDD$	
Space Cooling (SC)	*Floorspac*e x U*value*	$adjCDD\times\phi\downarrow 1\,/1+\exp[\phi\downarrow 2 - income/\phi\downarrow 3\ ]$	

Modelling energy demand:

Activity – Useful Energy Intensity – Final Energy Intensity

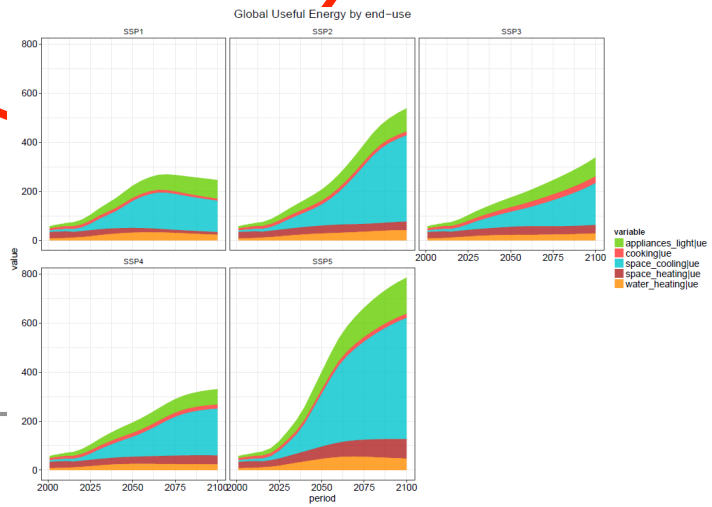
$$FE_s = A_s(GDP, Pop, X) \times UE_s \quad A_s(driver) \times FE_s / UE_s$$
$$(gdppop)$$

Activity

Useful Energy Intensity

Final Energy Intensity

Useful energy projections



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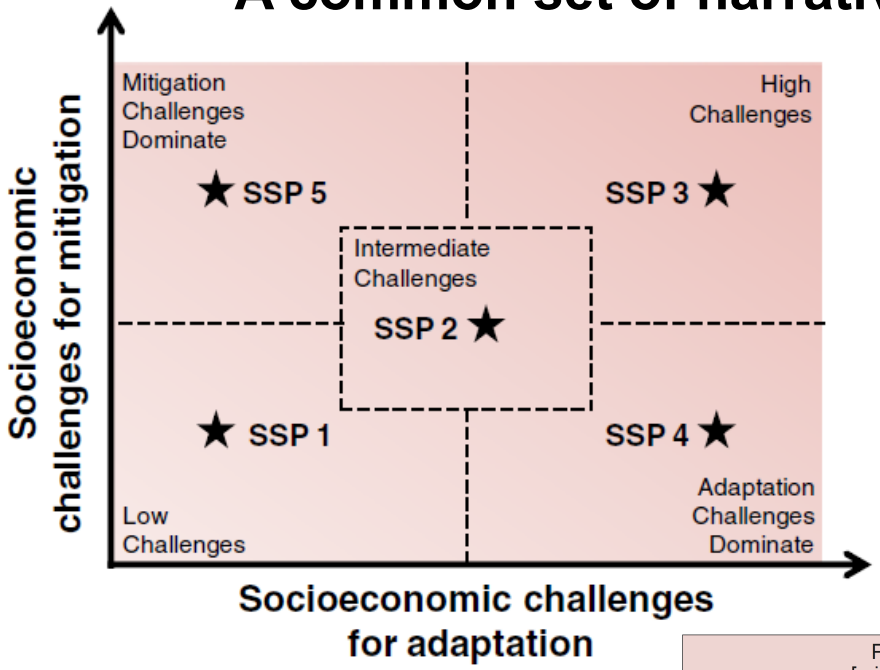
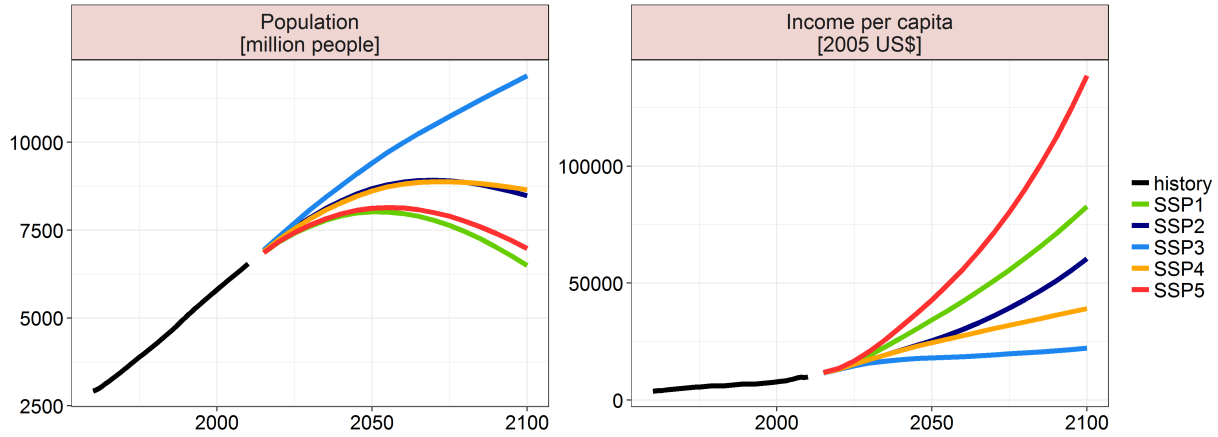
The socio-economic uncertainty is mapped with the Shared Socio-economic scenarios

A common set of narratives

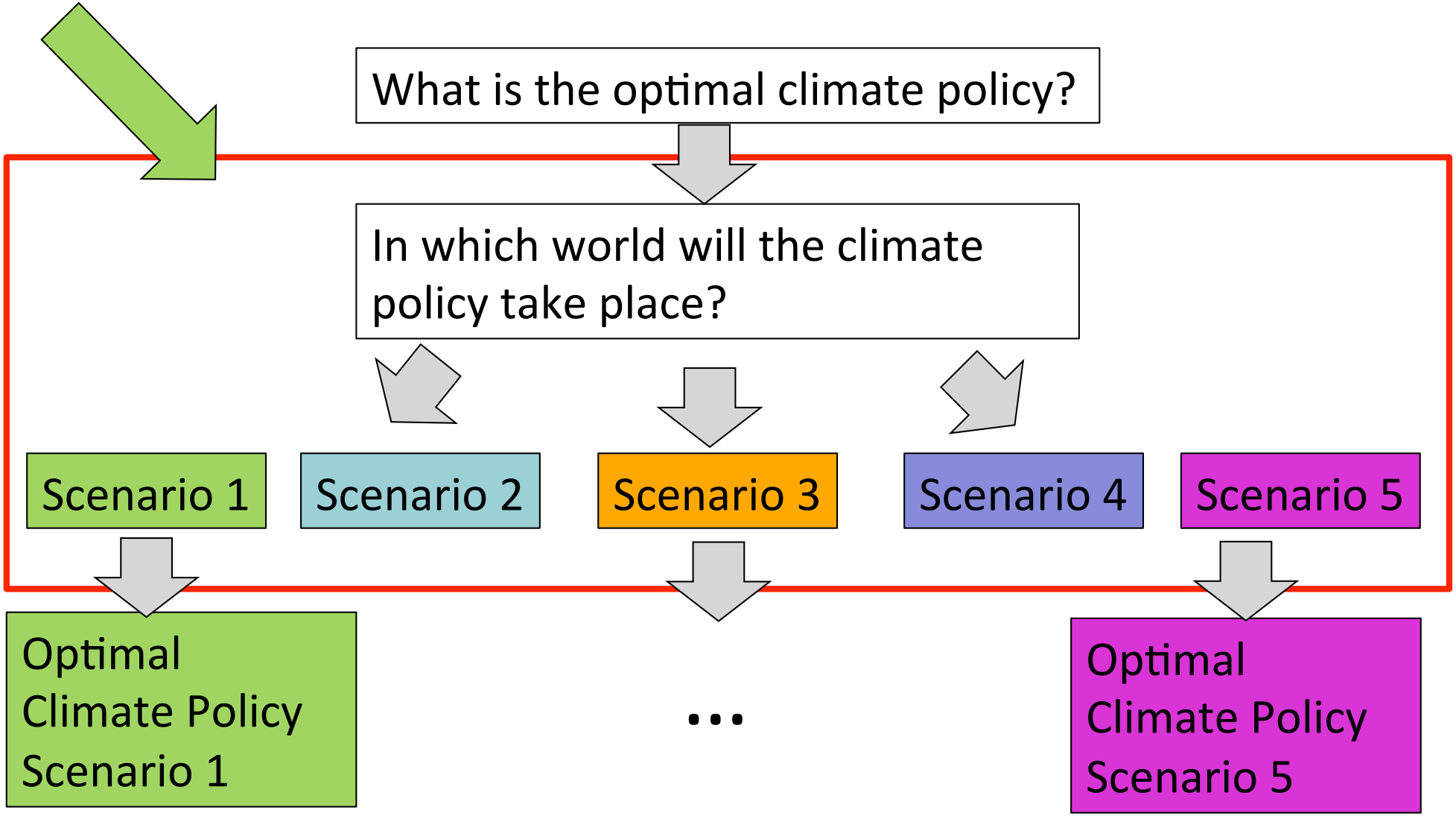


A small set of common quantitative projections



Source: O'Neill et al. A new scenario framework for climate change research: the concept of shared socioeconomic pathways

The scenarios do NOT include climate policy



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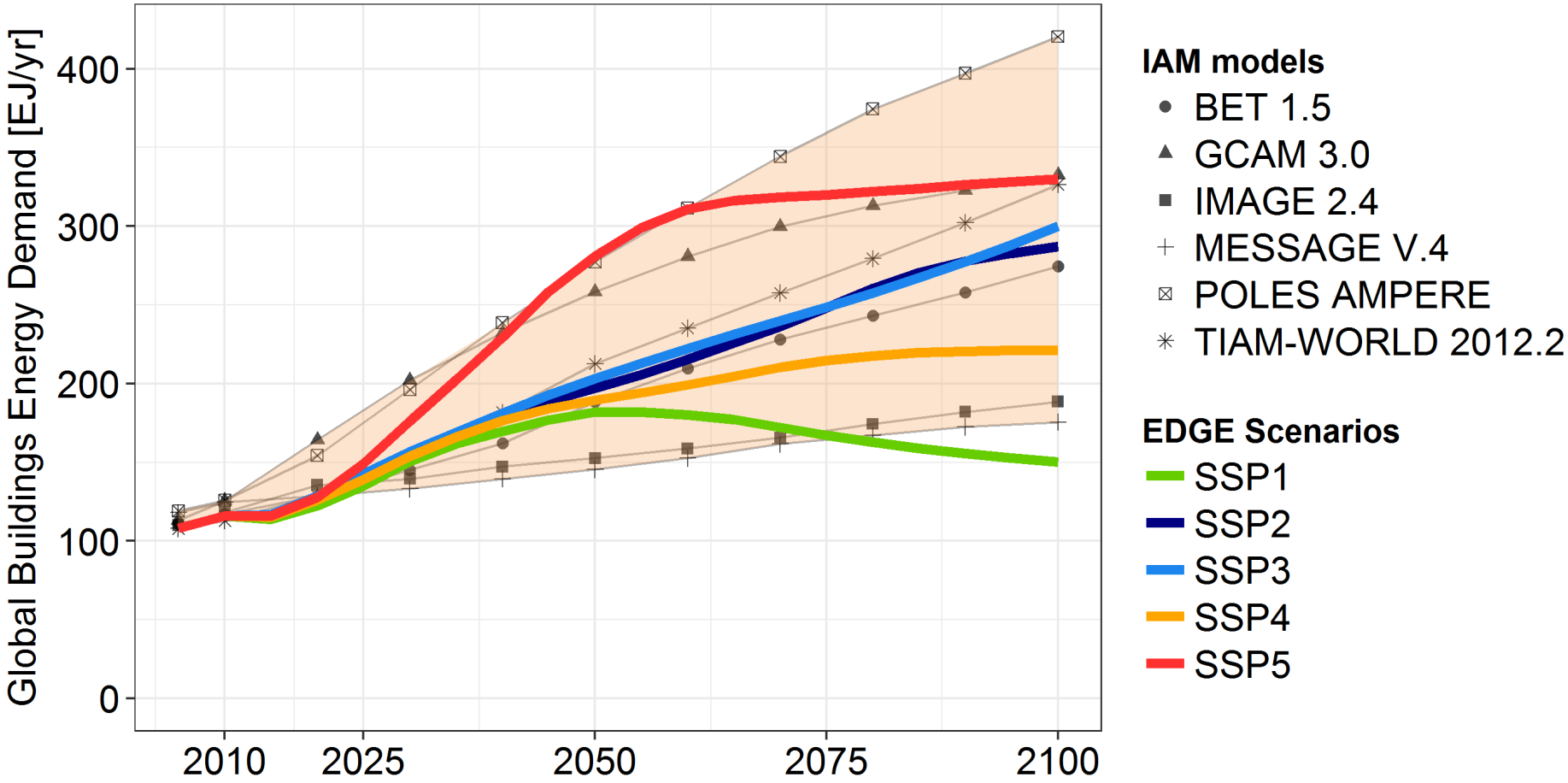
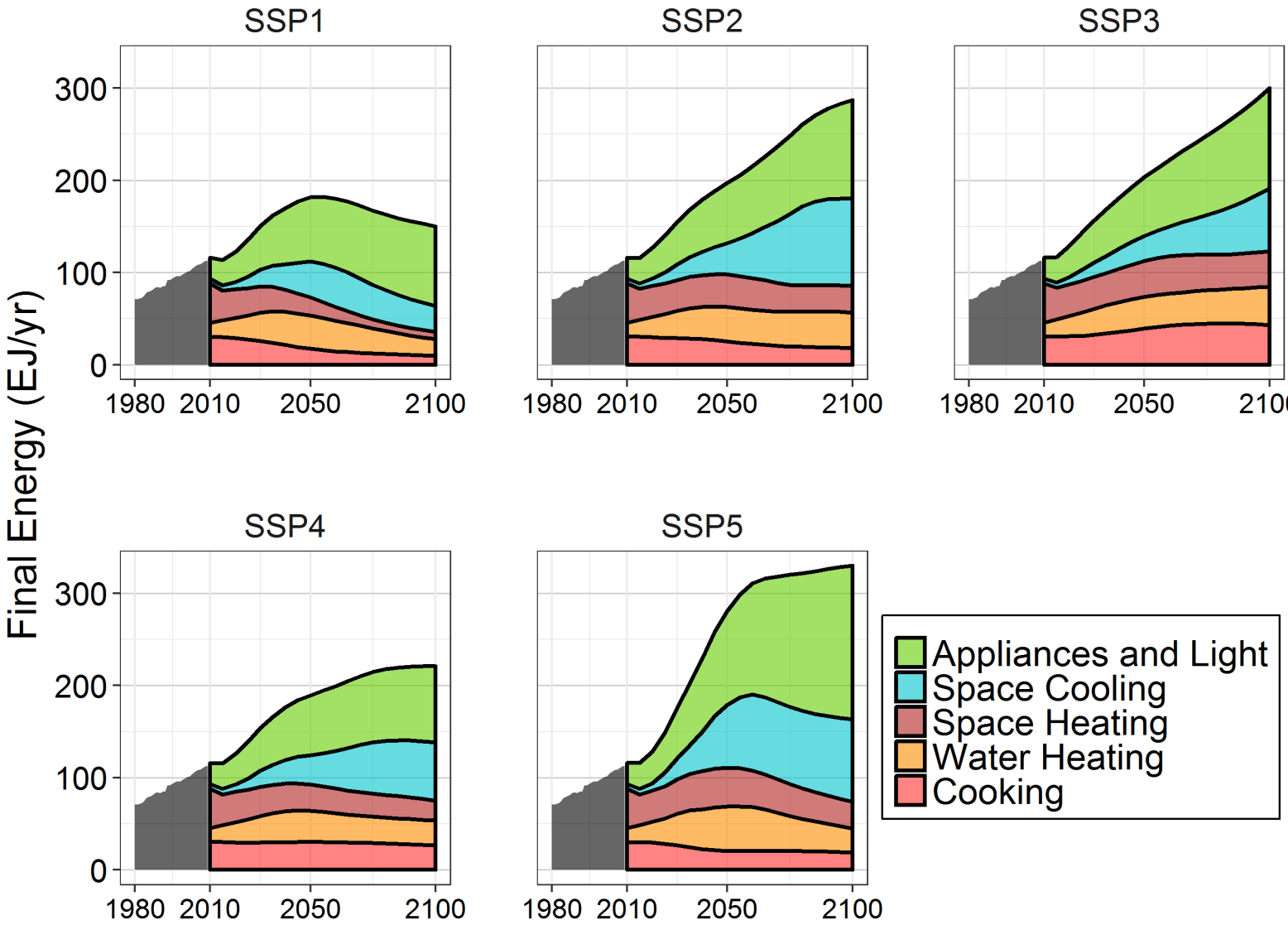
Buildings‘ energy demand increases 50% to 200% until 2100



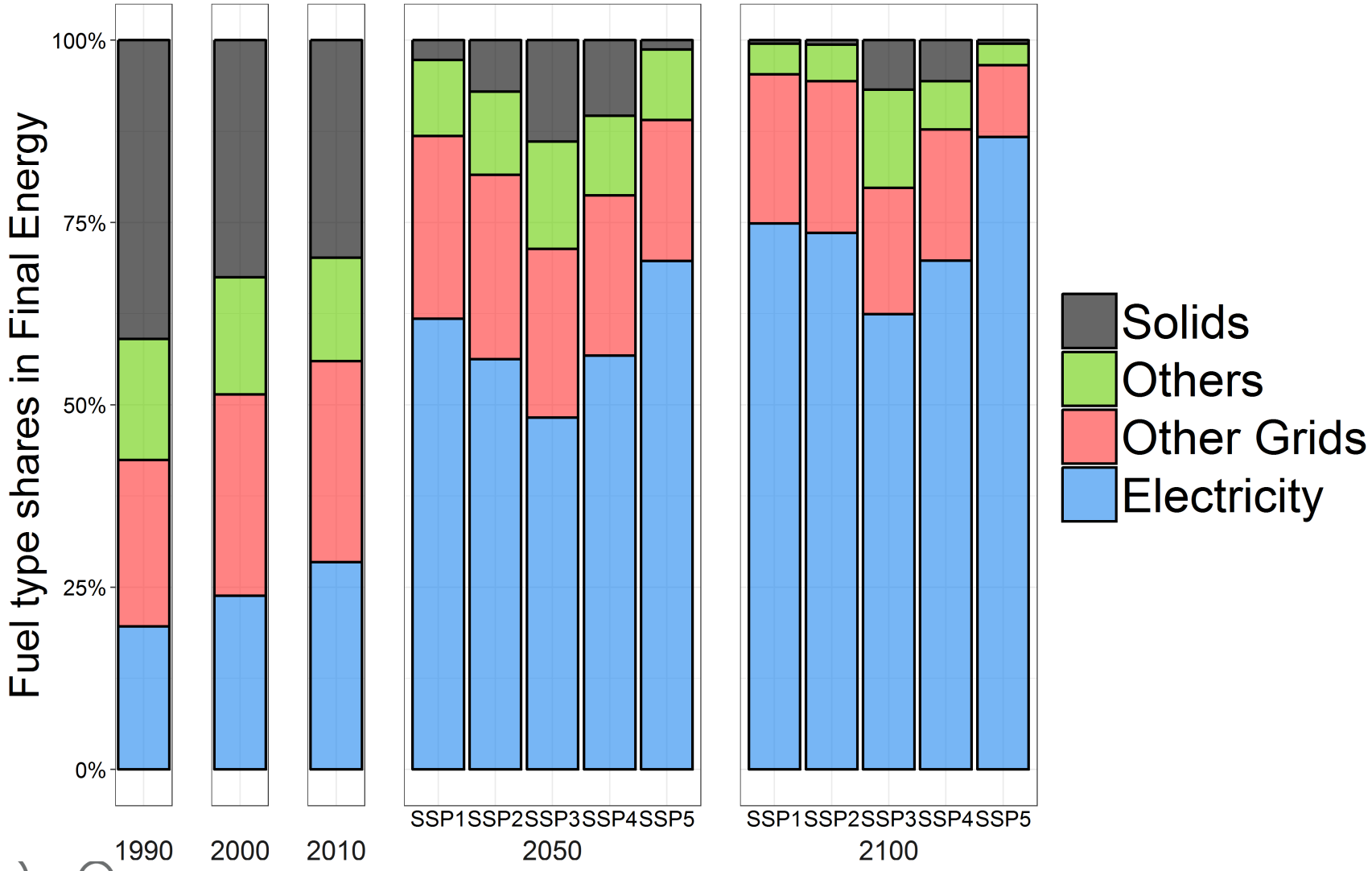
Source: Levesque et al., How much energy will buildings consume in 2100?, in prep

Appliances, Lighting and Space Cooling will outbalance Heat energy services



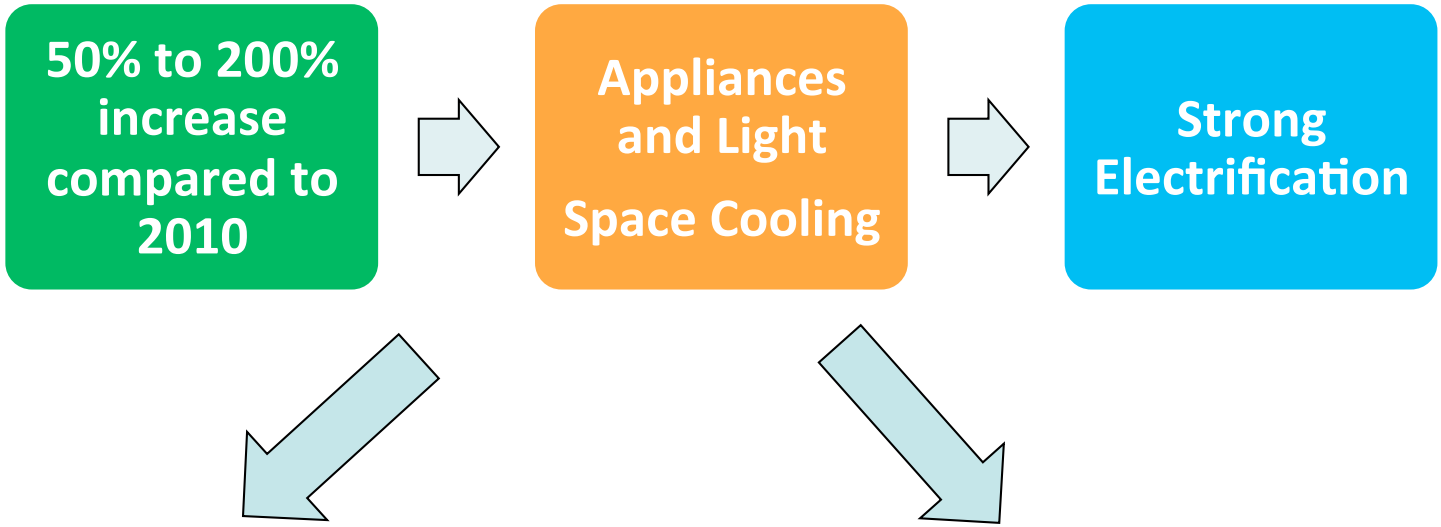
Source: Levesque et al., How much energy will buildings consume in 2100?, in prep

Electricity covers more that half the final energy demand



Source: Levesque et al., How much energy will buildings consume in 2100?, in prep

Why the results do (not) matter…



Results matter

Decarbonisation left to the supply sector for which there are solutions

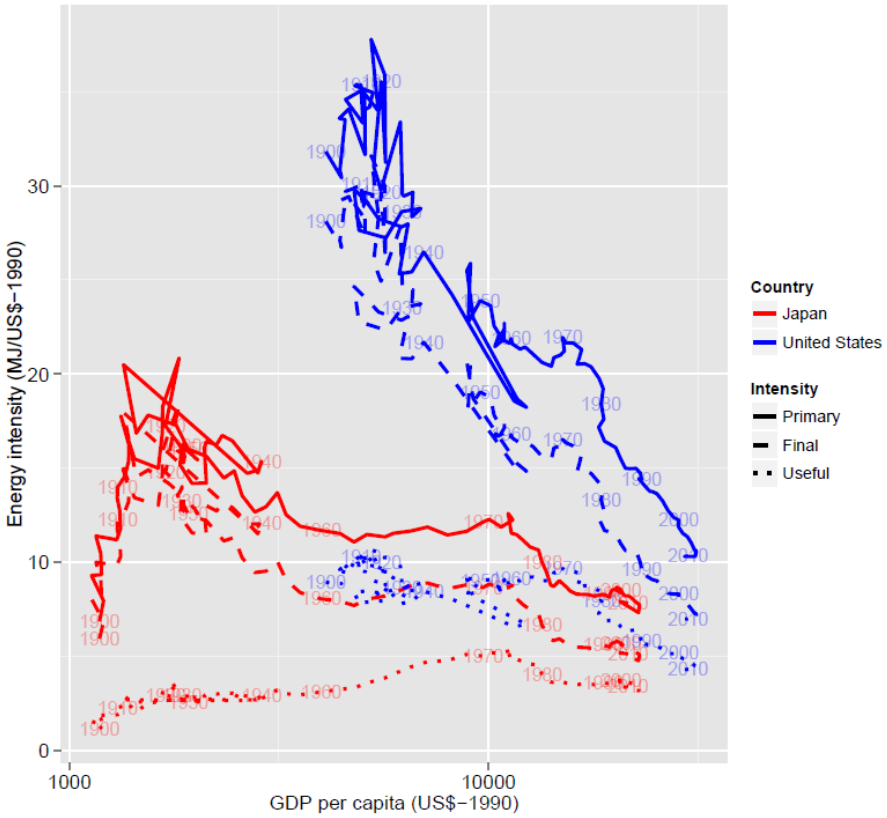
Results do not matter

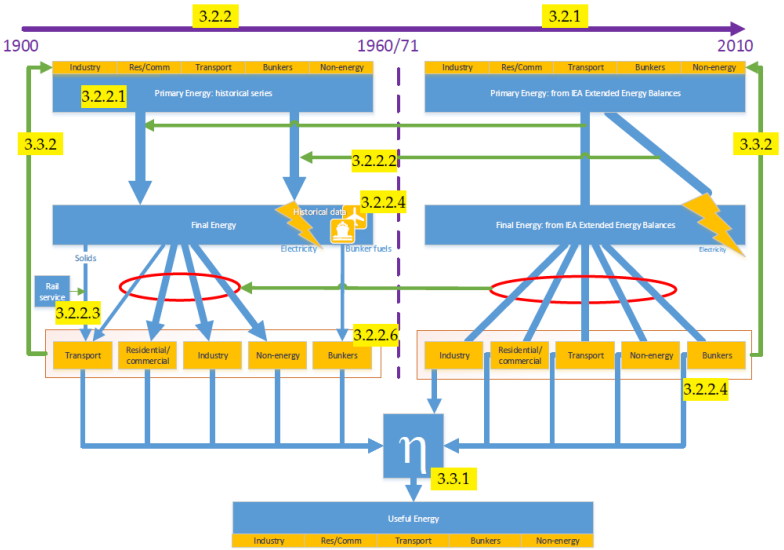
Reducing heat demand remains important for decarbonisation until 2050

Thank you

Final and Useful energy database by end-use and energy carrier - PFUDB

- **Explain PFUDB (data base with UE and FE, do not go into the detail)**





Modelling energy demand: Final energy intensity

For final energy projections we need projections of

- **Final energy shares (γ)** of each energy carrier and
- **efficiencies (θ)** of each energy carrier.

$$UE_{s} = \sum_{ec} UE_{s,ec} = \sum_{ec} \theta_{s,ec} FE_{s,ec} = \sum_{ec} \theta_{s,ec}$$

$$\Leftrightarrow FE_{s} = UE_{s} / \sum_{ec} \theta_{s,ec} \gamma_{s,ec}$$

$$FE_{s,ec} = \gamma_{s,ec} UE_{s} / \sum_{ec} \theta_{s,ec} \gamma_{s,ec}$$

Modelling energy demand: focus on appliances

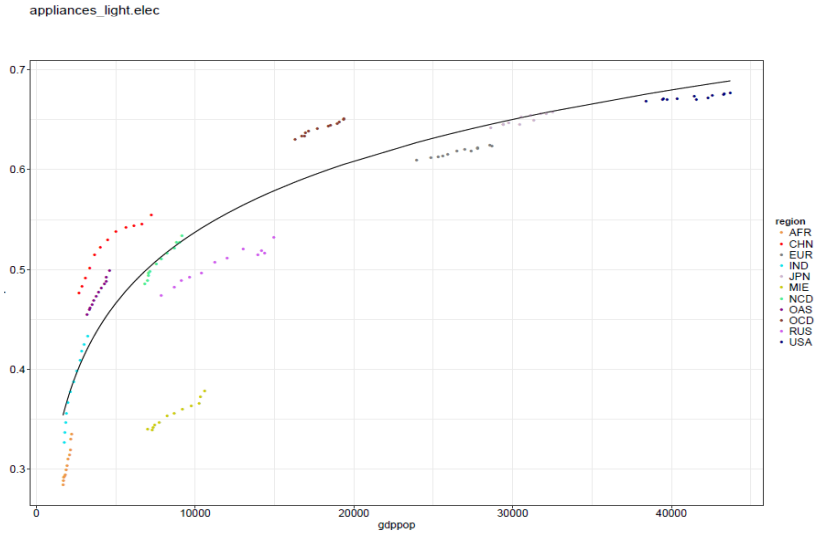
Final Energy: electricity, kerosene

Conversion:

Useful Energy: FE – heat losses

Relation ES-UE

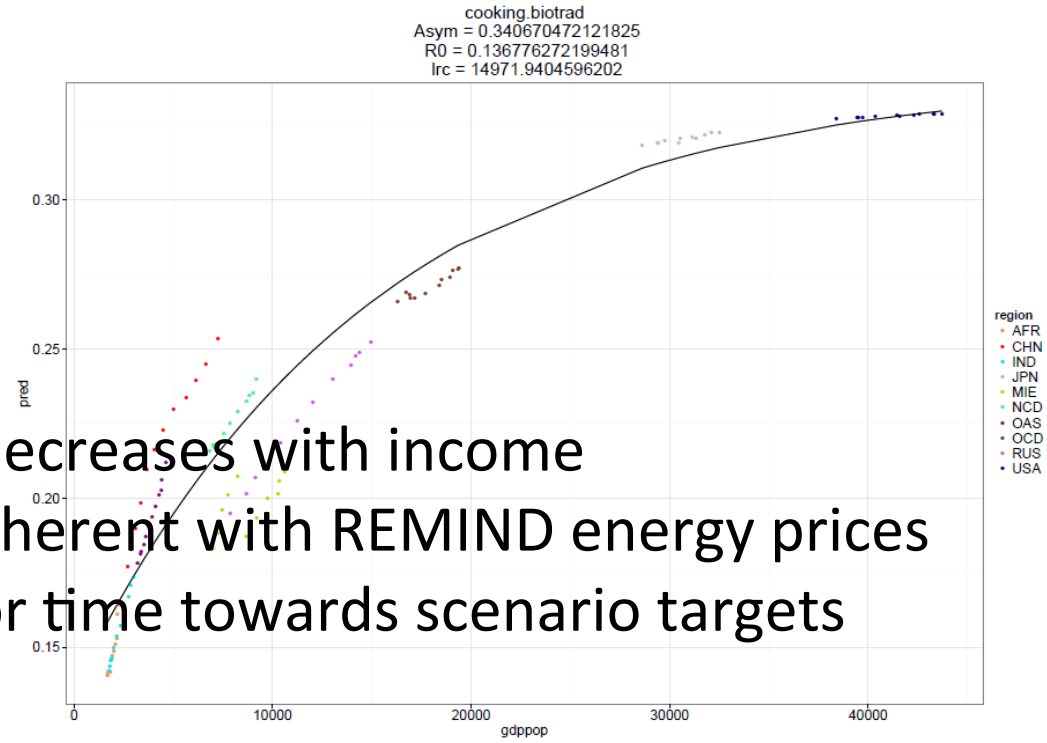
Energy service: Entertainment Communication, Clean clothes, dishes, …



Modelling energy demand: Final energy intensity

Useful to Final energy efficiency

- Improving with income
- Saturated growth function from PFU, recalibrated

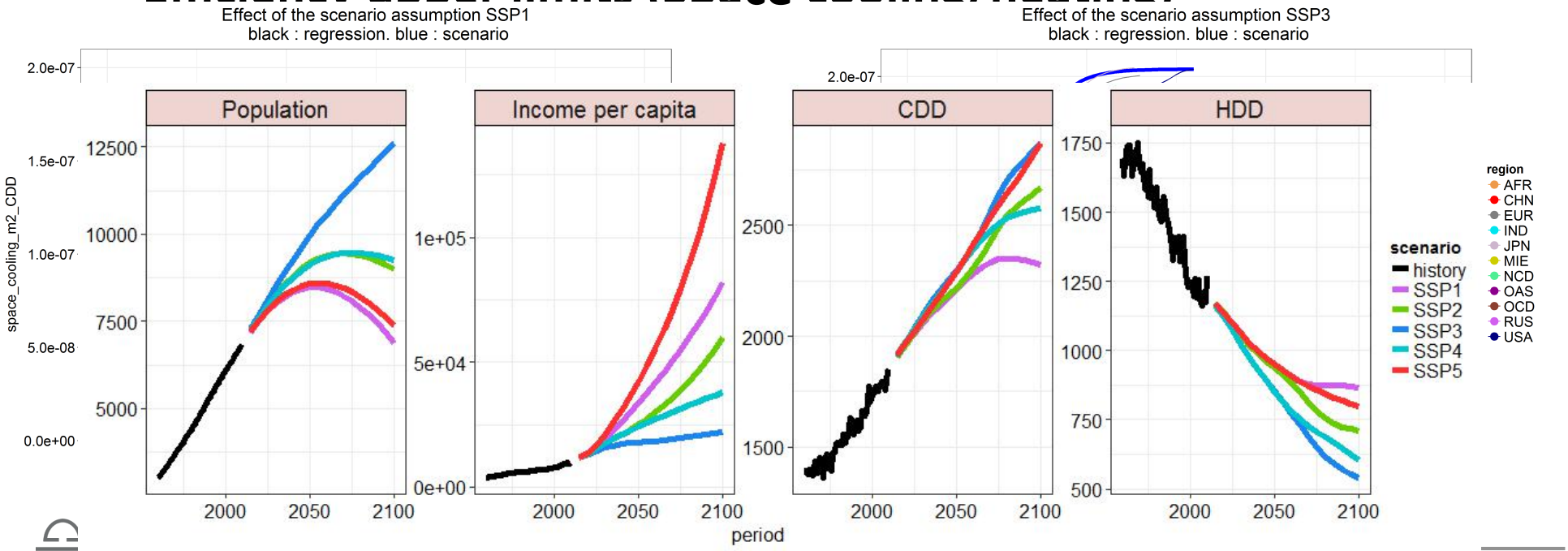


Final energy shares:

- For traditional energy : decreases with income
- Scenario assumptions coherent with REMIND energy prices
- Convergence with GDP or time towards scenario targets

The implementation of SSPs in the model

- **Exogenous Population, Income and Climate projections**
- **Coefficient on Useful energy intensity**
- **Convergence assumptions – Speed of convergence**
- **FE shares depending on REMIND prices**
- **Efficiency upper limits (Space cooling/heating)**



SSP1
Sustainbility

SSP3
Regional Rivalry