MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM

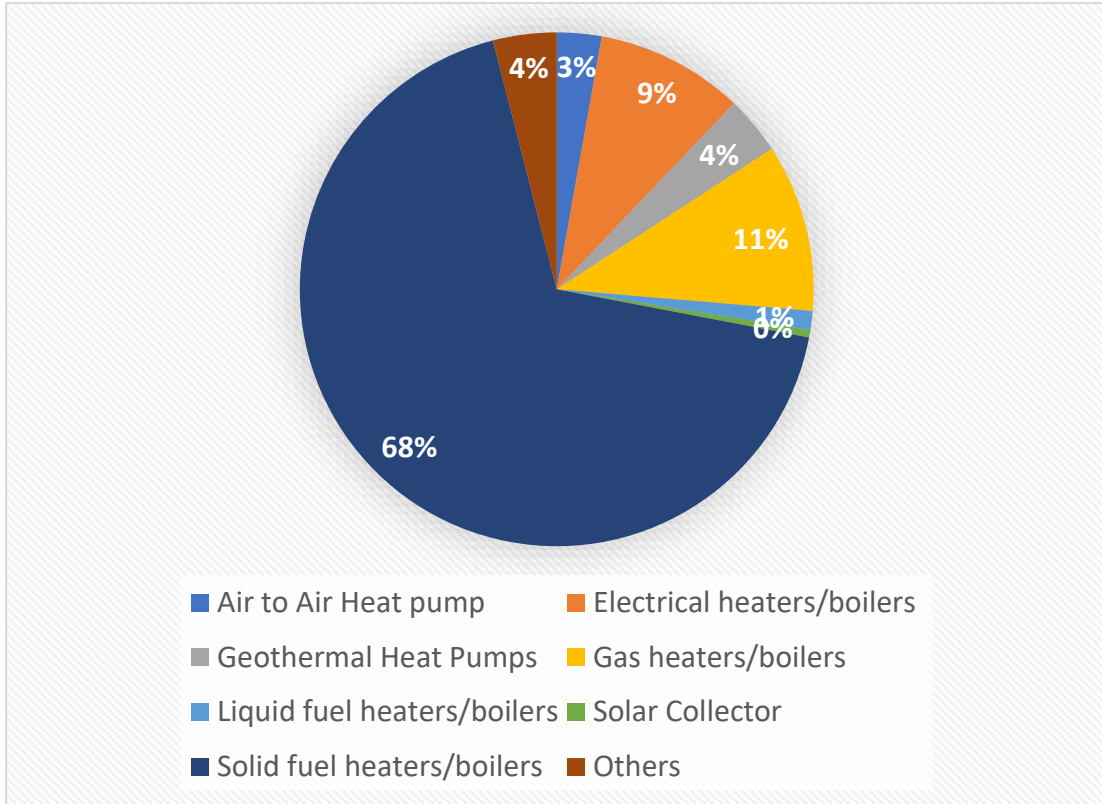
Transitioning to a climate-neutral heating and cooling in Estonia - Refurbishment & green transition of existing DHC & CHP

Ketli Lindus, Department of Energy
Ministry of Economic Affairs and Communications of Estonia

Current situation

MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM

- Estonian district heating is highly regulated, and it is 93% efficient according to Directive 2012/27/EU (EED) definition
- Ca 65% (4,450 GWh) of the total heat demand is covered district heating
- Technology mostly based on biomass – *status quo*
- Biomass ca 51% in district heating and 20% natural gas (before 2021) – gas declining



Challenges

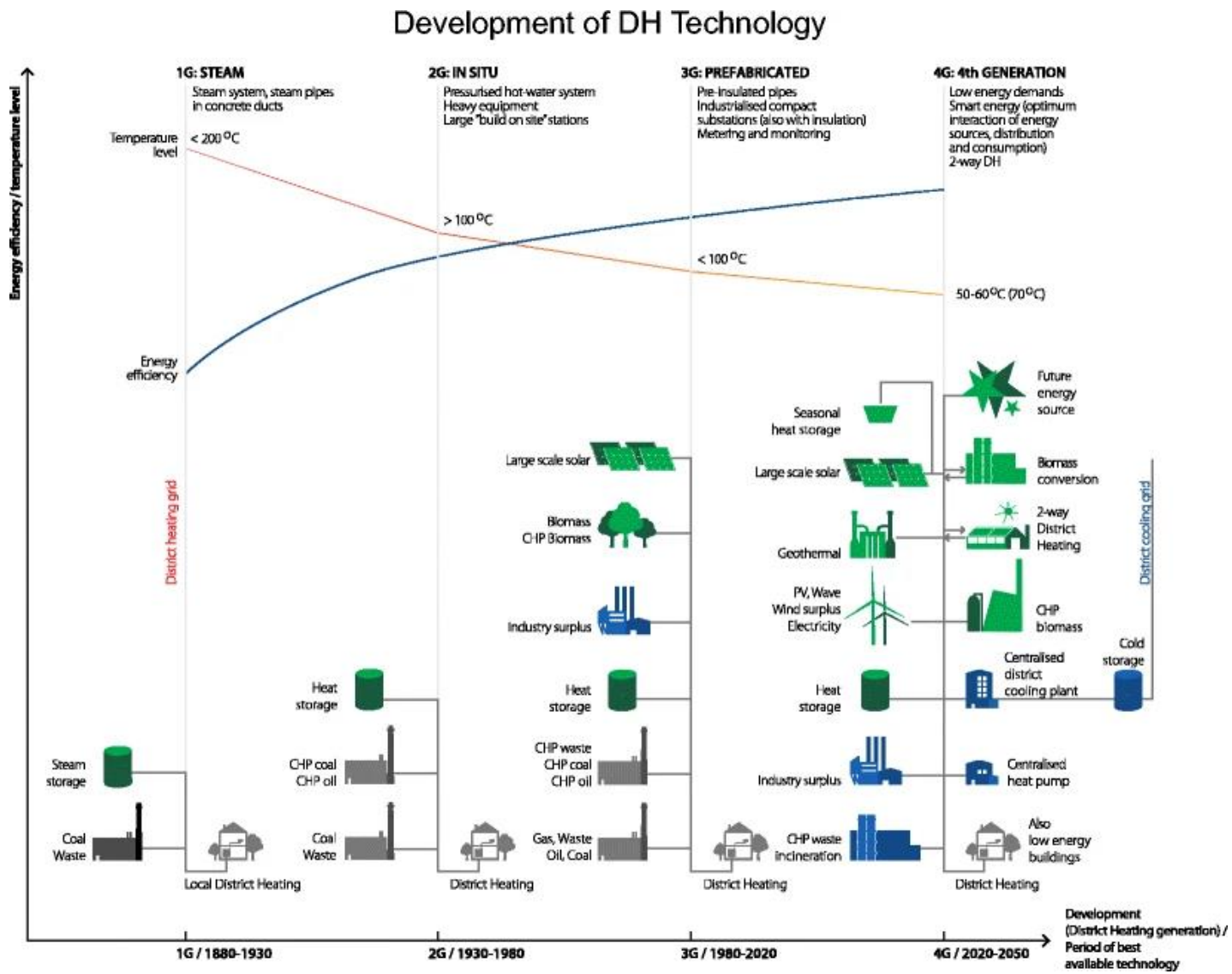
- Buildings infrastructure not efficient
- Demographic changes causing falling out of use of buildings – urbanisation
- Regional differences vary when considering solutions for decarbonisation of H&C
- Lack of data – smartmeters are mostly used but gaining detailed information is not easy

Building renovation parameters

Building Type	Area (million m^2)	Falling rate by 2050 (million m^2)	Area (million m^2) required for renovation
Single houses	27.6	4.8	22.8
Apartment buildings	23.6	5	18.6
Services/Commercial/Public	22.9	5.9	17.0

Challenges

- What will subsitute biomass?
- What will substitute natural gas?
- How to achieve carbon neutrality and reach next generation of DH?



First steps

- Tender for the analyse „ Transitioning to a carbon neutral heating and cooling in Estonia by 2050“
- Outcomes:
  - Outcome 1: Descriptions and analyses of at least three scenarios (+BAU) towards carbon neutral heating and cooling in Estonia by 2050;
  - Outcome 2: Impact assessment of carbon neutral heating and cooling scenarios;
  - Outcome 3: Action Plans for carbon neutral heating and cooling scenarios in Estonia by 2050
- Outcomes gained in March 2023

Pillars for the analyze

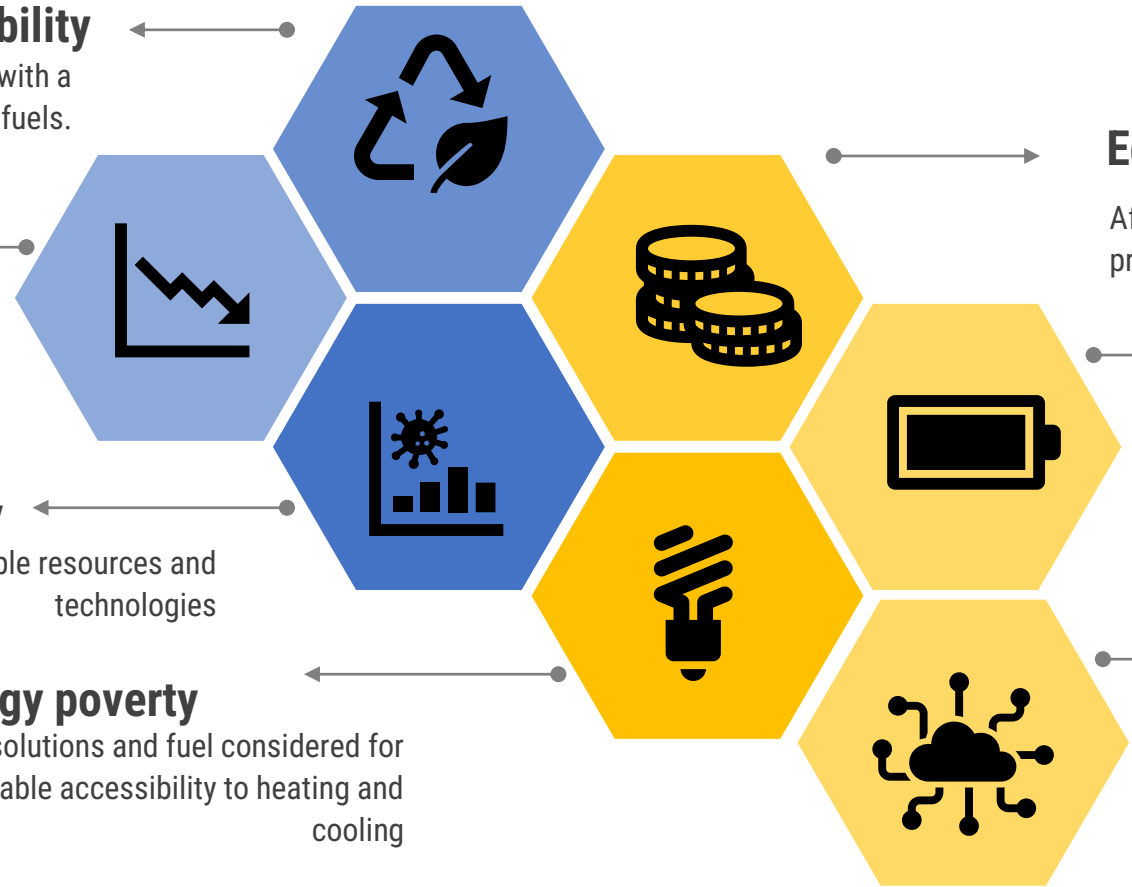
MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM

Sustainability
Electric and biomass solutions are considered with a phase out of fossil fuels.

Energy efficiency
Renovation wave to achieve high level of energy efficiency assumed in Estonia

Security of supply
Ensuring that energy demands are met with ample resources and technologies

Minimizing energy poverty
Cheapest and most accessible solutions and fuel considered for different market participants to enable accessibility to heating and cooling



Economically reasonable models
Affordable and cheap sources of heating and cooling preferred

Energy market integration
Consideration that the electricity, gas and heating market are all integrated. Availability of resources and market integration to be considered

High level of digitalization
Smart thermostats for heating and cooling technologies considered. Energy demand reduction can be up to 10% by 2040 (Source: IRENA)

Reaching energy efficiency- renovation

Single Houses
Heating: 140 kWh/m²
Cooling: 8 kWh/m²

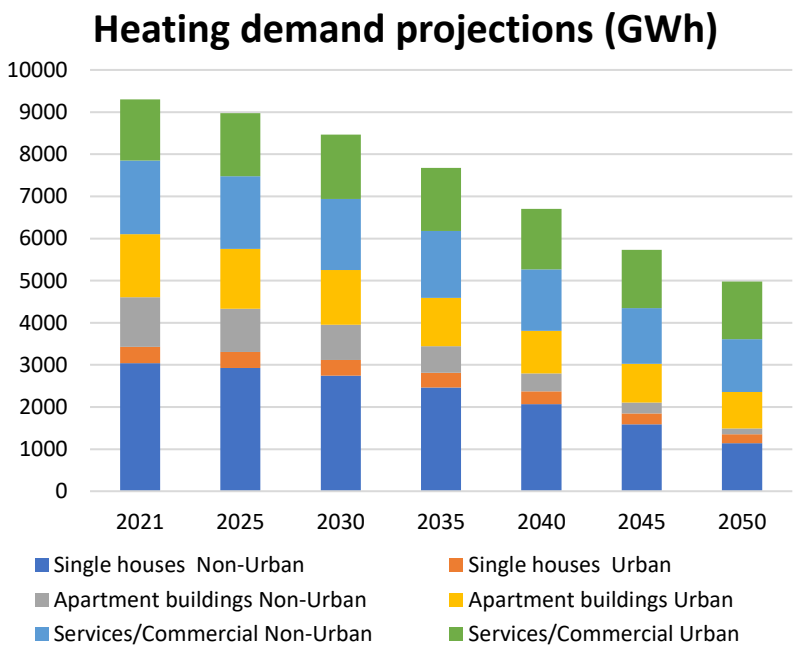
Apartment buildings
Heating: 130 kWh/m²
Cooling: 8 kWh/m²

Services and commercial
Heating: 160 kWh/m²
Cooling: 37.5 kWh/m²

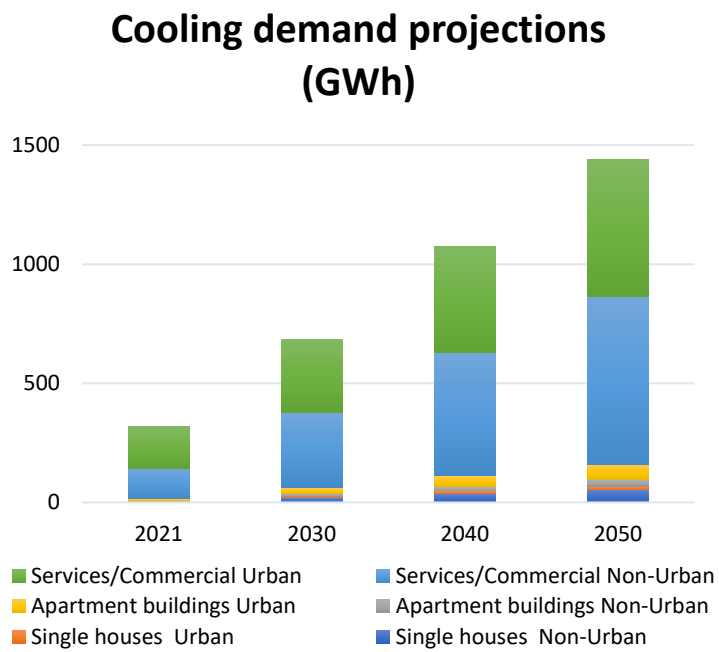
Table 1. Heat consumption factors before and after renovations.

	Before Renovation (kWh/m²)	After Renovation (kWh/m²)
Single houses	140	60
Apartment buildings	130	50
Services/Commercial	160	80

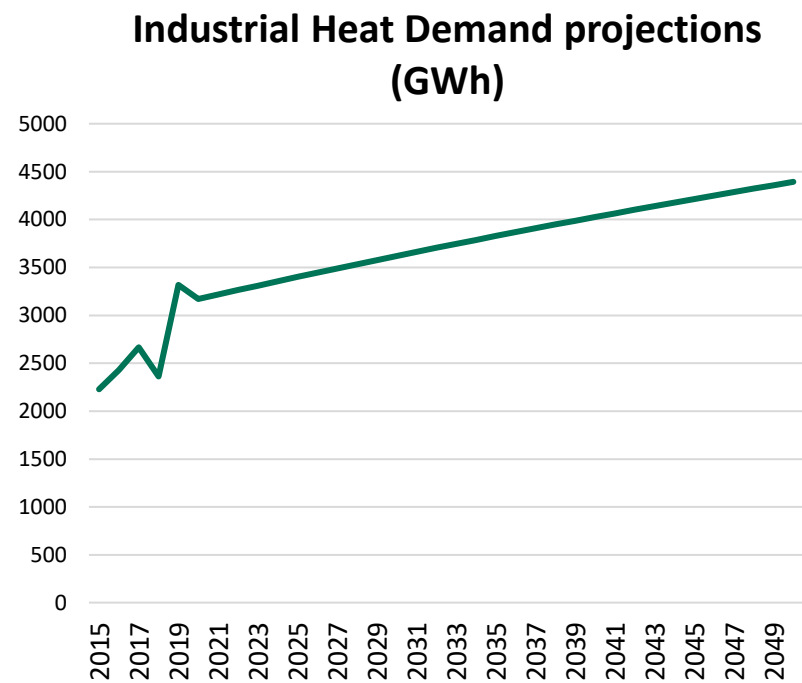
Heating and cooling demand projections



*Heating demand projections: based on the **renovation wave**, **buildings falling out of use** and **new building construction rates***



*Cooling demand projections: based on the **renovation new building construction rates***



*Industrial heat demand Projections: based on the **potential of heat conservation** and **probable increase in activity** (Energy saving potential is taken as 30% from Odyssee and increase in activity is taken as double of 2018 values)*

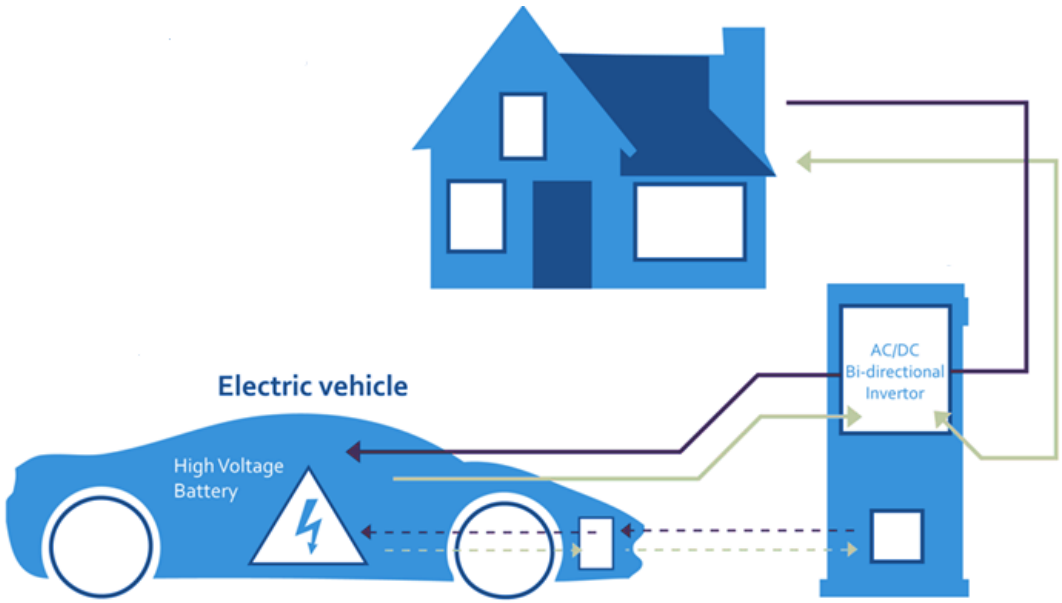
Scenarios

Scenarios	Description
BUSINESS AS USUAL (BAU) SCENARIO	Heating and cooling mix which assumes that there will be limited changes in people's attitudes and priorities. The BAU pathway will focus on technologies that are already commercialized or nearly so and will account for existing climate and energy policies that affect Estonia's heating sector.
HEATING & COOLING THROUGH ELECTRIFICATION ONLY	All infrastructure and technologies will be based on electric solutions (both district & local). The electricity needs will be covered by renewable electricity and will be added progressively depending on the resource availability, TRL, financial feasibility and access.
EXTREME PUSH TOWARDS DISTRICT HEATING AND COOLING (DHC)	All possible heating & cooling requirements will be based on district heating & cooling solutions. Energy source will be based on technologies that are considered sustainable and usable for district heating systems. Local heating solution will be as limited as possible (only placed where district solutions are not in line with the balance of the pillars).
EXTREME PUSH TOWARDS LOCAL HEATING AND COOLING (LHC) SOLUTIONS	Mainly single house-based solutions and local autonomous systems. The district grid will be phased out while shifting all the possible demand towards local solutions. Industry needs are integrated though industrial clusters which allows local solutions to be integrated with industry.
TECHNOLOGY NEUTRAL / ALL TECHNOLOGIES	No preference towards any type of infrastructure (local and district) with the flexibility of using any kind of renewable technology, in accordance with the pillars.

Role of mobility in carbon neutral heating and cooling

MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM

Vehicle 2 Home (V2H) / Vehicle 2 Building (V2B)



Electrical Energy Provision Potential of BEVs

	2030		2050	
Number of cycles	Number of cars	Energy provision (GWh)	Number of cars	Energy provision (GWh)
1	97,500	4.7	600,000	22.0
25	97,500	117.5	600,000	551.7

Total electricity requirement to provide heating and cooling for different market participants across different scenarios

Electricity consumption requirement for heating and cooling (GWh)						
	Single houses		Apartment buildings		Services/Commercial	
Scenarios	2030	2050	2030	2050	2030	2050
BAU Scenario	261	164	58	70	360	545
DHC	251	121	42	7	282	201
LHC	270	184	87	173	421	792
Electrification	449	444	125	153	510	926
Neutral	269	181	60	70	368	569

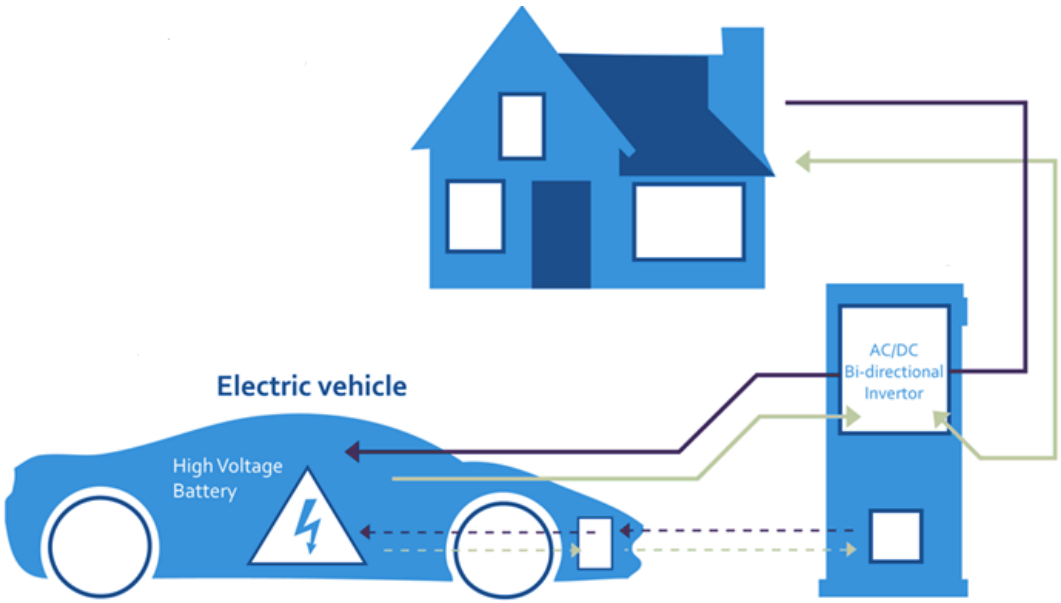
https://www.evconsult.nl/en/cashing-in-with-your-electric-car-with-v2g-technology/

Role of mobility in carbon neutral heating and cooling

MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM

Indicative electrical demand coverage by BEVs for electric based heating and cooling solutions for different market participants

Vehicle 2 Home (V2H) / Vehicle 2 Building (V2B)

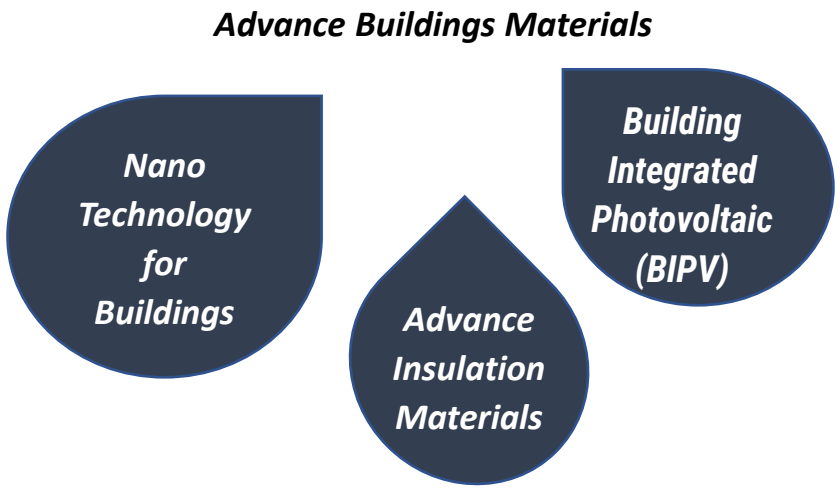


https://www.evconsult.nl/en/cashing-in-with-your-electric-car-with-v2g-technology/

Houses (GWh)						
	2030			2050		
Scenarios	H&C demand	coverage from 1 cycle	coverage from 25 cycles	H&C demand	coverage from 1 cycle	coverage from 25 cycles
BAU Scenario	261	1.8%	45.1	164	13.4	100.0%
DHC	251	1.9%	46.9	121	18.1	100.0%
LHC	270	1.7%	43.5	184	12.0	100.0%
Electrification	449	1.0%	26.2	444	5.0	100.0%
Neutral	269	1.7%	43.7	181	12.2	100.0%
Apartment buildings						
BAU Scenario	58	8.1%	100.0	70	31.5	100.0%
DHC	42	11.2%	100.0	7	100.0	100.0%
LHC	87	5.4%	100.0	173	12.7	100.0%
Electrification	125	3.8%	93.8	153	14.4	100.0%
Neutral	60	7.9%	100.0	70	31.4	100.0%
Services/Commercial						
BAU Scenario	360	1.3%	32.6	545	4.0	100.0%
DHC	282	1.7%	41.7	201	10.9	100.0%
LHC	421	1.1%	27.9	792	2.8	69.5%
Electrification	510	0.9%	23.0	926	2.4	59.4%
Neutral	368	1.3%	31.9	569	3.9	96.7%

Effect of advanced building materials on heating and cooling

MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM



An indicative energy reduction potential if 10% of the total building stock in Estonia is renovated with advance building materials by 2030 and 2050.

Energy saving potential on total heating and cooling with building materials				
	2030		2050	
	Nano materials	Insulation Materials	Nano materials	Insulation Materials
Single houses (GWh)	251.4	188.5	135.5	101.6
Apartment buildings (GWh)	173.9	130.5	87.6	65.7
Services/ Commercial (GWh)	306.5	229.8	311.9	233.9

An indicative energy production potential of installing BIPV on 10% of the building area for different market participants by 2030 and 2050

Building type	2030		2050	
	Installation area (mil. m_2)	Energy production (GWh)	Installation area (mil. M_2)	Energy production (GWh)
Single houses	28.79	1834.2	31.5	2006.6
Apartment buildings	25.63	1632.7	30.2	1925.8
Services /commercial	29.85	1901.5	45.3	2883.1

Unique cases for district grid

Cases	Technologies	Unique source/Configuration
Case 1	A/W HP	Low temperature industrial heat source
Case 2	W/W HP	Mine water, sewage plant water, sea water
Case 3	GT HP	East Estonian Geothermal resources (shallow to mid deep geo-energy)
Case 4	Solar collector + Electrical Boiler	Complementary use of solar energy with electrical boilers
Case 5	Hydrogen Boiler + Electrical Boiler	Use of hydrogen boilers to cover peak demands and electrical boilers to cover base load
Case 6	Biomass boiler / Biomass CHP	Biomass based energy community
Case 7	Biogas boiler	Biowaste based energy community
Case 8	Absorption chiller	Usage of heat from return lines of DH networks

Barriers

MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM

Main problems

- Low energy performance of buildings
- Biomass resource sustainability
- Low performing DHC
- Limited affordable alternatives to replace fossil-based & bio-based heating (building & industry)

Led by…

Key barriers

- ***Policy barriers***: clear path to full H&C decarbonisation; limited integrated planning (at national and local levels); lack of sustainability criteria
- ***Market barriers***: high upfront costs; lack of certainty for long-term viability of DH; lack of economies of scale
- ***Financial barriers***: (*aversion to loans)*; lack of affordable financial resources (for low-income households); (*split incentive problems)*
- ***Capacity barriers***: lack of sufficient, skilled labour; lack of R&D and innovation; lack of well developed supply chains; lack of knowledge of local players (service providers and authorities)
- ***Technical barriers***: lack of required infrastructure; local constraints; building conditions
- ***Social barriers:*** lack of awareness of owners/end-users; public acceptance & sustainability of biomass

Actions

Action sets	Objective	Timeline	Responsible	Other key stakeholders	Cost
1. Streamline integrated H&C planning process	Increase planning coherence and optimize EE and RES actions	Mainly short-term	MKM	Local authorities, DHC and electricity grid operators, CA, KEM, MEM	Low
2. Phase the renovation wave and integrate renewable supply	Improve the energy performance of buildings to reduce heat demand and encourage the integration of RES H&C in renovation	Short/medium-term	BA & KredEx	Ministry of Finance, local authorities, construction sector, building owners	Medium/High
3. Development of the required infrastructure	Ensure that the DHC sector sufficiently invests in the extension and refurbishment of the DHC network	Short-term	MKM	DHC network operators, local authorities, KEM, CA, energy communities	Medium/High
4. Strengthen local authorities' role in H&C decarbonisation	Engage local authorities to be active in H&C decarbonisation planning	Short to long-term	MKM	Local authorities, CA	Medium
5. Set up level playing field and creating a market	Ensure that RES H&C technologies are competitive with fossil-based H&C	Short to long-term	KredEx & CA	HP sector, RM	Medium/High
6. Empower all consumers, especially households	Engage consumers to be active in H&C decarbonization	Mainly short/medium-term	MKM	KredEx, KIK, local/regional authorities, BA, industry, building owners	Medium
7. Strengthen professionals' skills and knowledge	Ensure that there is enough labor capacity in H&C sector	Short-term	Ministry of Education	Unemployment insurance fund, KIK, BA, professionals in H&C sector	Medium/high
8. Mobilize and mainstream financing and funding	Ensure that all financing/funding is effectively mobilized to H&C sector and consumers	Short to long-term	MKM	Financial institutions, building owners	High

Key messages (action sets) as per responsible stakeholders (consumers, State Government, local authorities etc.)

MKM = Ministry of Economic Affairs and Communication; RM = Ministry of Finance; CA = Competition Authority; KEM = Ministry of Environment; MEM = Ministry of Rural Affairs; BA = Building Authority; KIK = Environmental Investment Centre

Timeline: short-term = 2023-2024; medium-term = 2025-2030; long-term = 2030+

Costs: low = admin. costs only; medium = admin costs but long-term; high = admin. costs + investment costs required

Pathway forward ?

Indicator	All electric	DHC	LHC	Tech. neutral	Best achieving pathway
Carbon emissions **CO_2 emissions in 2050* ($ktCO_2$)**	0	0	0	0	All pathways, when assuming fully decarbonised electricity and zero-emitting bioenergy
Biomass dependency **Total biomass consumption in 2050 (TWh) / Total biomass consumption in 2021 (TWh)**	0/12	11.37/12	7.93/12	9.99/12	All electric is biomass independent by 2050. It will be the favourable option in case there is a biomass status quo shift.
Energy efficiency **Fuel consumption for H&C in 2050 (TWh)**	7.55	14.17	10.75	12.85	All electric requires the least input energy for heating and cooling owing to high co-efficient of performances of heat pumps.
Electricity (TWh) – implication on the electricity grid (qualitative impact)	6.6	1.8	2.8	2.3	
Overall socio-economic impact*					DHC and Tech. neutral, but price volatility (and increase) of bioenergy make performance uncertain
Average heating costs for households in 2050 (EUR/MWh)	97	62	74	68	
Average cooling costs for households in 2050 (EUR/MWh)	112	114	113	110	
H&C employment as % of total employment in 2050	2.6%	3.3%	2.4%	2.9%	DHC pathway
Stakeholder risk perception	-	--	--	0	Tech.neutral and All electric
Total investment requirements (2022-2050)	€19,066M	€18,859M	€18,027M	€17,956M	Tech. neutral
H&C technologies	€2,274M	€1,108M	€1,236M	€1,164M	DHC
DHC infrastructure	€53M	€1,012M	€52M	€53M	All pathways but DHC
Building renovation	€16,739M	€16,739M	€16,739M	€16,739M	All pathways
Environmental and social impacts	+	-	-	-	All electric (See Error! Reference source not found., last row)

Pathway forward ?

- Not one specific scenario will not bring the desired result
  - Integrated scenario, based on regional approach!
    - Where reasonable to use district heating/cooling!
    - Implement Renewable energy and other Resources locally available – geothermal, seawater, PV, wasteheat, Hydrogen?? etc
- Combined Electricity and District Heating and Cooling scenario could provide the best result
  - Electricity scenario includes goethermal, sea water and other heat exchanger technologies
- Status quo for biomass has the effect on the choices
- **To set course for carbon neutrality but keep agility in the process**

Next steps

- Strategical meetings with related stakeholders to start taskforce implementing actionplan - 2023
  - Local governments to use the analyse to create vision for themselves according to local conditions
  - Cooperation between DH companies and Competition Authority to create the common ground in updating regulative framework
  - Interdisplinary approach to different markets – more electricity in HC means more renewable energy in the electricity system (+biomass)
- 2023 June - masterplan for concrete actions for the next 4 years

MAJANDUS- JA
KOMMUNIKATSIOONI-
MINISTEERIUM

Thank you for your attention!