Energy Renovations for Lower Temperature District Heating

LT Ready Symposium

14 October 2021 | Prateek Wahi

11%

*CO_2 Emissions comes from the residential sector, **2018***

35%

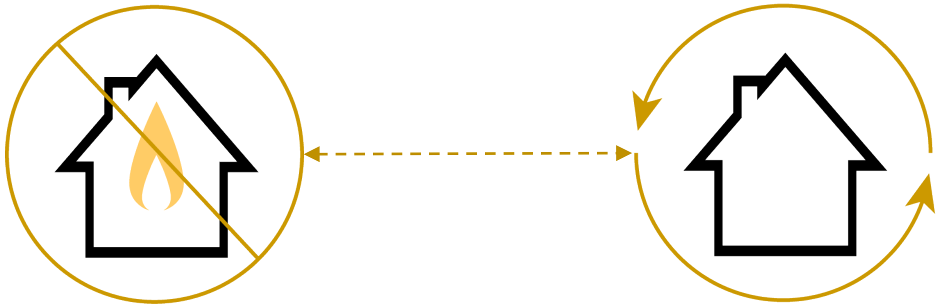
*Natural gas consumption by Residential Sector, **2018***

90%

*of residential heating demands is satisfied by natural gas, **2018***

Climate Agreement Goals : 2030

Decarbonising the built environment by transition towards sustainable source of heating



Making **1.5 million** homes gas free

Transformation rate of **200,000** homes / year

District heating with lower temperature supply

Energy Renovations for integrating lower temperature supply

Source: Dutch Ministry of Economic Affairs and Climate, 2019; EUKN Secretariat, 2018,2019; IEA,2020

Why District heating?

Alternative options for Gas-Free Heating

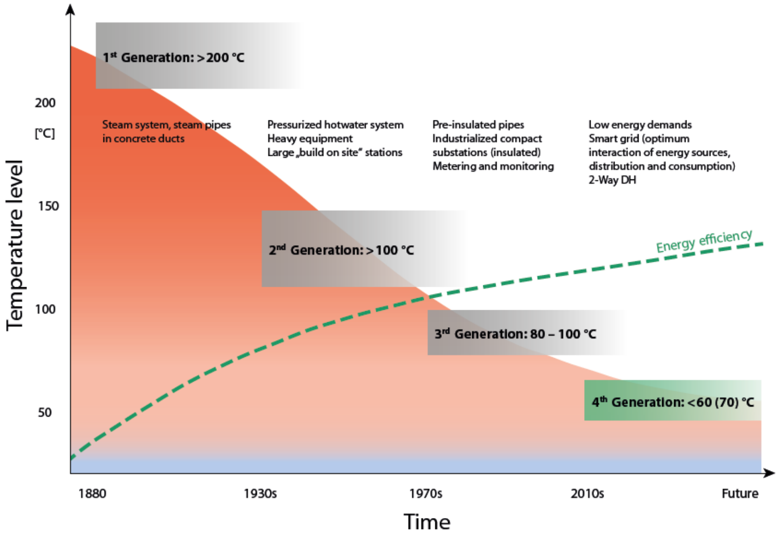
Collective Heating	All electric	Hybrid System
District Heating	Heat Pumps	HP+ Sustainable Gas

5%
Heat is supplied by District heating, ***2019***

50%
Heat is supplied by District heating, ***2050***

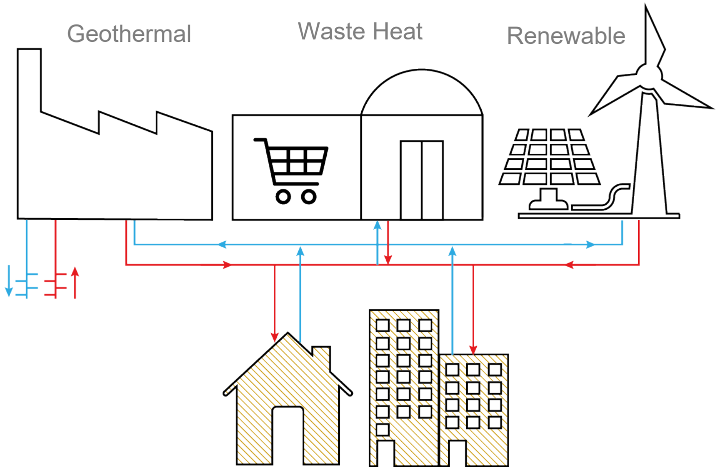
District heating will play a key role in achieving energy transition goals

What is Lower Temperature District Heating?



Third Generation : Traditional DH grids operate at 100 ˚C

Fourth Generation : Reduced temperature supply of about 50˚C



Integration of renewable and waste heat sources.

Potential to curb GHG emissions.

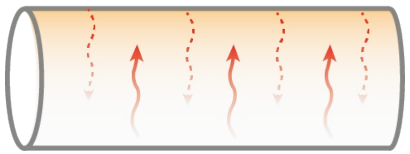
Source: Annex TS1,2017; Beckman & van den Beukel, 2019; CBS,2019; Dutch Ministry of Economic Affairs and Climate, 2019; Klip,2017

Why Lower Temperature supply ?

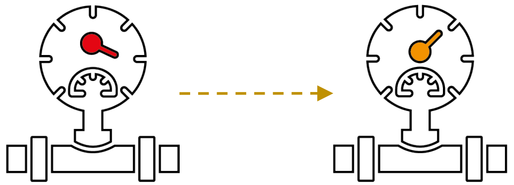
Based on direct use of heat for space heating and tap water

High Temperature	Ta > 75˚C	Direct use of heat
Medium Temp.	55 ≤ Ta ≤ 75 ˚C	Direct use of heat. Heating of tap water Ta>65
Low Temperature	25 ≤ Ta ≤ 55 ˚C	Direct use of heat with LT systems. Booster for tap water
Ultra Low Temp.	Ta ≤ 25 ˚C	Upgrading the heat for space heating and hot water

District Heating Level



Reduced heat loss in the pipe network



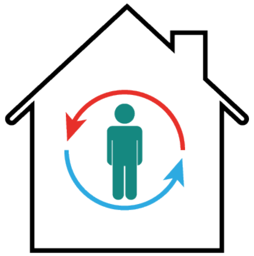
≥ 90℃ High Temp. Supply

≤ 60℃ Low Temp. Supply

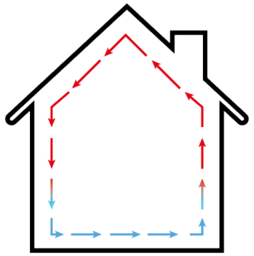
Increased efficiency of heat production and distribution

Increased price stability due to **use of locally available** surplus resources

Building Level



Better temperature gradient

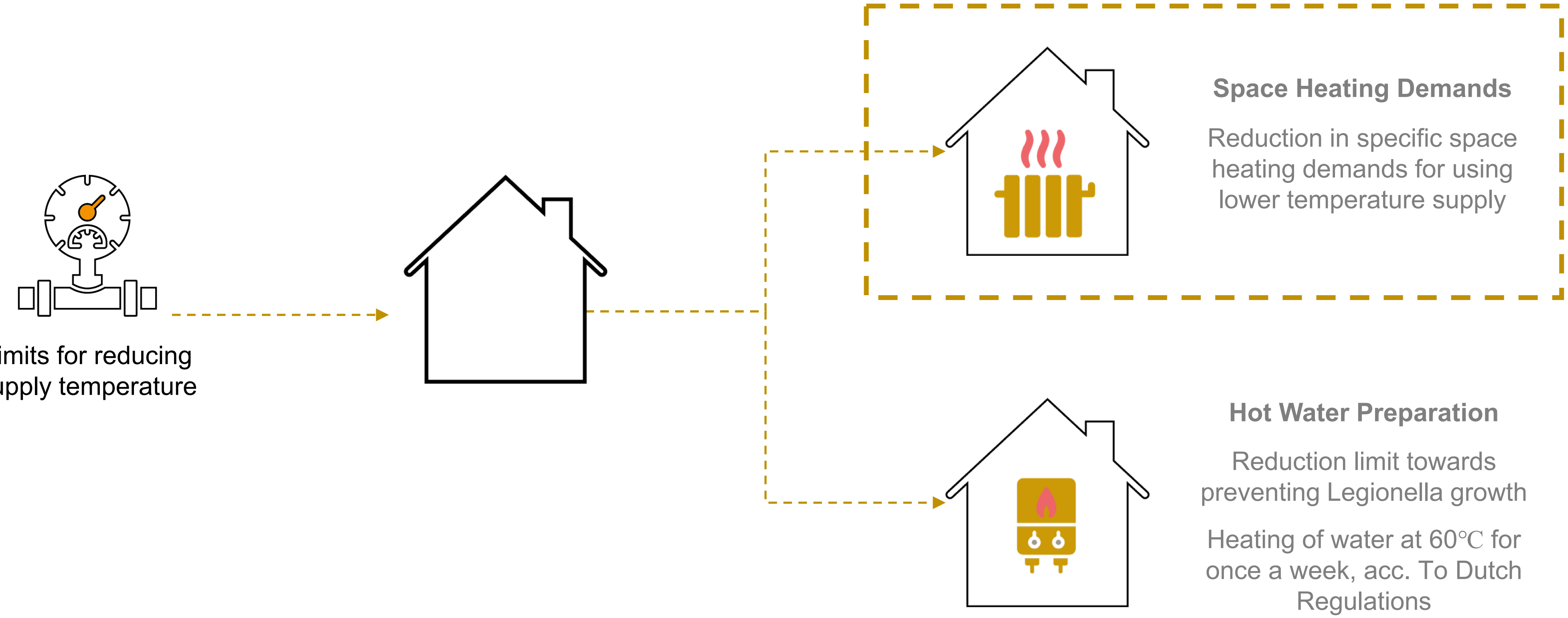


Better thermal comfort

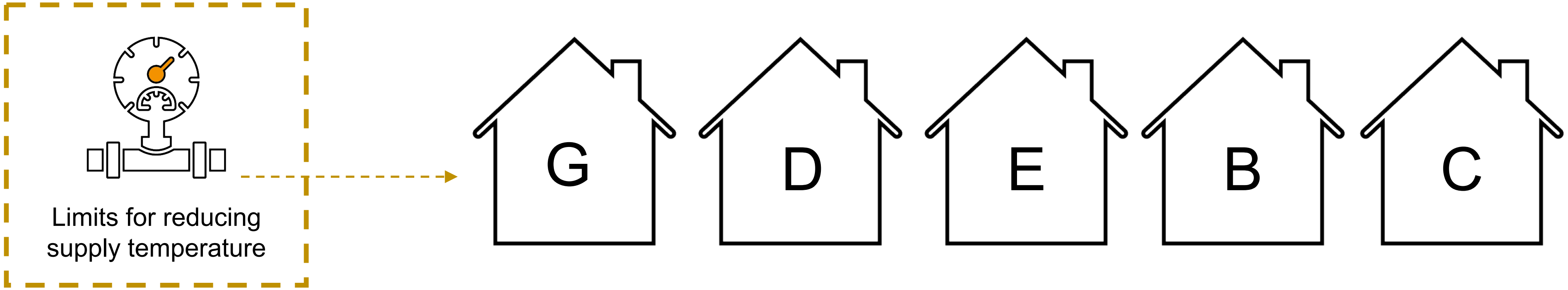
Better indoor air quality

Source: Annex TS1,2017 ; Hesaraki & Holmberg, 2013; Kruit & Schepers, 2019; Lund et al.,2014., Østergaard et al., 2018; Schmidt et al., 2017; TKI Urban Energy, 2020; Tunzi et al.,2018;

What level of insulation is needed for a comfortably heated home ?

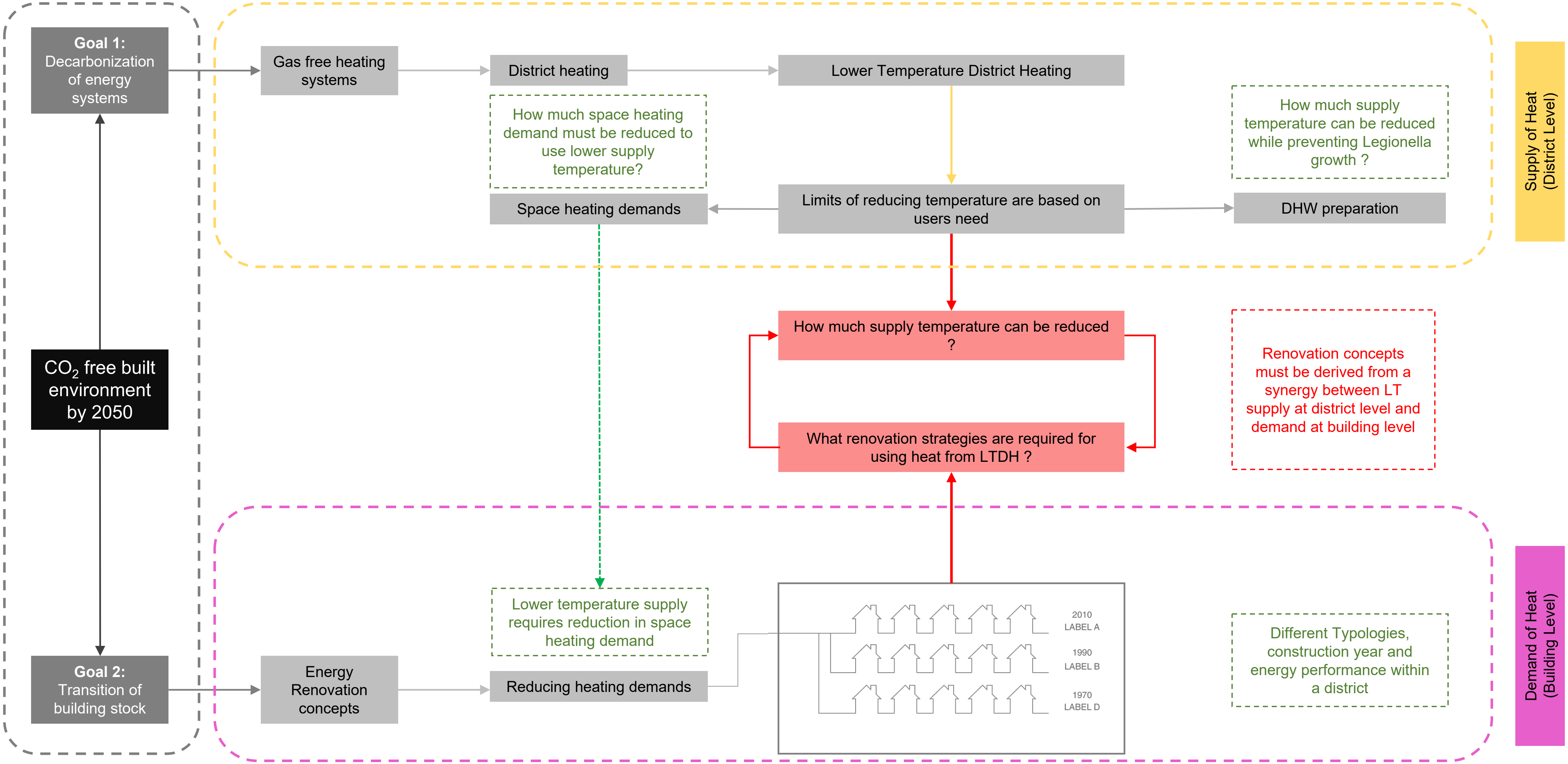


Source: Dutch Ministry of Economic Affairs and Climate, 2019; Østergaard et al., 2018; Vliet et al., 2016.



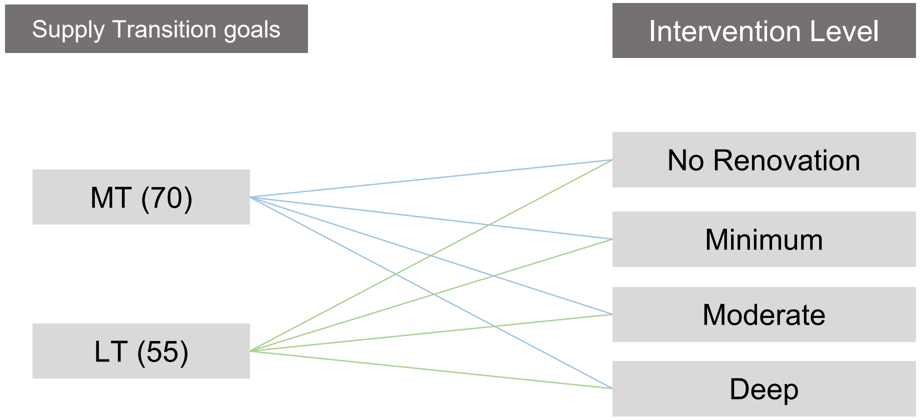
How far can temperature be lowered without comfort loss ?

Different typologies , construction , heating demands within a district



Goal 1:
Decarbonization of energy systems
Gas free heating systems
District heating
Lower Temperature District Heating
How much space heating demand must be reduced to use lower supply temperature?
How much supply temperature can be reduced while preventing Legionella growth ?
Space heating demands
Limits of reducing temperature are based on users need
DHW preparation
Supply of Heat
(District Level)
CO_2 free built environment by 2050
How much supply temperature can be reduced ?
What renovation strategies are required for using heat from LTDH ?
Renovation concepts must be derived from a synergy between LT supply at district level and demand at building level
Lower temperature supply requires reduction in space heating demand
2010
LABEL A
1990
LABEL B
1970
LABEL D
Different Typologies, construction year and energy performance within a district
Demand of Heat
(Building Level)
Goal 2:
Transition of building stock
Energy Renovation concepts
Reducing heating demands

Investigating renovations
needed for
low temperature supply scenario
for a
worst case reference example ?



Intervention Level	Condition	Example
No Renovation	Existing condition of the house	Reference
Minimum Renovations	No changes to building envelope. Increasing heat output of radiators	Increasing heat output of radiators
Moderate Renovations	No integral changes to the building envelope. Renovations <25% of the building envelope surface area.	Post insulation of cavity walls, roof, floor. Internal or external insulations.
Deep Renovation	Holistic changes to the building envelope. Renovations >25% of the building envelope surface area	Complete replacement of building envelope components. Changing ventilation system.

Replacing existing radiators with LT Radiators

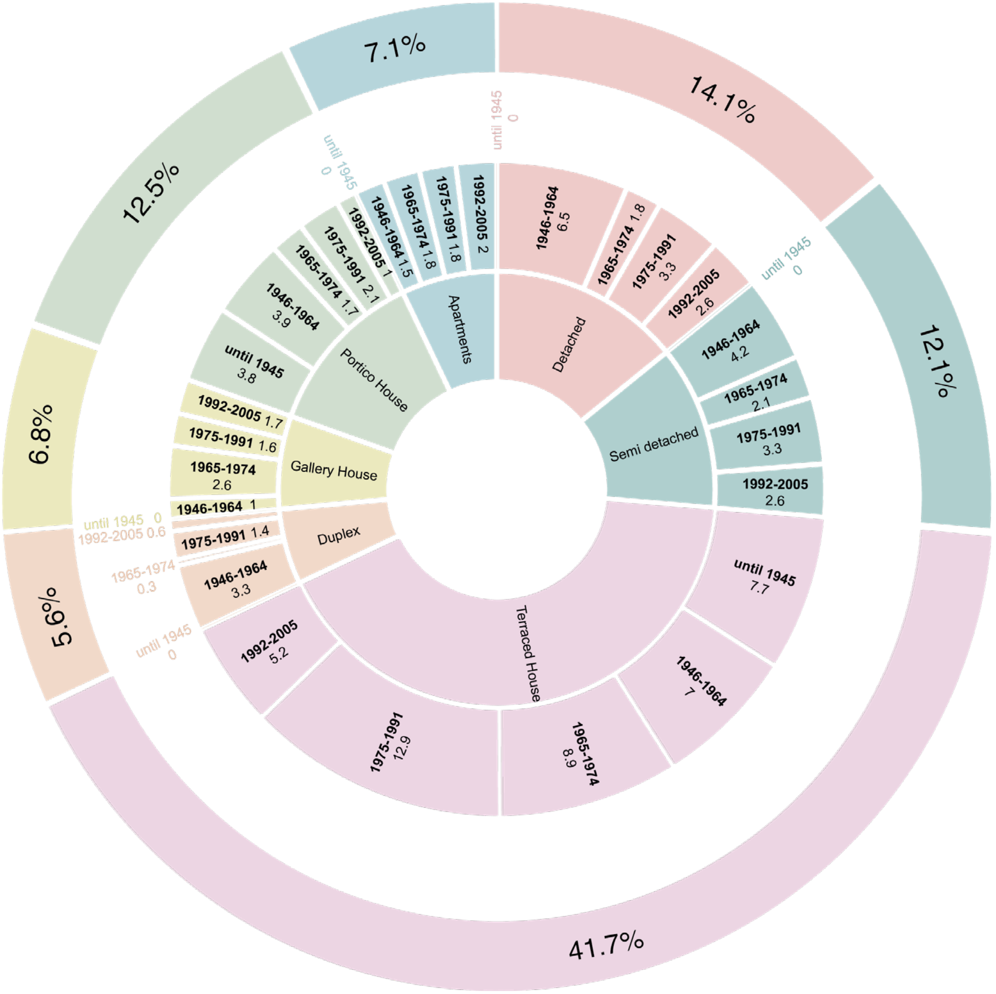
Post insulation of cavity wall

Internal Insulation

Replacement of building envelope

Image: homeserve.com; BCCA.com; insofast.com; Carl-peter Goossen

Source: Bouwbesluit, 2021, Chapter 5; Kamari et al., 2018.

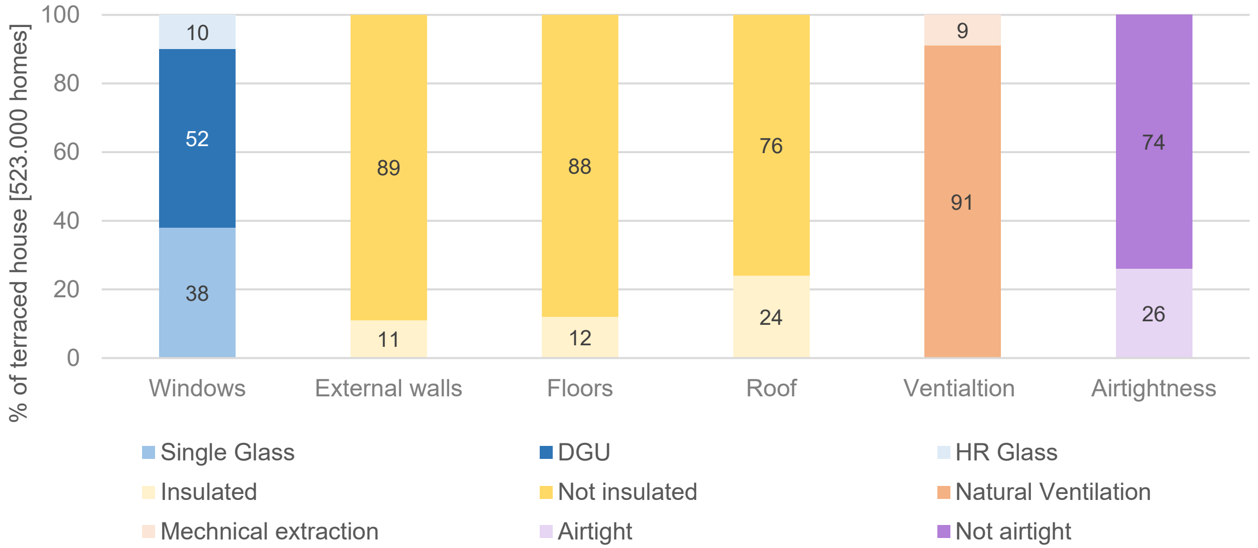


Preliminary studies : Terraced House

Sample size: 5 construction year and 2 location subtype : **10 reference.**

Year of construction	Energy Labels / Energy Index
Until 1945	G (2.18)
1946-1964	F (2.49)
1965-1971	E (2.08)
1975-1991	D (1.64)
1992-2005	C (1.31)

Terraced house : Current condition



Source: AgentschapNL,2011

	Criteria	Parameter	KPI	Unit	Description
Supply Level	Lower Peak Demands	Supply Temperature	Exceeding hours of DH supply	%	% of hours peak demand exceeds lower supply temperatrue regime
Supply Level	Maintain lower supply and return temperature	Return temperatures	ΔT = Supply-return	%	% of hours ΔT (supply-return) is above 30K
Demand Level	Improving energy efficiency	Heating demand	Specfic Space heating demand	kWh/m2	Determine heating energy required to compensate heat losses
Demand Level	Improving energy efficiency	Heating demand	Heat losses	W	To determine transmission and ventilation het loss
Demand Level	Improving energy efficiency	Annual energy consumption	Total annual energy consumption	kWh/m2	Total energy conumed for space heating , DHW and ventialiton
Demand Level	Improve thermal comfort	Existing heat emission system	Maximum radaitor power	W	To determine if radaitors can suffice heat losses under lower supply temperatrue.
Demand Level	Improve thermal comfort	Thermal comfort	Hours too cold	%	% of hours too cold due to lower supply temperatrue

Testing with lower supply temperature

Lowering the supply temperature would also reduce the existing radiator power.

Effect of lowered capacity on peak demand can also be seen in the thermally uncomfortable hours.

Reduced Radiator power was calculated analytically with difference between supply and return temperatures as 20K

- Medium : 70/50˚C
- Low : 55/35 ˚C

Source: Brand & Svendsen, 2013; Dalla Rosa & Christensen, 2011; Harrestrup & Svendsen, 2013; Hesaraki & Holmberg, 2013; Nagy et al., 2014; Sakellari & Lundqvist, 2004

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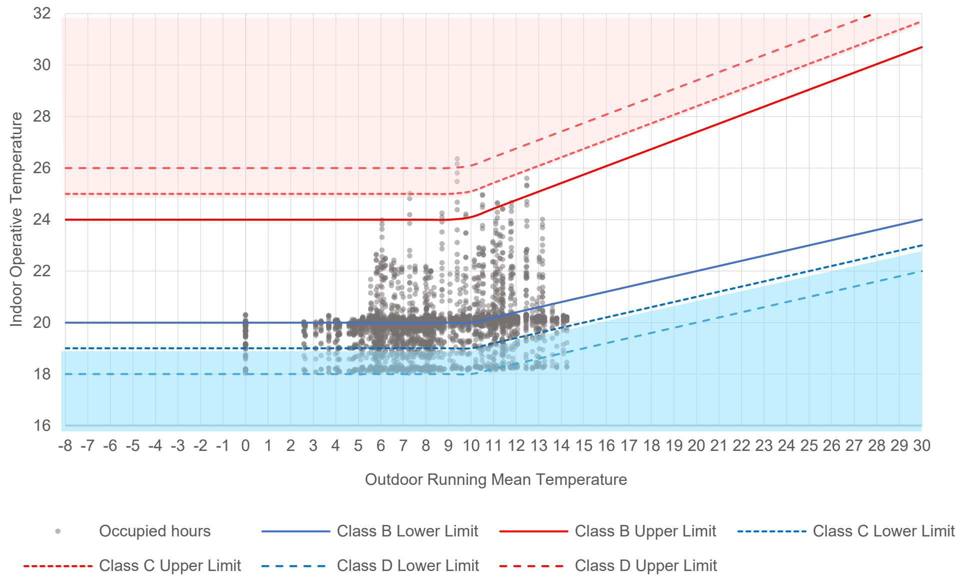
Thermal Comfort (ATG Method)



- Only living room was analyzed.
- Simulated for winter season as specified by ISSO 32, October – April
- Occupancy : 7:00-23:00
- Total Occupied hours : 3604
- Thermal comfort limit (class C) : Maximum 15% (540 hours)

Source: Brand & Svendsen, 2013; Dalla Rosa & Christensen, 2011; Harrestrup & Svendsen, 2013; Hesaraki & Holmberg, 2013; Nagy et al., 2014; Sakellari & Lundqvist, 2004

An aggregated or lumped model. Energy due to hot water preparation and cooking were not considered.

Suitability of lower temperature supply was assessed based on energy delivered by heating systems, radiator power and thermal comfort

Existing condition of the house

Scenario 1 : No Renovation
- S1.1 MT(70-50)
- S1.2 LT(55-35)

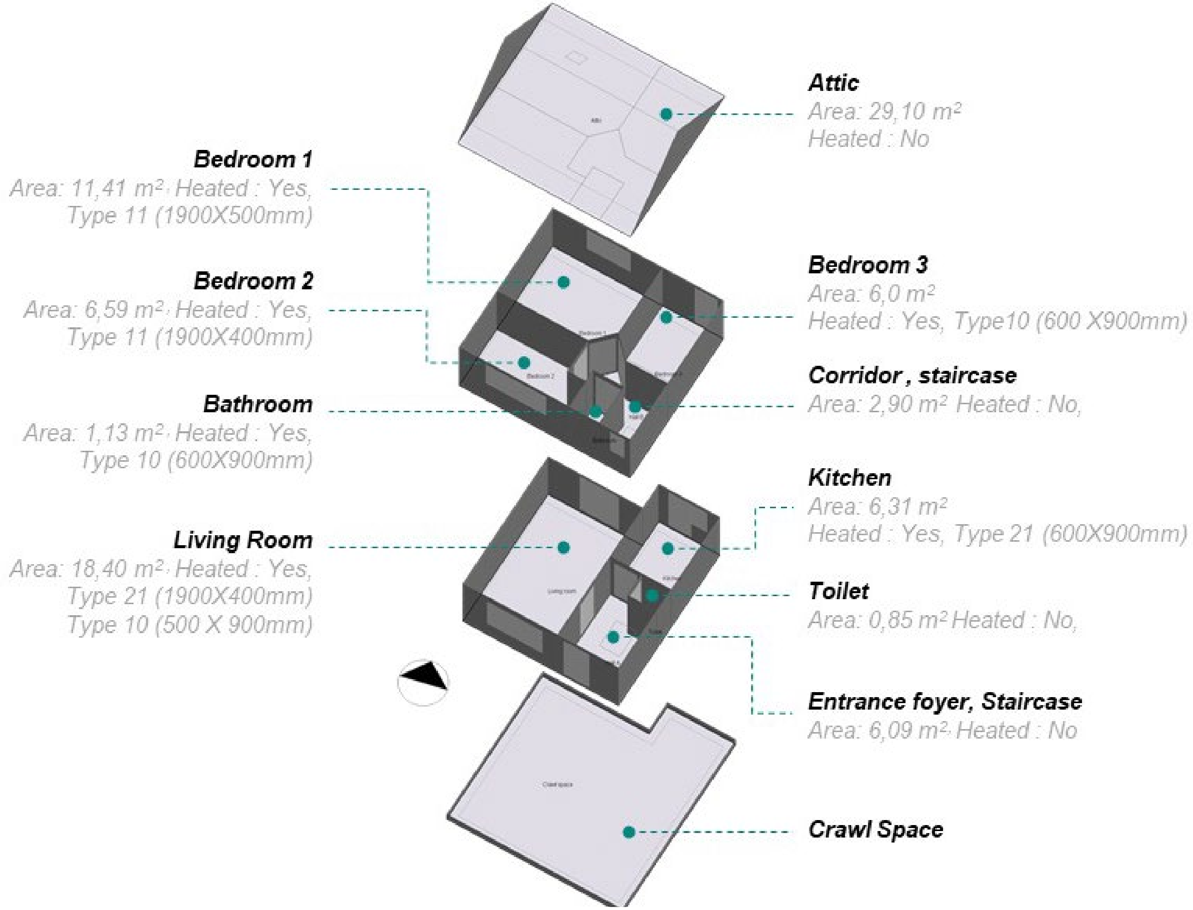
Scenario 2 : Minimum Renovation
- S2.1 MT(70-50)
- S2.2 LT(55-35)

Scenario 3 : Moderate Renovation
- S3.1 MT(70-50)
- S3.2 LT(55-35)

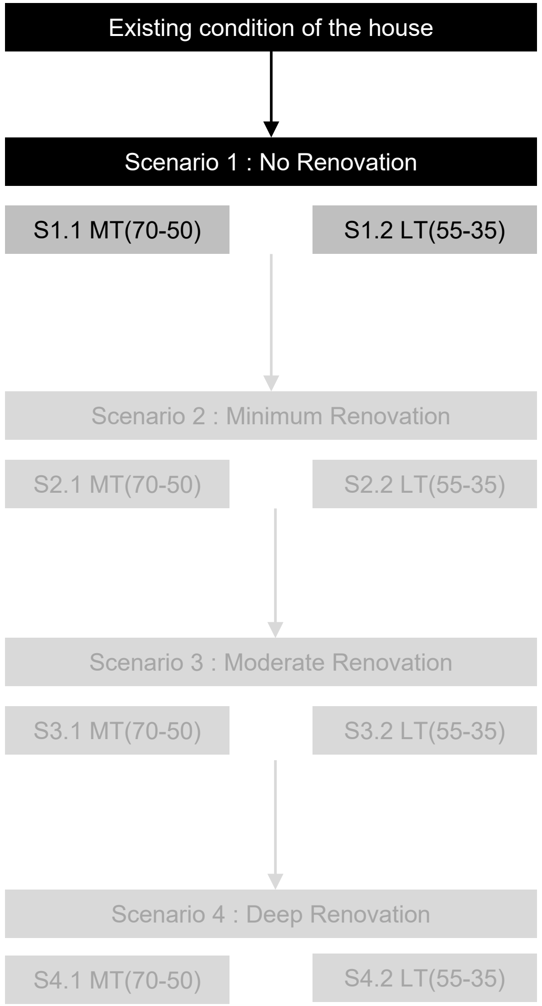
Scenario 4 : Deep Renovation
- S4.1 MT(70-50)
- S4.2 LT(55-35)

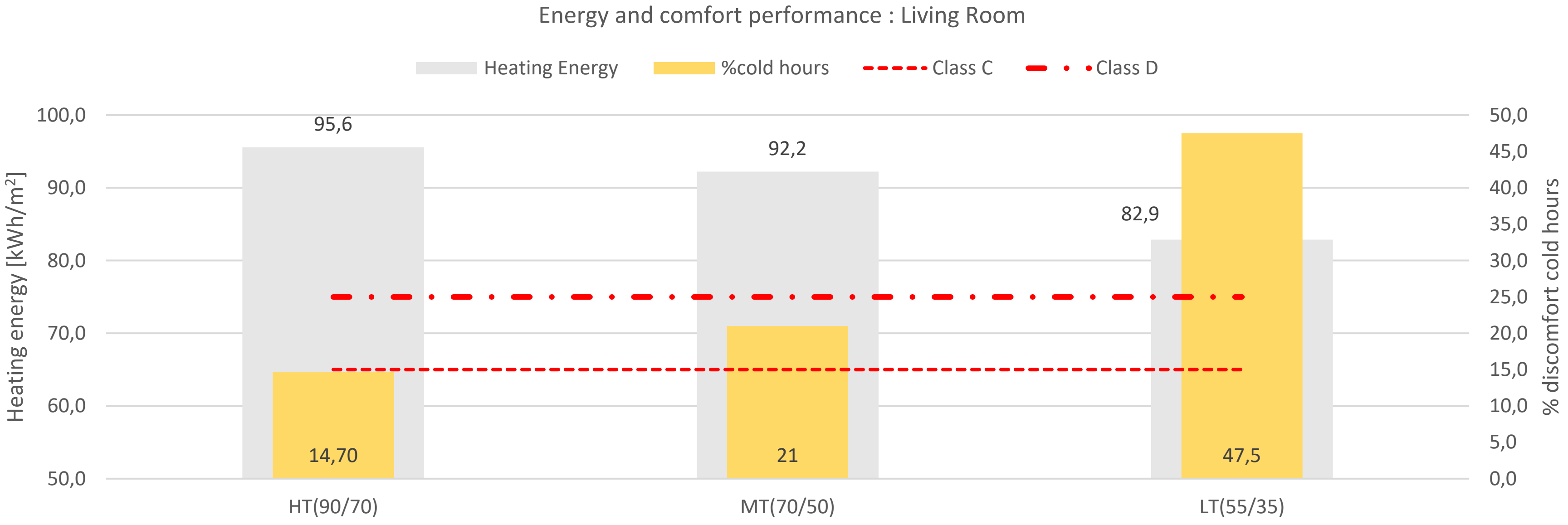
Typical Terraced intermediate house

Terraced house	
Subtype	Intermediate
Construction Year	1938
Renovation year	2020
Usable Area	90m^2
Heat generation	Gas boilers
Original supply	90℃



Source: AgentschapNL,2011; LT Ready, 2021; Rutten, 2021





Parameter (LIVING ROOM)	Existing HT(90/70)	MT (70/50)	LT(55/35)
Radiator power [W]	3093	1514	765
Reduction in radiator capacity (static)	-	51%	75%
Heating Energy [kwh/m2]	95,6	92,2	82,9
Reduction in Heating Energy (dynamic)	-	4%	13%
Hours exceeding class c upper and lower limits (540)	530 / 3604	757 / 3604	1712 / 3604
% discomfort hours	14,7%	21%	47,5%

- At building level, the radiator capacity reduced by **45% in MT** and **70% in LT** as compared to existing HT supply.
- For **MT supply** : **minimum and moderate** renovations are suggested.
- For **LT supply : Moderate to deep renovations** are suggested.

Renovation strategies for different intervention level

Component	Existing	Minimum Renovations	Moderate Renovations		Deep Renovations		
			Strategy 1 (MD1)	Strategy 2 (MD2)	Strategy 1 (DP1)	Strategy 2 (DP2)	Strategy 3 (DP3)
Radiators	HT Radiators (90/70)	Existing Radiators Increasing convector plates LT Radiators	Existing Radiators Increasing convector plates LT Radiators		LT radiators		
Source	-		Bouwbesluit, 2021	RVO,2012	-	NTA 8800,2021	
External Wall [R-Value]	0.69 m²k/W		1.4 m²k/W	2.53 m²k/W	2.53 m²k/W	4.7 m²k/W	
Floor [R-Value]	0.638 m²k/W		2.6 m²k/W	2.53 m²k/W	3.6 m²k/W	3.7 m²k/W	
Roof [R-Value]	1.735 m²k/W		2.1 m²k/W	2.53 m²k/W	3.5 m²k/W	6.3 m²k/W	
Glazing [U-Value]	DGU 2.40 W/m²k		DGU 1.9 W/m²k	HR+ 1.5 W/m²k	HR++ 1.1 W/m²k	HR++ 1.1 W/m²k	
Infiltration [ach]	0.4		0.3	0.3	0.2	0.2	
Internal Partition [R-Value]	0.24 m²k/W				2.53 m²k/W	4.7 m²k/W	
Ventilation system	Natural Ventilation				C2 Demand driven	C2 Demand Driven	Balanced with HR

Source: AgentschapNL,2011; Bouwbesluit, 2021, Chapter 5 ; NTA8800,2021

Scenario 3.1 : Moderate Renovation for MT

Existing condition of the house

Scenario 1 : No Renovation

S1.1 MT(70-50) | S1.2 LT(55-35)

Scenario 2 : Minimum Renovation

S2.1 MT(70-50) | S2.2 LT(55-35)

Scenario 3 : Moderate Renovation

S3.1 MT(70-50) | S3.2 LT(55-35)

Scenario 4 : Deep Renovation

S4.1 MT(70-50) | S4.2 LT(55-35)

Transition from HT(90/70) to MT(70/50)

Terraced house
Until 1945

Existing Condition
Wall : *0,69 m2K/W*
Floor : *0,6 m2K/W*
Roof : *1,7 m2K/W*
Glazing *: 2,40 W/m2K*
Infiltration : *0,4*

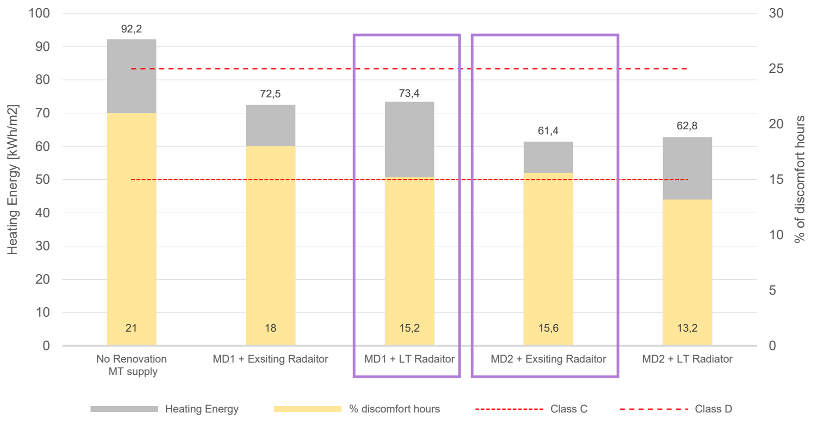
Minimum Renovation

Moderate Renovation

MD1 (Building Decree,2012)
Wall : *1,4 m2K/W*
Floor : *2,6 m2K/W*
Roof : *2,1 m2K/W*
Glazing *: 1,9 W/m2K (HR+)*
Infiltration : *0,3*
Radiator : *Inc. Plates / LT Radiator*

MD2 (RVO,2011)
Wall : *2,53 m2K/W*
Floor : *2,6 m2K/W*
Roof : *2,53 m2K/W*
Glazing *: 1,5 W/m2K (HR+)*
Infiltration : *0,3*
Radiator : *Existing radiators/LT Radaitor*

Deep Renovation



	No Renovation	Moderate Renovations			
Parameter	**Existing MT(90/70)**	**MD1 + existing radiators**	**MD1 + LT Radiators**	**MD2 + Existing radiators**	**MD2 + LT Radiators**
Heating Energy [kwh/m2]	92,2	72,5	73,4	61,4	62,8
% reduction	-	21%	20,4%	33,4%	32%
Hours exceeding class c upper and lower limits (540/3604 hours)	757/3604	649/3604	548/3604	562/3604	476/3604
% discomfort	21%	18%	15,2%	15,6%	13,2%

Scenario 3.2 and 4.2 : Moderate and Deep Renovation for LT

Existing condition of the house

Scenario 1 : No Renovation
- S1.1 MT(70-50)
- S1.2 LT(55-35)

Scenario 2 : Minimum Renovation
- S2.1 MT(70-50)
- S2.2 LT(55-35)

Scenario 3 : Moderate Renovation
- S3.1 MT(70-50)
- S3.2 LT(55-35)

Scenario 4 : Deep Renovation
- S4.1 MT(70-50)
- S4.2 LT(55-35)

Transition from HT(90/70) to LT(55/35)

Terraced house Until 1945

Existing Condition
Wall : *0,69 m2K/W*
Floor : *0,6 m2K/W*
Roof : *1,7 m2K/W*
Glazing *: 2,40 W/m2K*
Infiltration : *0,4*

Minimum Renovation

Moderate Renovation

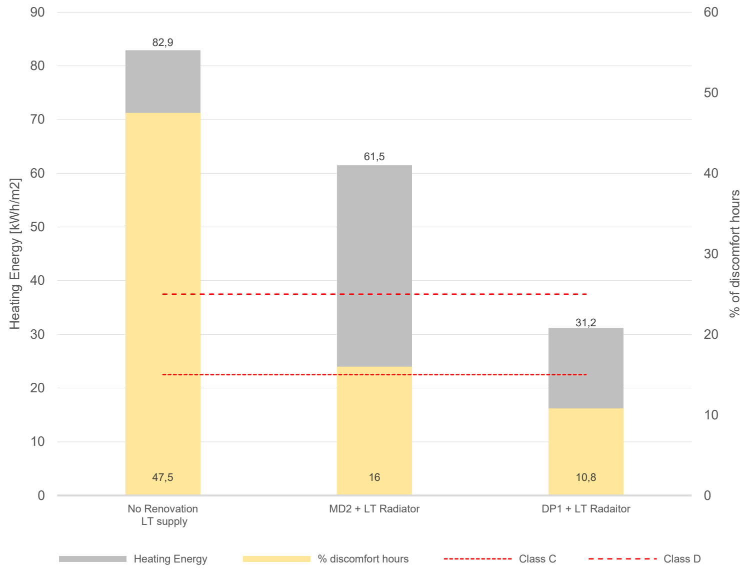
MD2 (RVO,2011)
Wall : *2,53 m2K/W*
Floor : *2,6 m2K/W*
Roof : *2,53 m2K/W*
Glazing *: 1,5 W/m2K (HR+)*
Infiltration : *0,3*
Radiator : *LT Radiators*

Deep Renovation

DP1
Wall : *2,53 m2K/W*
Partition *: 2,53 m2K/W*
Floor : *3,6 m2K/W*
Roof : *3,5 m2K/W*
Glazing *: 1,1 W/m2K (HR++)*
Infiltration : *0,2*
Ventilation *: Demand Driven*
Radiator : Inc Plates / LT Radiator

Could be a no regret option for transitioning from HT to LT

	No Renovation	Moderate	Deep
Parameter	**Existing LT(90/70)**	**MD2 + LT radiators**	**DP1 + LT Radiators**
Heating Energy [kwh/m2]	82.9	61.5	31.2
% reduction	-	26%	62.3%
Hours exceeding class c upper and lower limits (540/3604)	1712/3604	577/3604	389/3604
% discomfort	47,5%	16%	10,8%



What level of insulation is needed for a comfortably heated home?

For a pre-war terraced house (built before 1945)

Medium temperature supply from district heating.

Moderate renovation intervention can be coupled with changing radiator system.

Lower Temperature supply from district heating.

Moderate renovation with change in ventilation systems and radiators

Deep Renovation

Preparation for hot water

Next Steps

The renovation strategies must also be tested for environmental and economical feasibility.

Advanced simulation for testing the dynamic effect on return temperatures.

Extending the studies to other building types.

Integrating the process in a decision-making framework for identifying appropriate renovation strategies.

Energy Renovations for
Lower Temperature District Heating

Thankyou for your attention

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