Navigating the Roadmap for Clean, Secure and Efficient Energy Innovation

SET-Nav
Strategic Energy Roadmap

Regional Workshop Budapest:

Heating and Cooling demand and supply in buildings in transition pathways

Sebastian Forthuber, Michael Hartner, Andreas Müller, Eric Aichinger: TU Wien

Content – Energy demand in Buildings

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- Introduction and Methodology
- Results for Heating and cooling demand developments in several scenarios
  - EU28
  - Results for Hungary
- Summary and lessons learned from Scenarios

BUILDING STOCK MODEL: INVERT/EE-LAB

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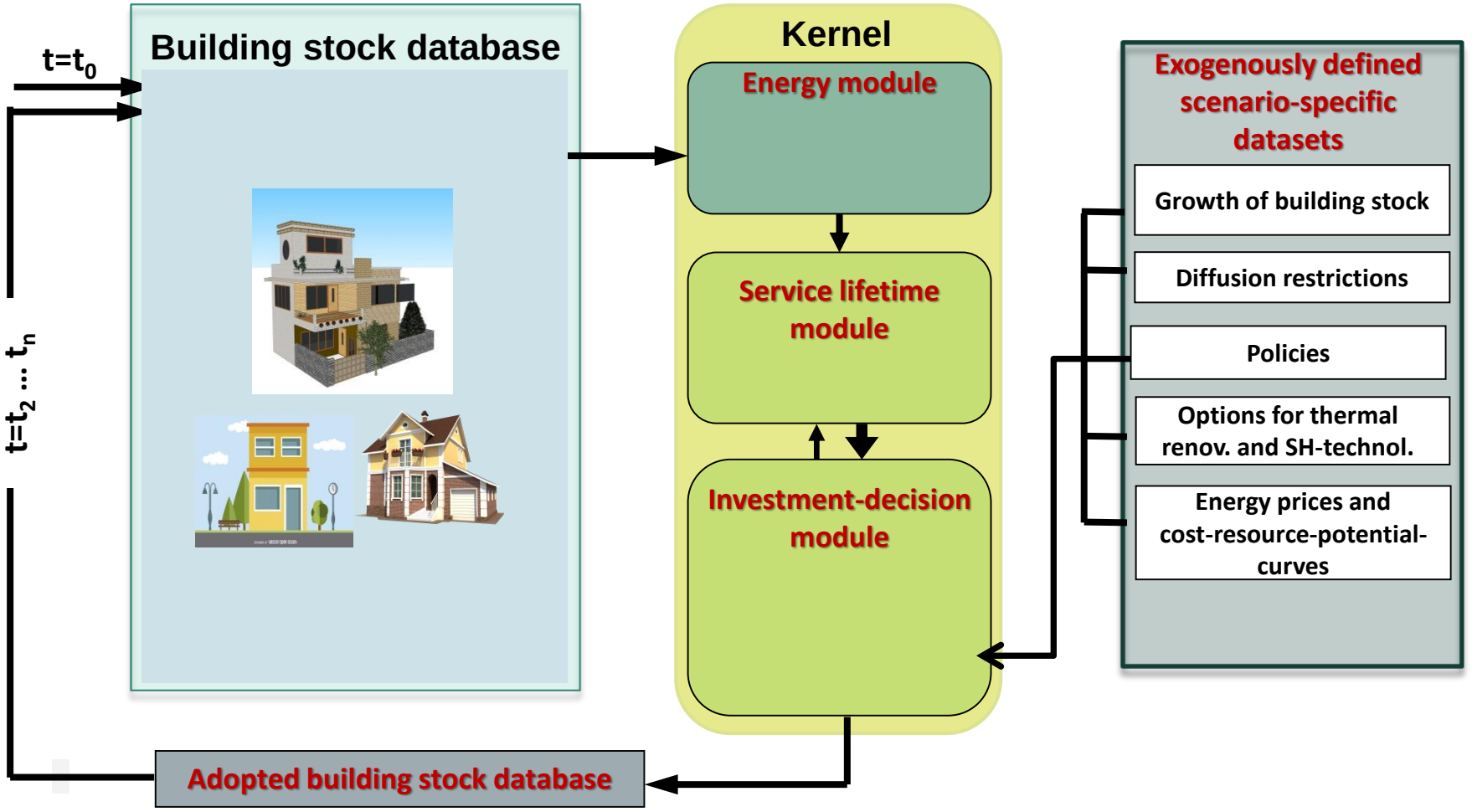
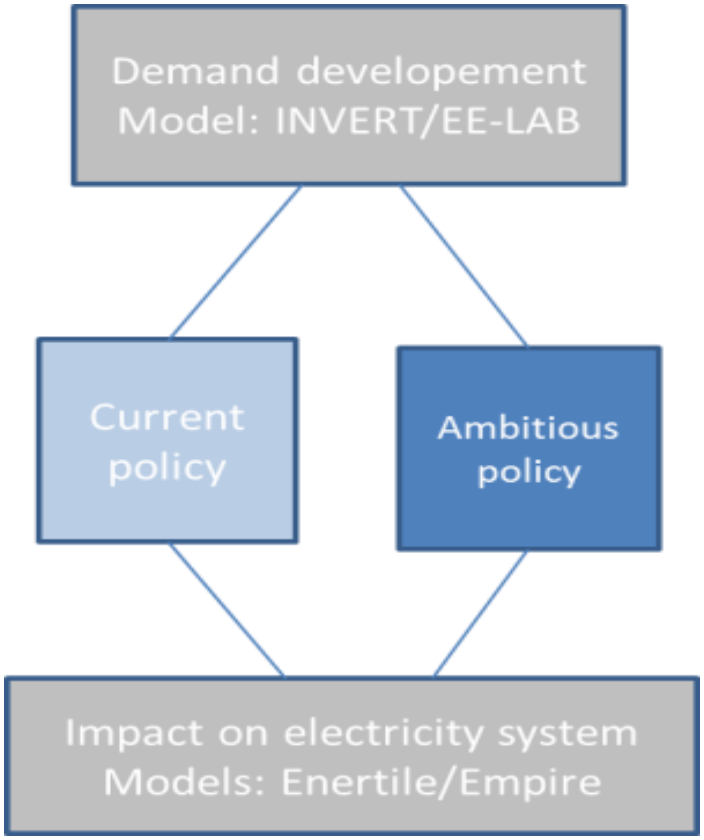


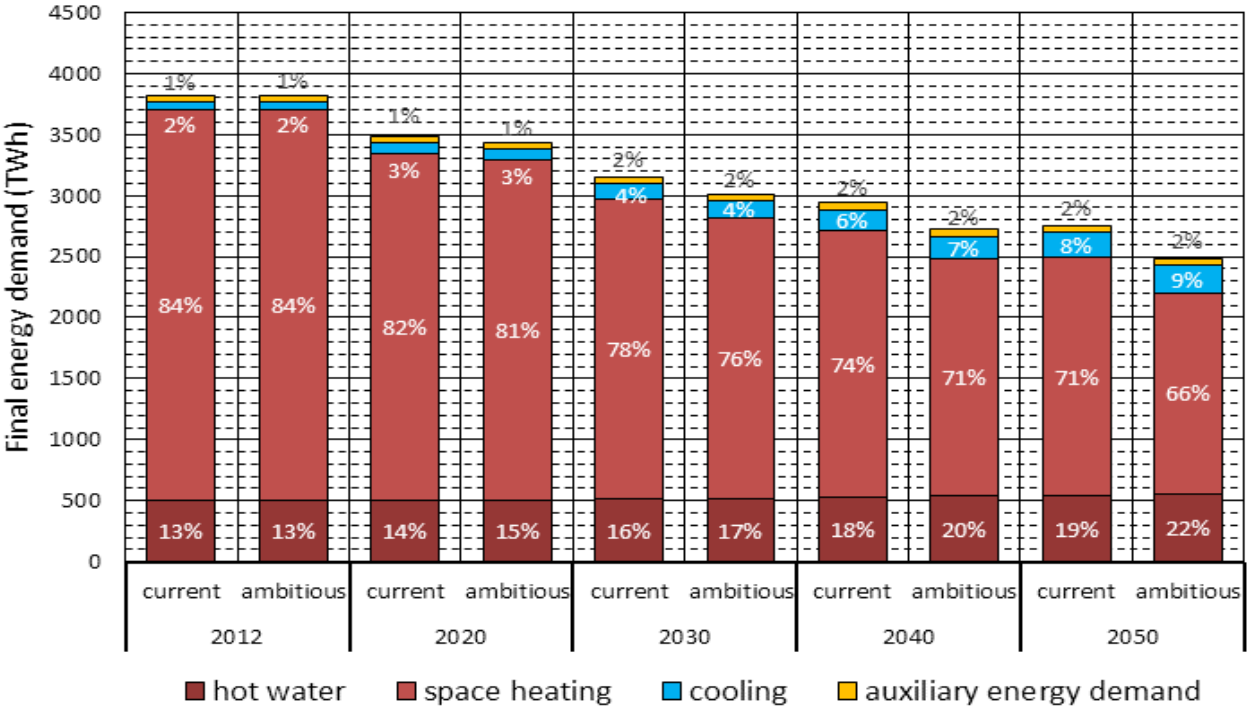
www.invert.at

SCENARIO CALCULATIONS FOR EU28

- Step 1 – Calculations of first EU28 scenarios to learn for pathway calculations



FINAL ENERGY DEMAND FOR HEATING AND COOLING



- Decrease in final energy demand for heating and cooling (-28% in current policy, -38% in ambitious policy scenario)
- 3 fold increase in final energy demand for space cooling

FINAL ENERGY DEMAND FOR HEATING AND COOLING

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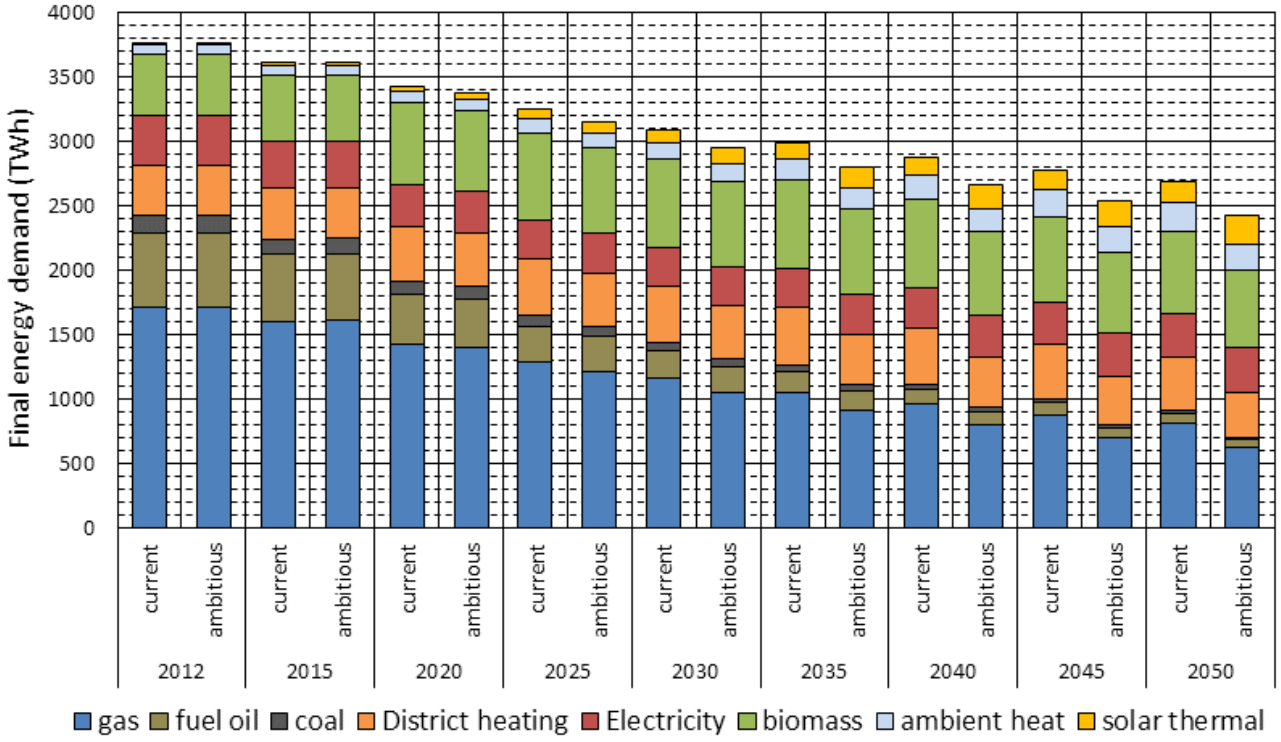
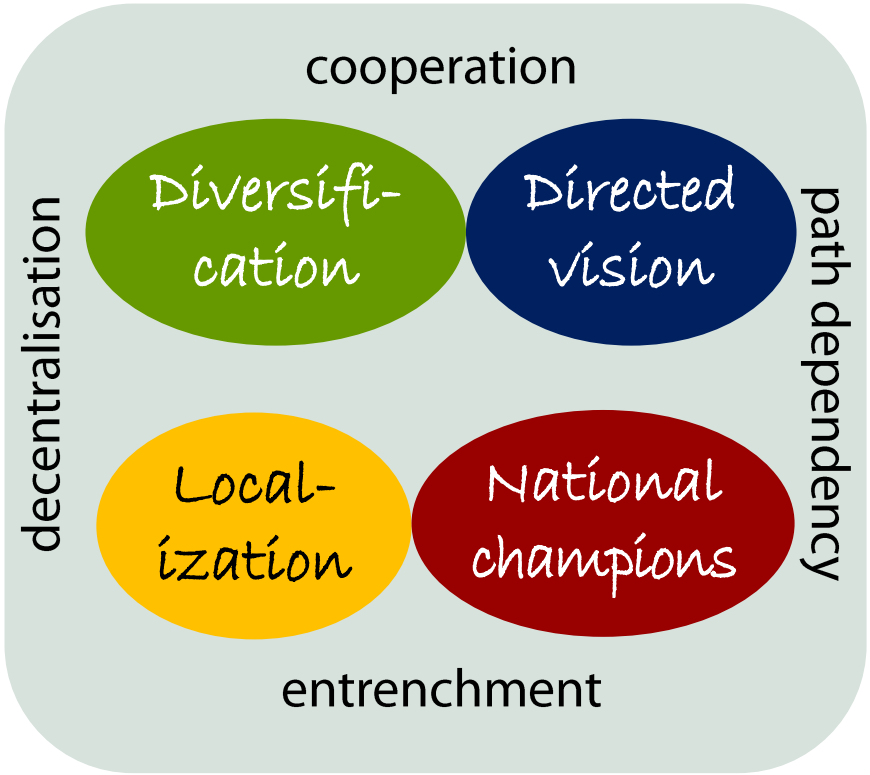


- Oil and coal disappear from the energy carrier mix, Natural gas decreases by more than -50% but still 25% to 30% of final energy demand in 2050
- Biomass use increases by around 34% in current and 26% in ambitious scenario
- Strong uptake in installation of heat pumps and solar thermal
- CO_2 emission reductions up to -80% in ambitious scenario

SET-NAV: PATHWAYS STORYLINES

Pathway analysis: **Pathway definition / Storylines**

- heterogeneous actors
- coordination (beyond markets)
- digitalization (open IP)
- regulatory change
- disrupt incumbents



- EU/state-directed
- shared vision
- strong EU policy framework

- local resources
- resistance to big infrastructure
- experimentation & diversity (many niches)
- digital winners-take-all

- utilities & incumbents
- regulatory capture
- low transition costs

- ALL Pathways in the building sector needed to be more ambitious than the ambitious scenario in the Case study! Emission reductions ~90% or higher

FINAL ENERGY DEMAND FOR HEATING AND COOLING

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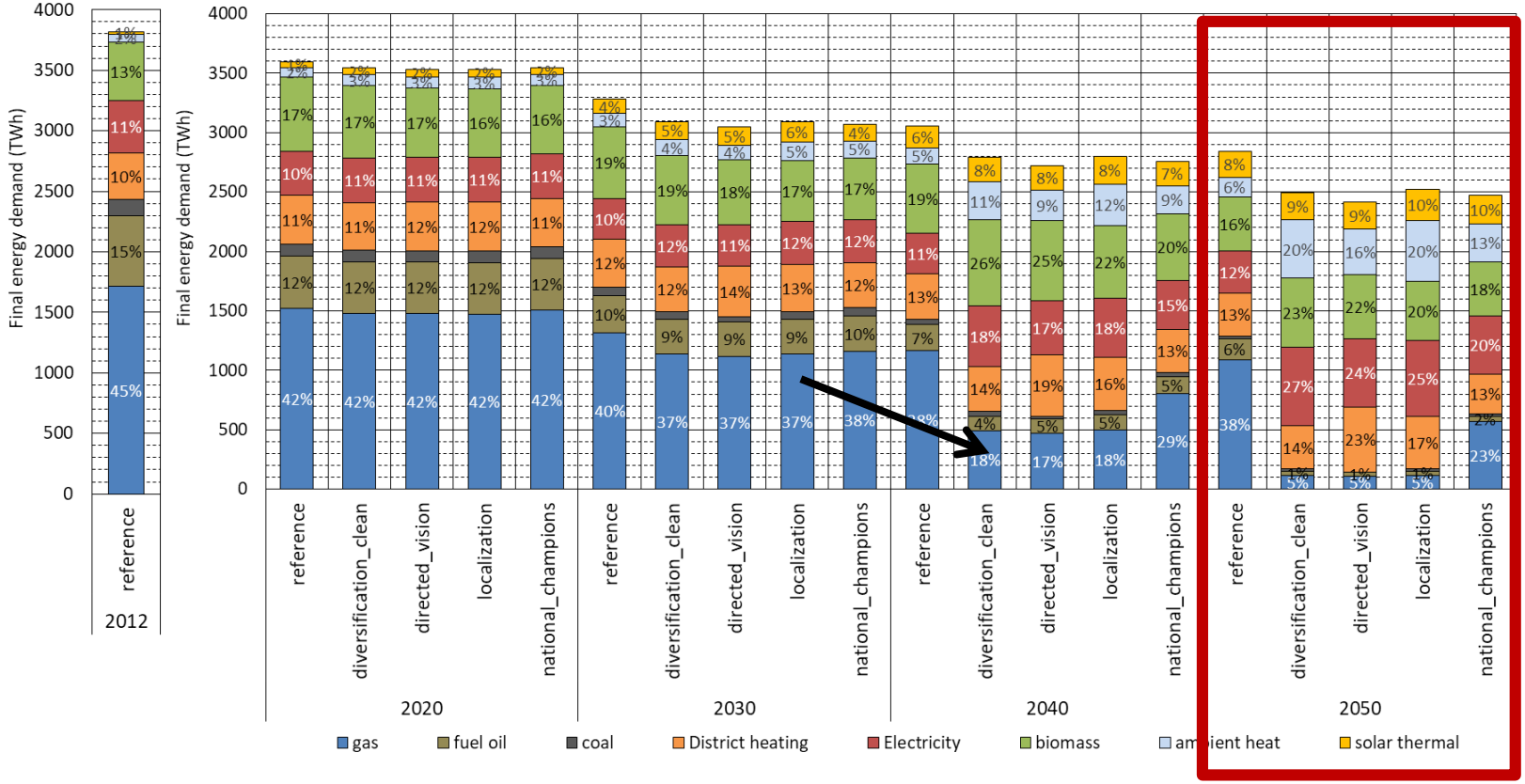
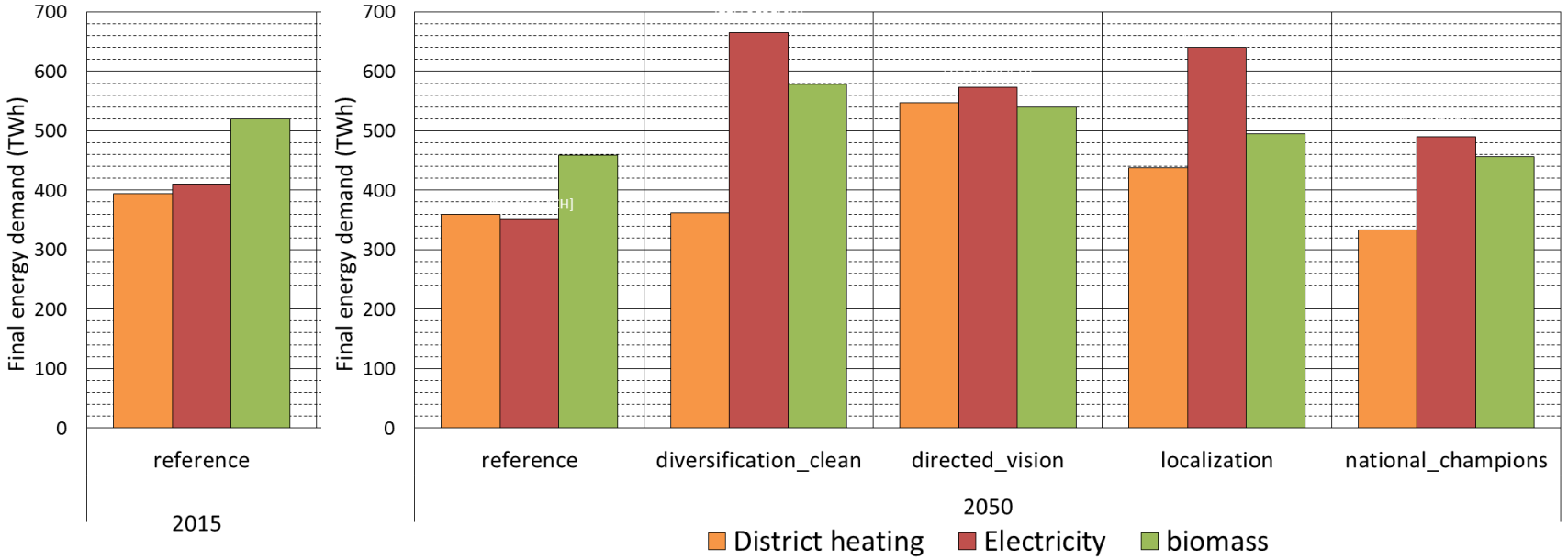


- Decrease of final energy demand by -36% to -34%
- Gas disappears due to ban of fossils by 2030 – triggers investments into heat pumps, district heating and biomass
- If gas is allowed it dominates the supply mix until 2050
- Assuming that electricity and district heat supply is decarbonized the building sector achieves up to -95% of emissions reductions in the pathways!

Pathways – Relevant differences for Supply models



- Increase of electricity demand from around 400 TWh to 660 TWh in the diversification pathway (compared to decrease in the reference scenario)
- Biomass increase is only moderate - maximum +20% in diversification pathway (580 TWh). Restricted potentials in the model!
- Substantial increase of district heating demand only in directed vision pathway
- All results include the effects of significant thermal efficiency increases

Results for Hungary

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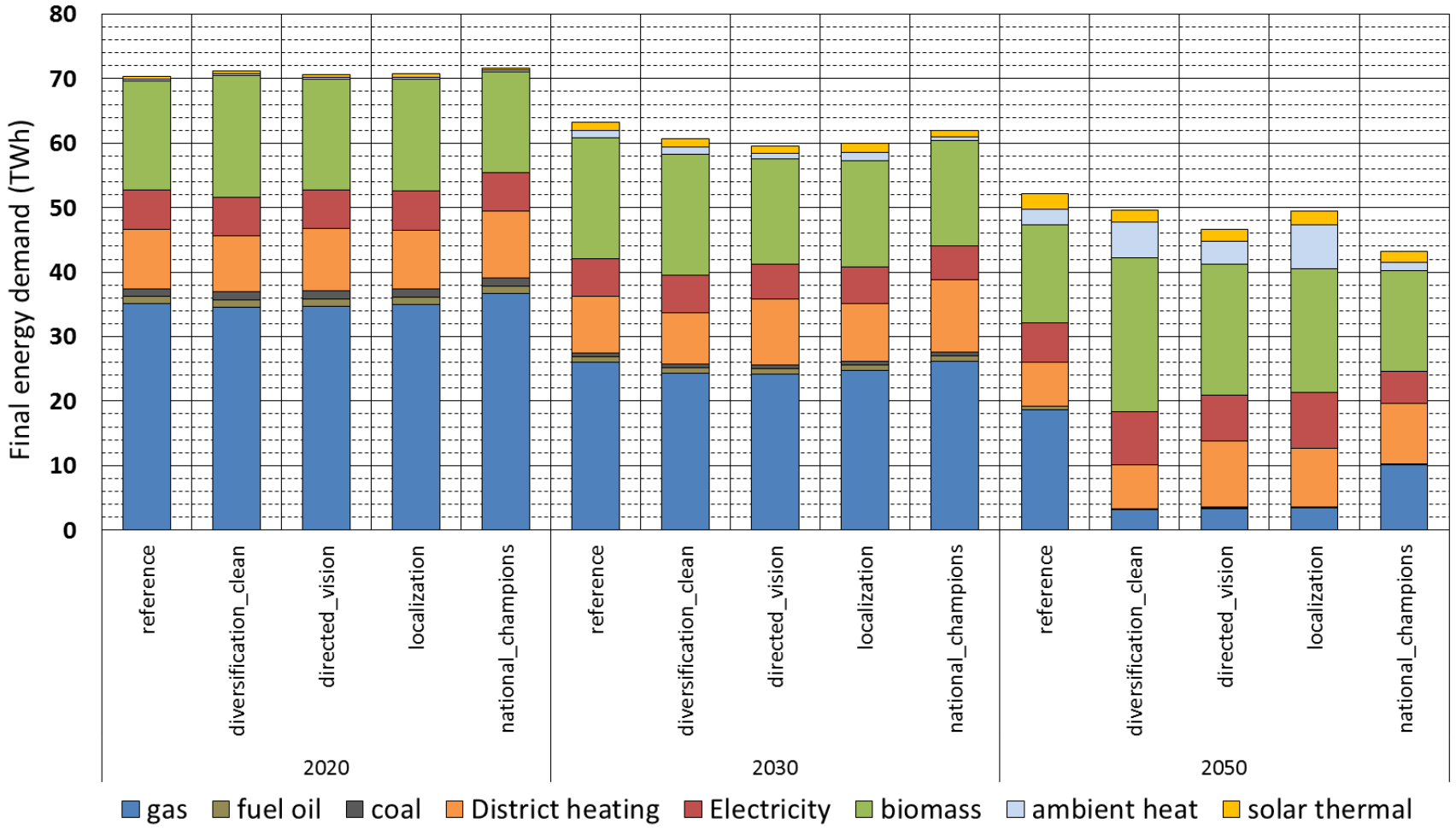

Summary – Pathways Buildings

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- Heat pumps play a crucial role in all scenarios – in very ambitious mitigation targets electricity demand from heating and cooling increases significantly
- Increase in Biomass use is moderate in the calculated pathways
- Thermal renovation and efficient new construction help to conserve biomass and limit the impact of electricity demand for heat pumps
- In all pathways there would still be additional potentials for district heating - highest share is 25% in the directed vision pathway
- Even with very ambitious RES support Natural Gas stays in the mix – only strong RES obligations or bans on fossil heating systems lead to CO2 emission reductions >90%

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Thank you!

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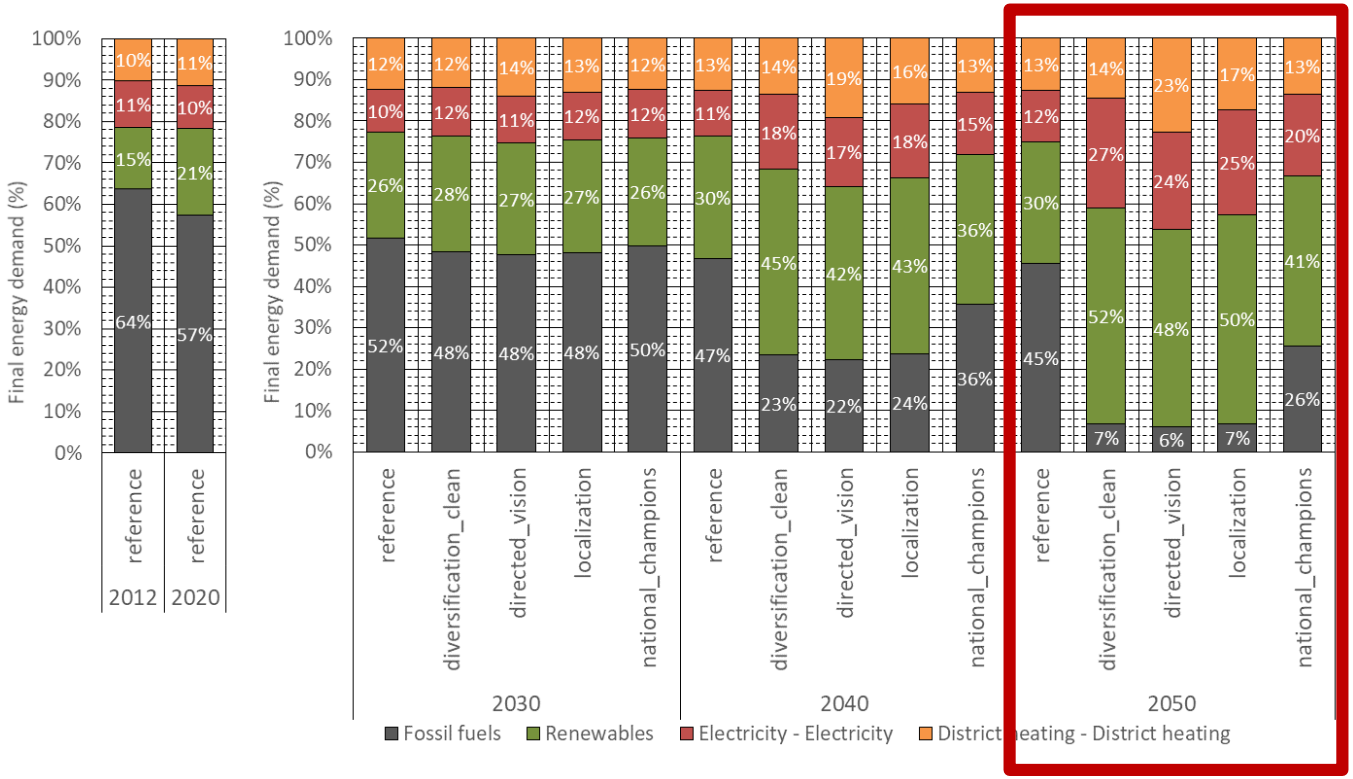
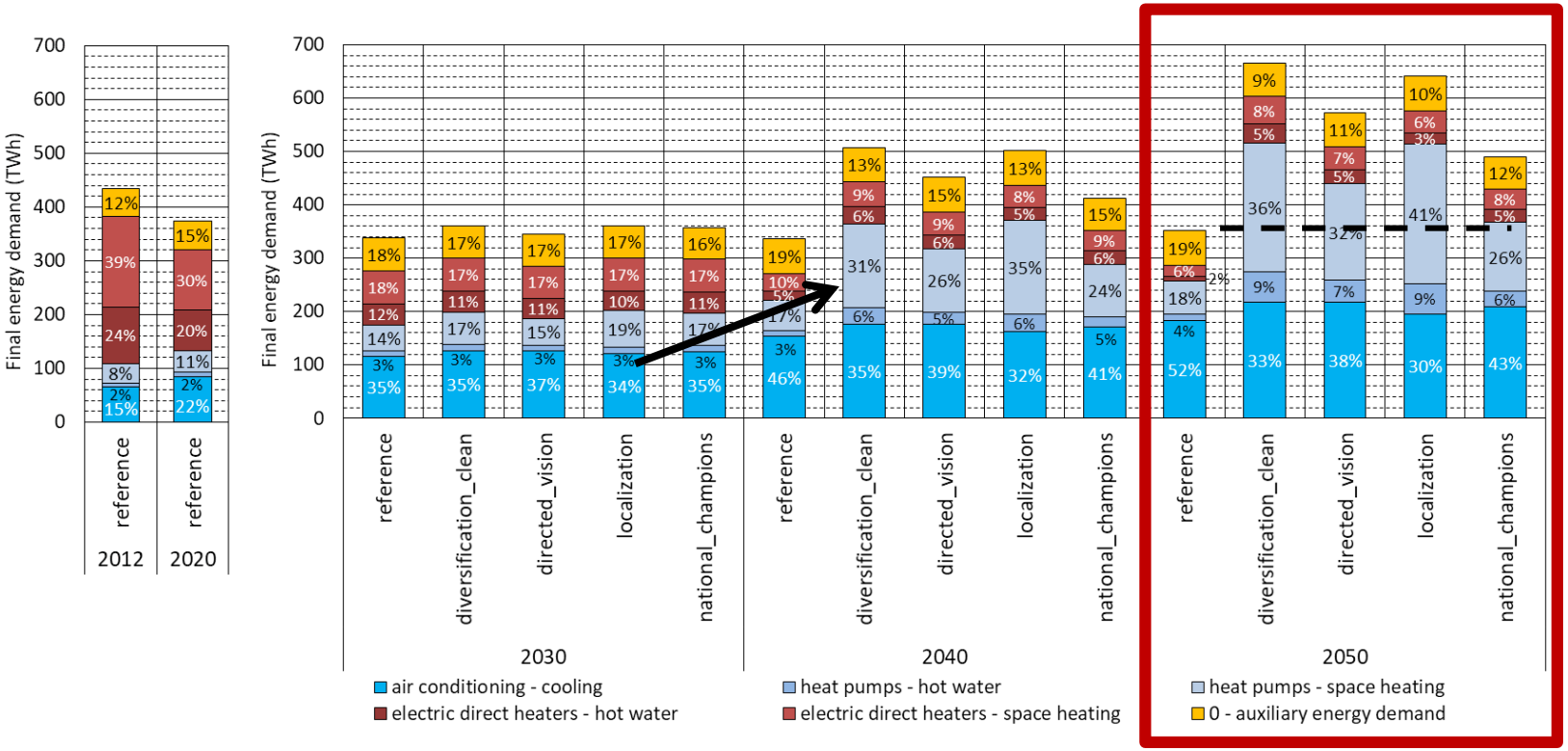


- Direct CO2 emissions are reduced to more than -90% (national champions close to -90% - green gas?)

ELECTRICITY DEMAND FOR HEATING AND COOLING



Electricity demand increase triggered by **new** installations of heat pumps and cooling systems – making them demand response ready would decrease pressure on the electricity system

FINAL ENERGY DEMAND FOR HEATING AND COOLING

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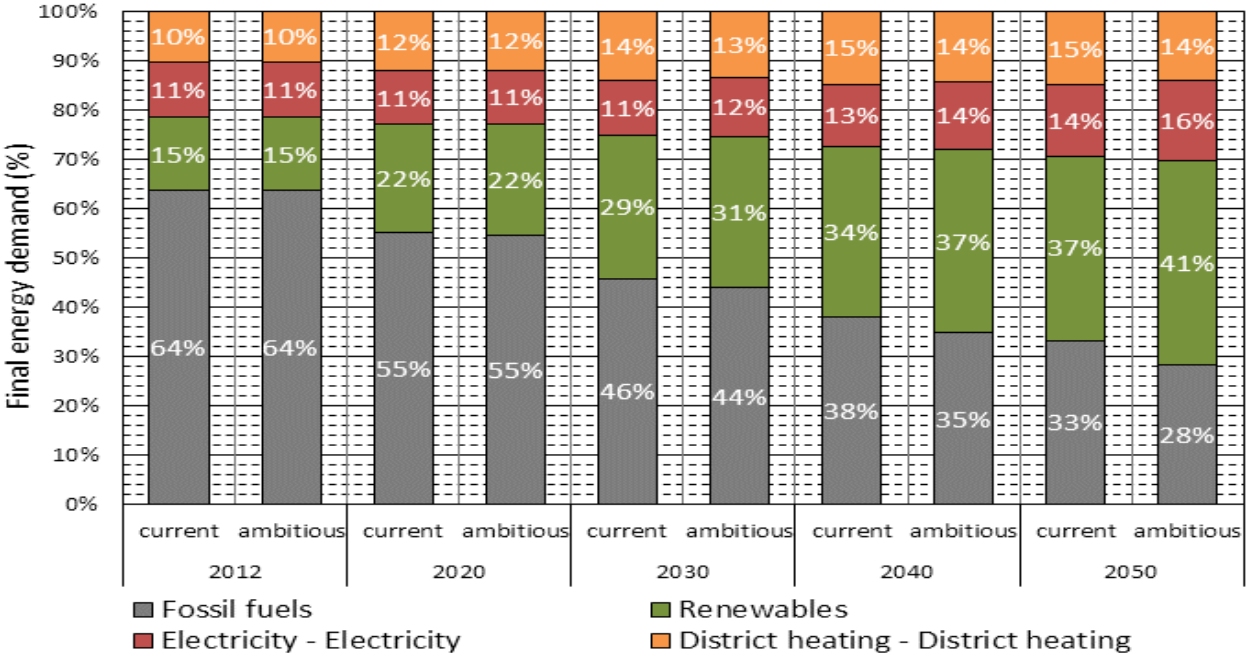

- Share of decentral renewable heating of around 40% in 2050
- Decarbonization of electricity and district heat generation is essential
- Natural gas accounts for the main share of CO_2 emissions
- CO_2 emission reductions below -75% in current, around -80% in ambitious scenario
- Future role of (natural) gas for heating?

Investments and Subsidies – total (env + hvac)

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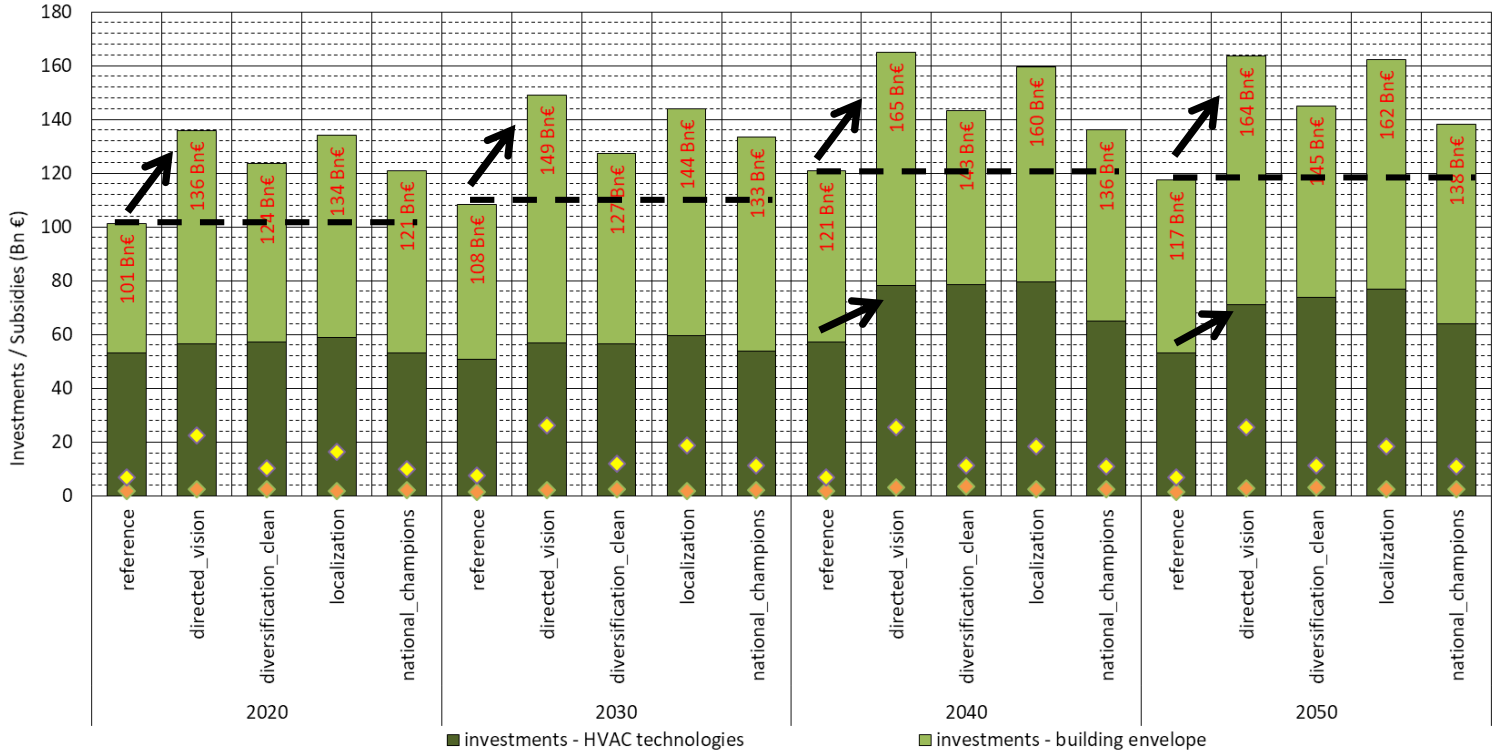

All pathways lead to substantially higher investments due to more thermal renovation activity but also higher investments in heating systems (fast substitution of natural gas)

PATHWAY DESCRIPTION

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	SET-Nav			
	Diversification	**Directed Vision**	**Localisation**	**Nat. champ.**
Financial support of RES heating systems	direct investement subsidies for all renewable heating systems	moderate direct investment subsidies for thermal efficiency measures	direct investement subsidies for all renewable heating systems More subsidies for PV and solar thermal	country dependent
Obligations for renewable shares for heating per building	new installations of fossil heating systems prohibited from 2030	new installations of fossil heating systems prohibited from 2030	new installations of fossil heating systems prohibited from 2030	country dependent
Thermal efficiency improvement	**LOW** - investment subsidies - enhancement of building codes as in ambitious scenario	**HIGH** - enhanced investment subsidies for deep renovation - enhanced renovation obligations from 2025	**MODERATE** - moderate investment subsidies - moderately enhanced renovation obligations from 2025	country dependent
Biomass	**LOW** - reference scenario potentials - pessimistic diffusion of biomass - investment subsidies for pellets as in ambitious scenario - no investment subsidies for wood log, wood chips	**LOW** - reference scenario potentials - very pessimistic diffusion of biomass - investment subsidies for pellets as in ambitious scenario - no investment subsidies for wood log, wood chips	**LOW** - reference scenario potentials - very pessimistic diffusion - no investment subsidies	country dependent
District heating	**LOW** - pessimistic diffusion of district heating	**HIGH** - optimistic diffusion of district heating (zoning and connection obligations, cost reduction) - enhanced investment subsidies	**MODERATE** - moderately optimistic diffusion rates	country dependent
Heat pumps	**HIGH** - significant cost reduction (-20% until 2040) - high subsidies, as in ambitious scenario	**MODERATE** - moderate cost reduction (-10% until 2040) - moderate diffusion of heat pumps - moderate investment subsidies	**MODERATE** - moderate cost reduction (-10% until 2040) - moderate investment subsidies	country dependent
Green gas	**LOW**	**LOW**	**LOW**	country dependent
PV	**HIGH** - high diffusion - investment subsidies as in ambitious scenario	**MODERATE** - moderate diffusion - moderate investment subsidies	**HIGH** - high diffusion - investment subsidies as in ambitious scenario	country dependent
Solar thermal	**MODERATE** - moderate diffusion of solar thermal systems - investment subsidies as in ambitious scenario	**LOW** - low diffusion - investment subsidies as in ambitious scenario	**HIGH** - high diffusion rates - investment subsidies as in ambitious scenario	country dependent
Efficiency improvements through smart technologies	**HIGH** - strong support and acceptance of smart thermostats from 2025	**HIGH** - strong support and acceptance of smart thermostats from 2025	**MODERATE** - moderate support and acceptance of smart thermostats from 2025	country dependent

Pathway Assumptions – national champions

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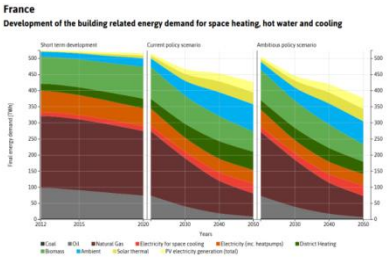
	Ambitious renovator	High district heating	High electrification	biomass country	Solar country	Smart heating	Allow Gas (green Gas)
AT	yes	yes	yes	yes	no	yes	no
BE	no	no	yes	no	no	yes	yes
BG	no	yes	no	yes	no	yes	no
CY	no	no	yes	no	yes	no	no
CZ	yes	yes	yes	no	no	yes	no
DE	yes	yes	yes	no	no	yes	yes
DK	no	yes	yes	no	no	yes	no
EE	no	yes	no	yes	no	yes	no
ES	no	no	yes	no	yes	no	no
FI	yes	yes	no	yes	no	yes	no
FR	yes	no	yes	no	no	yes	yes
GB	yes	no	yes	no	no	yes	yes
GR	no	no	yes	no	yes	no	no
HR	no	no	yes	no	yes	no	no
HU	yes	yes	no	yes	no	no	yes
IE	no	no	yes	no	no	yes	no
IT	no	no	yes	no	yes	yes	no
LT	yes	yes	no	yes	no	no	no
LU	yes	no	yes	no	no	yes	yes
LV	yes	yes	no	yes	no	no	no
MT	no	no	yes	no	yes	no	no
NL	yes	no	yes	no	no	yes	yes
PL	no	yes	no	yes	no	no	yes
PT	no	no	yes	no	yes	no	no
RO	yes	yes	no	yes	no	no	no
SE	yes	yes	yes	yes	no	yes	no
SI	yes	no	yes	yes	no	yes	no
SK	yes	yes	no	no	no	no	yes

Case study 5.2: Scenarios and model links

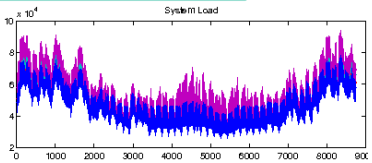
Building stock model:

Model: Invert-EE/Lab



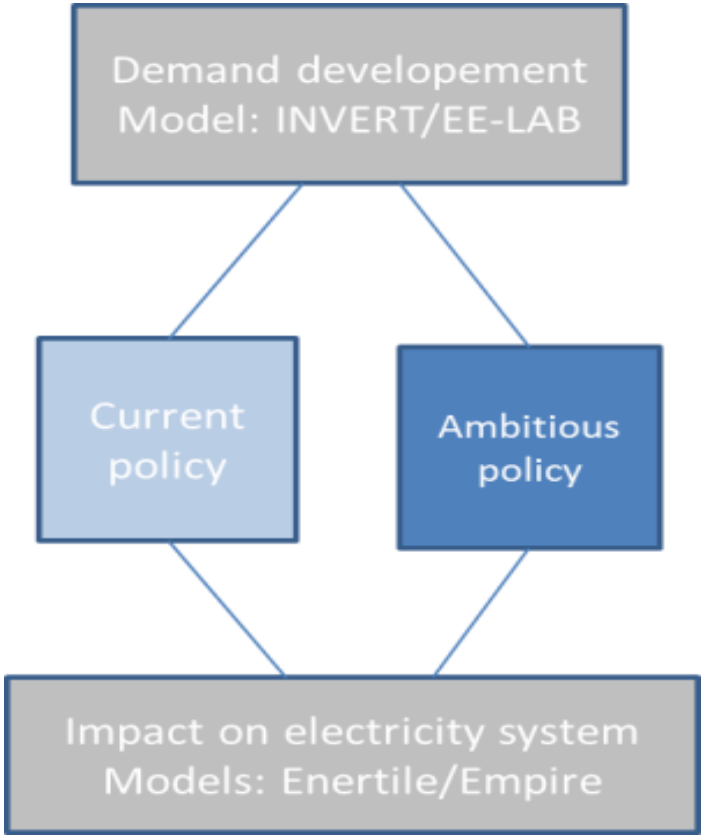
Transformation into hourly load profiles:

Model: eLoad



Electricity system models

Models: Enertile/Empire



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MAIN RESULTS

FINAL ENERGY DEMAND FOR HEATING AND COOLING

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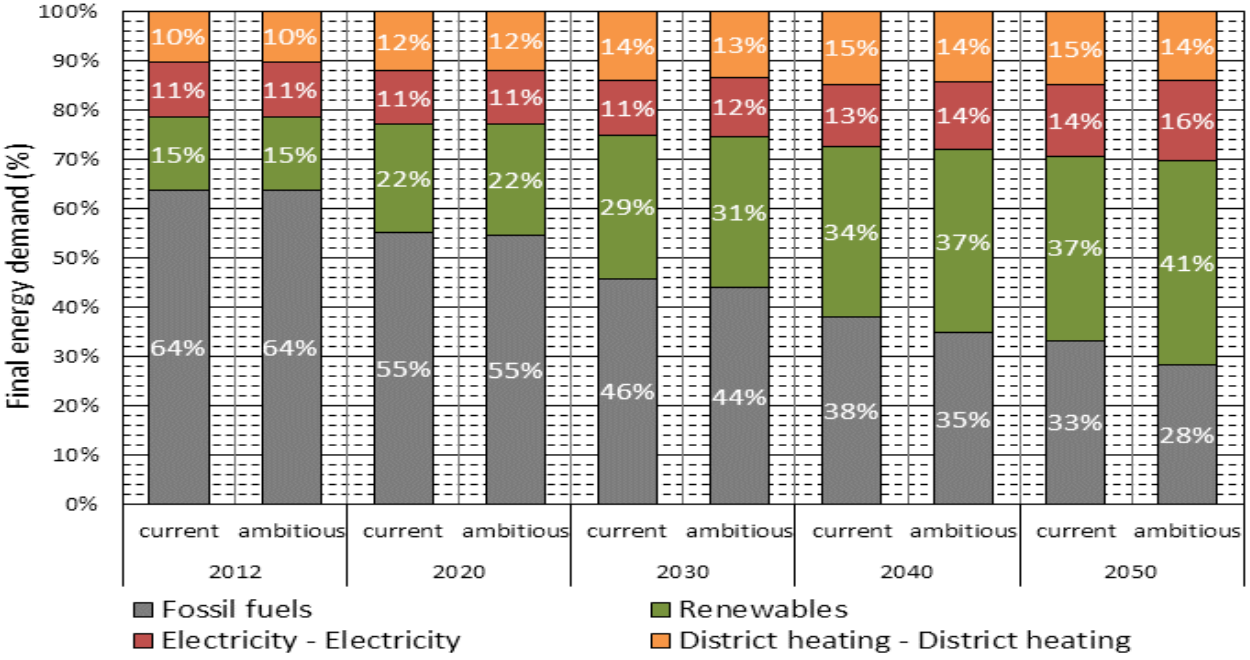

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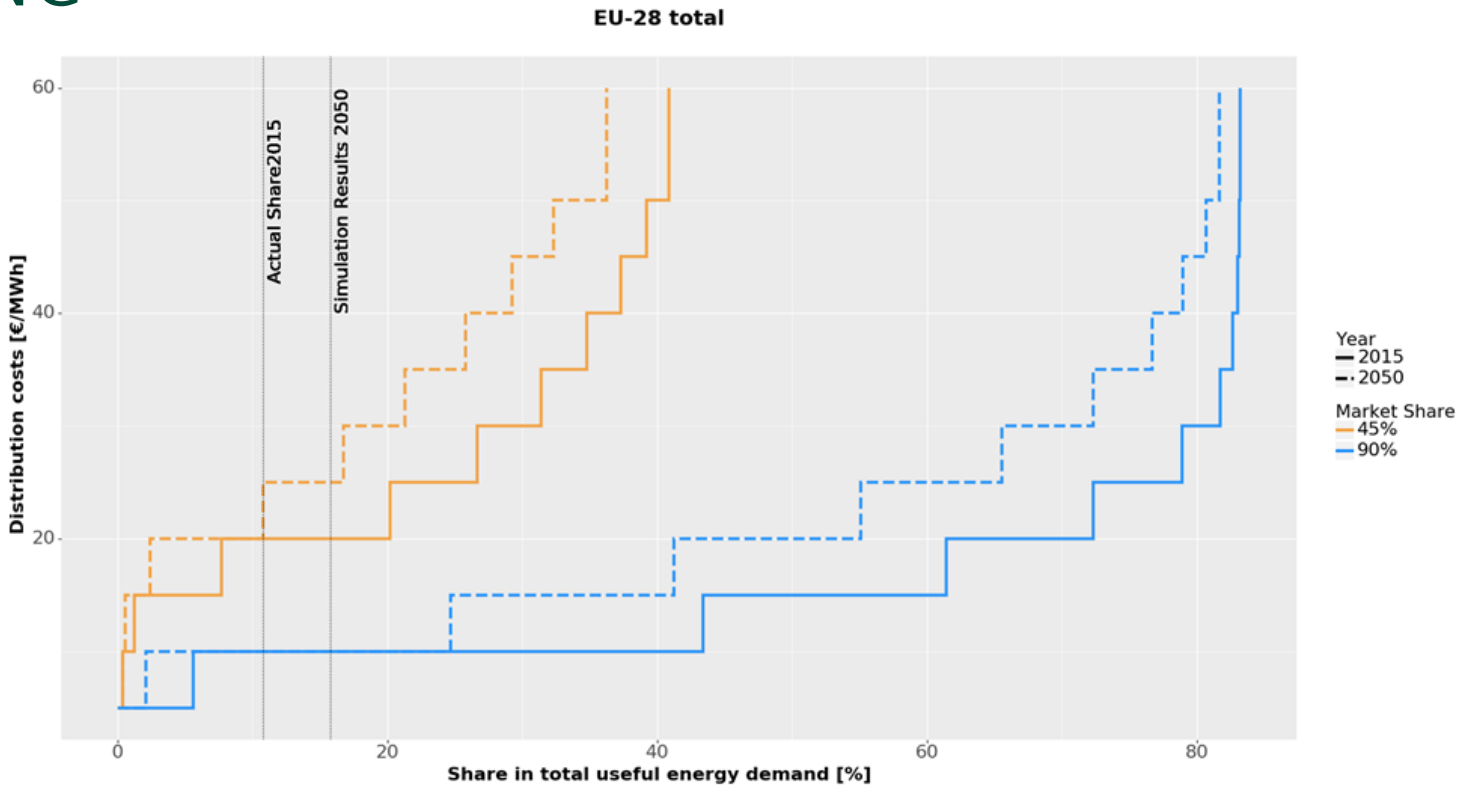
- Future role of (natural) gas for heating?

Potentials for District heating



- High additional potential for district heating networks with low heat distribution cost
- Only if high connection rates can be achieved
- Potential path to more district heating instead of natural gas
- Policy measures needed to achieve high connection rates (zoning + connection obligations?)

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Electricity for heating/cooling and flexibility

ELECTRICITY DEMAND FOR HEATING AND COOLING

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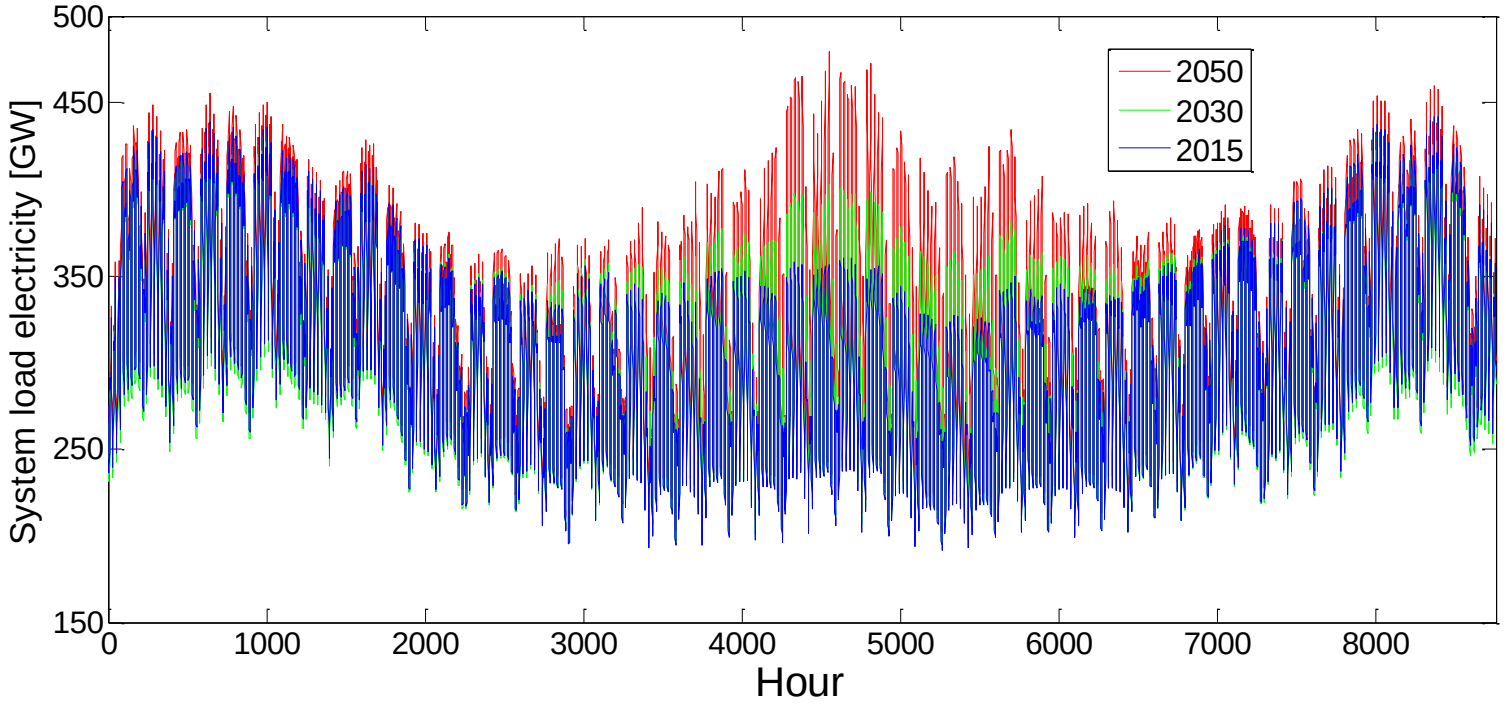
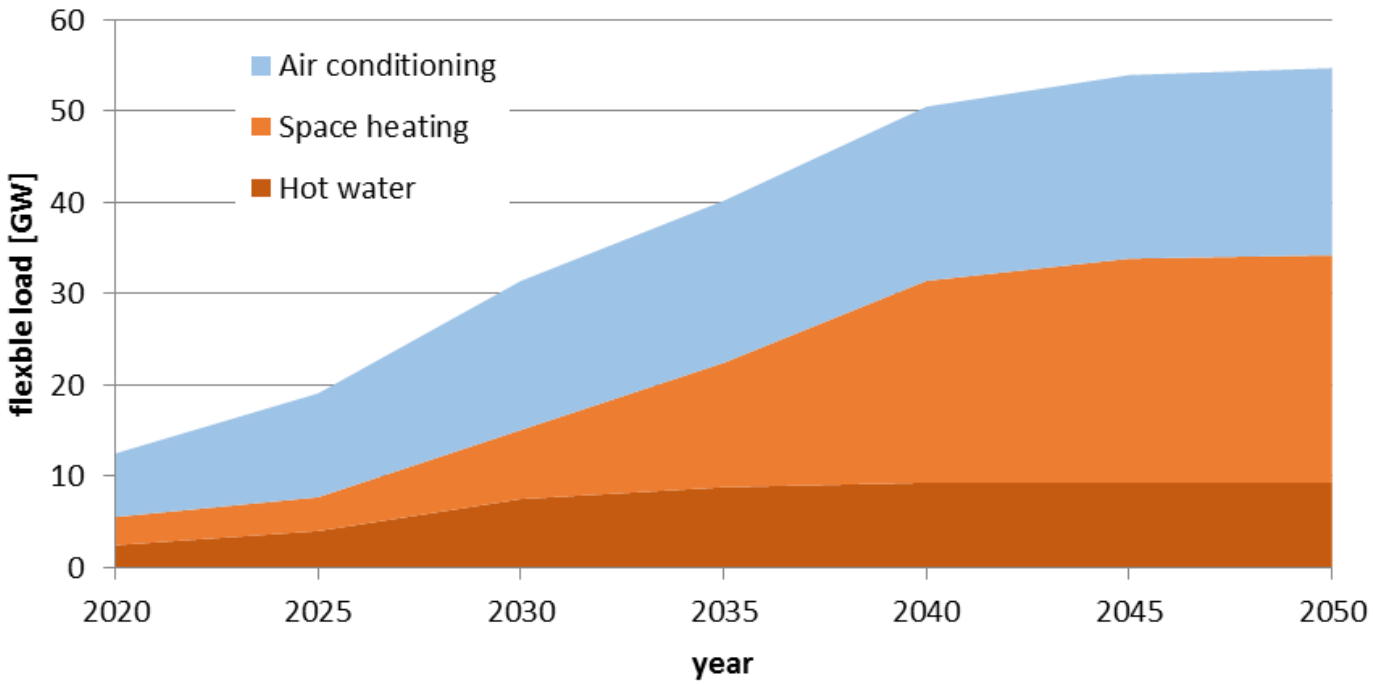


- Electrical loads in winter are not expected to increase in scenarios
- Uptake of decentral heat pumps expected to be feasible
- Demand peaks in summer could increase significantly

UPTAKE OF FLEXIBILITY OPTIONS IN EMPIRE



- Modelling results from the Empire model suggests strong uptake of flexibillity options to be cost efficient
- Flexible loads from heating and cooling in the range of 10% of peak loads for the year 2050

VALUE OF FLEXIBILITY IN ENERTILE

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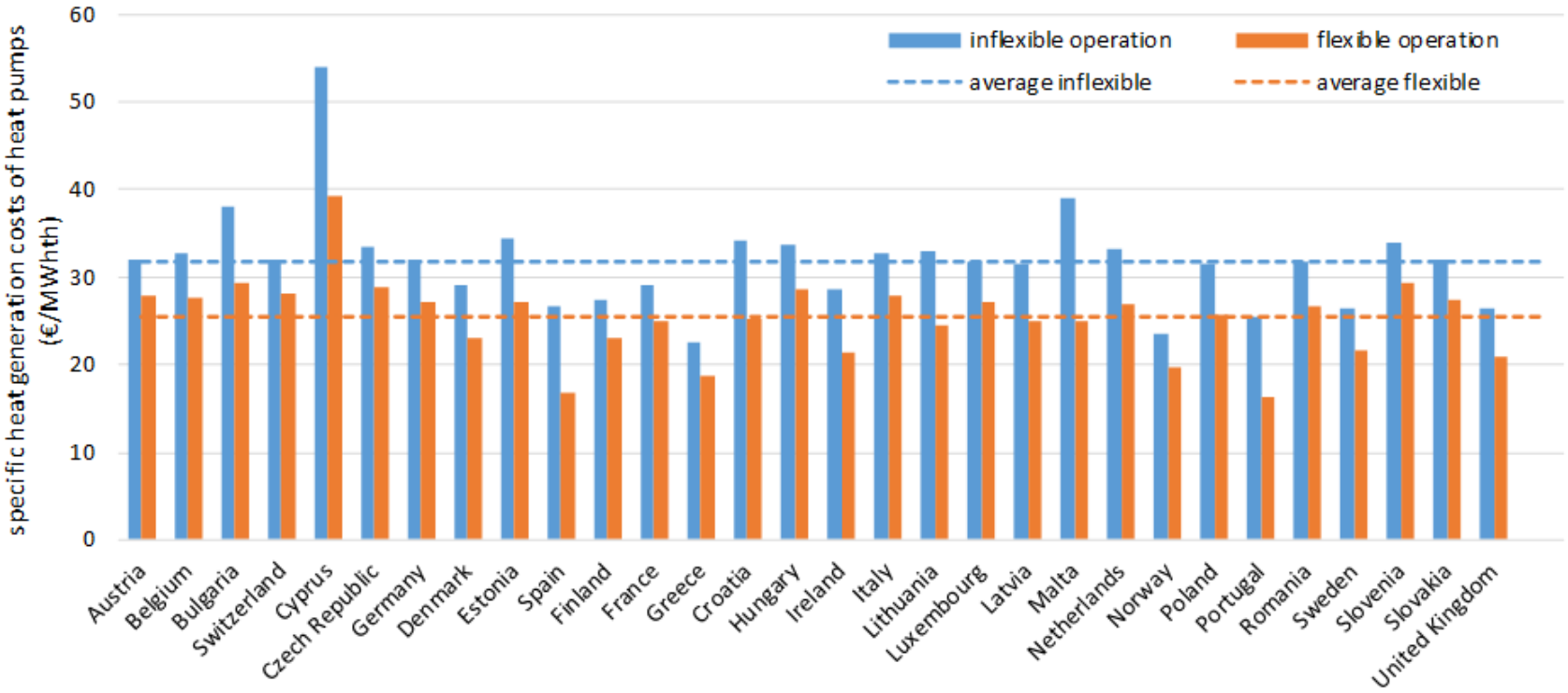

- Lower heat generation costs of heat pumps of ~6 €/MWh
- Flexible operation of heat pumps reduces systems costs by around -0.5%
- 25 GW less installed capacity of gas fired power plants

CONCLUSIONS

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- Strong decrease of final energy demand is expected – policies can lead to more renovation activities
- Uptake of solar thermal, heat pumps, and biomass. Thermal renovation and efficient new construction also help to conserve biomass and limit the impact of electricity demand for heat pumps
- Further reduction of natural gas is needed to achieve ambitious climate targets!
- High potential for district heating if high connection rates are achieved
- Heating and cooling provide high flexibility potentials for the electricity system – Competition with other flexibility options (grid, storage, other sectors)

ELECTRICITY DEMAND FOR HEATING AND COOLING

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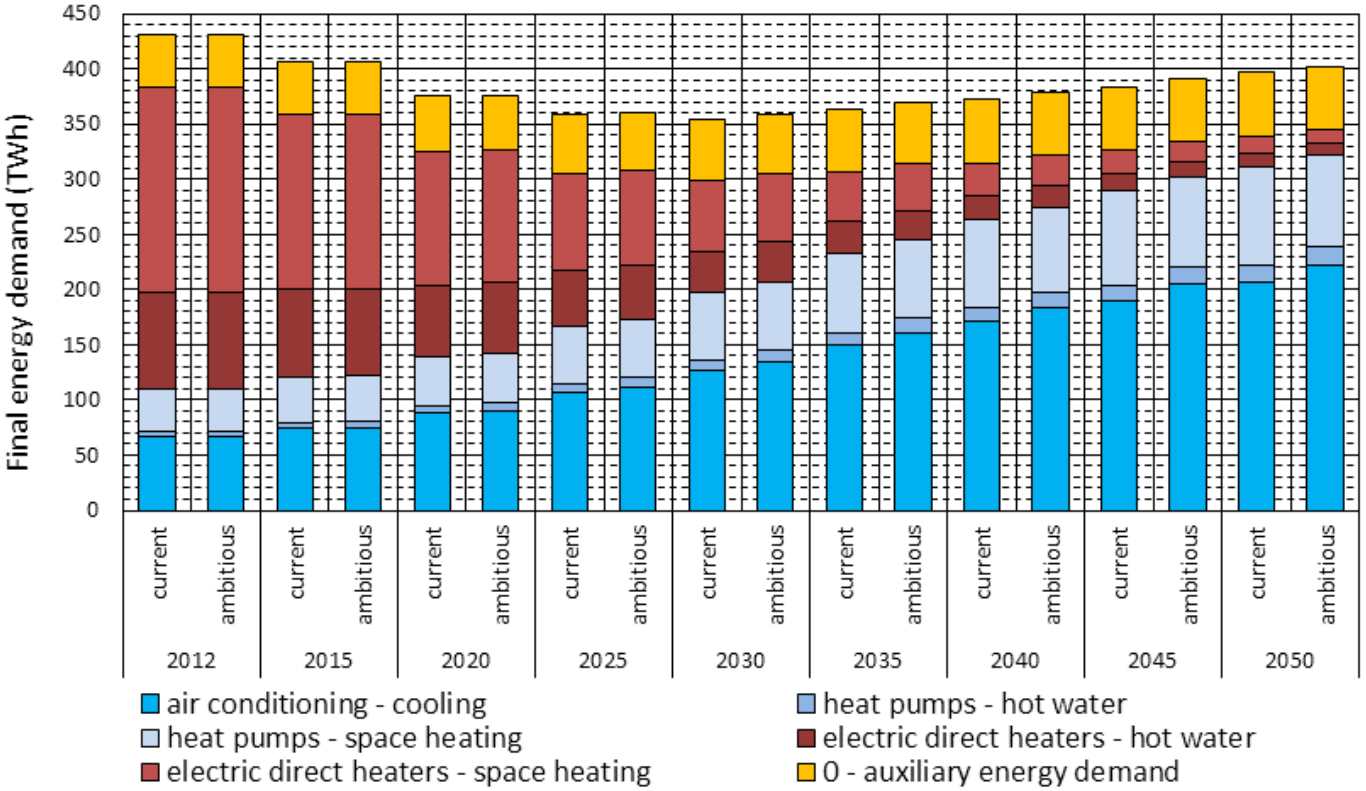

- Decrease of electricity demand for heating due to more efficient buildings and substitution of direct electric heaters
- Strong increase (>+200%) in electricity demand for space cooling

Final energy demand (TWh)	2015		2050									
Scenario	reference		reference		diversification		directed vision		localization		national champions	
	(TWh)	(%)	(TWh)	(%)	(TWh)	(%)	(TWh)	(%)	(TWh)	(%)	(TWh)	(%)
gas	1664	45%	1090	38%	116	5%	110	5%	118	5%	571	23%
fuel oil	515	14%	176	6%	33	1%	33	1%	34	1%	43	2%
coal	122	3%	24	1%	20	1%	3	0%	20	1%	20	1%
District heating	394	11%	360	13%	362	15%	547	23%	438	17%	333	13%
Electricity	410	11%	351	12%	663	27%	573	24%	641	25%	490	20%
biomass	520	14%	459	16%	578	23%	540	22%	495	20%	456	18%
ambient heat	73	2%	164	6%	489	20%	383	16%	514	20%	319	13%
solar thermal	22	1%	216	8%	232	9%	229	9%	260	10%	241	10%
TOTAL	3720	100%	2840	100%	2493	100%	2417	100%	2520	100%	2473	100%