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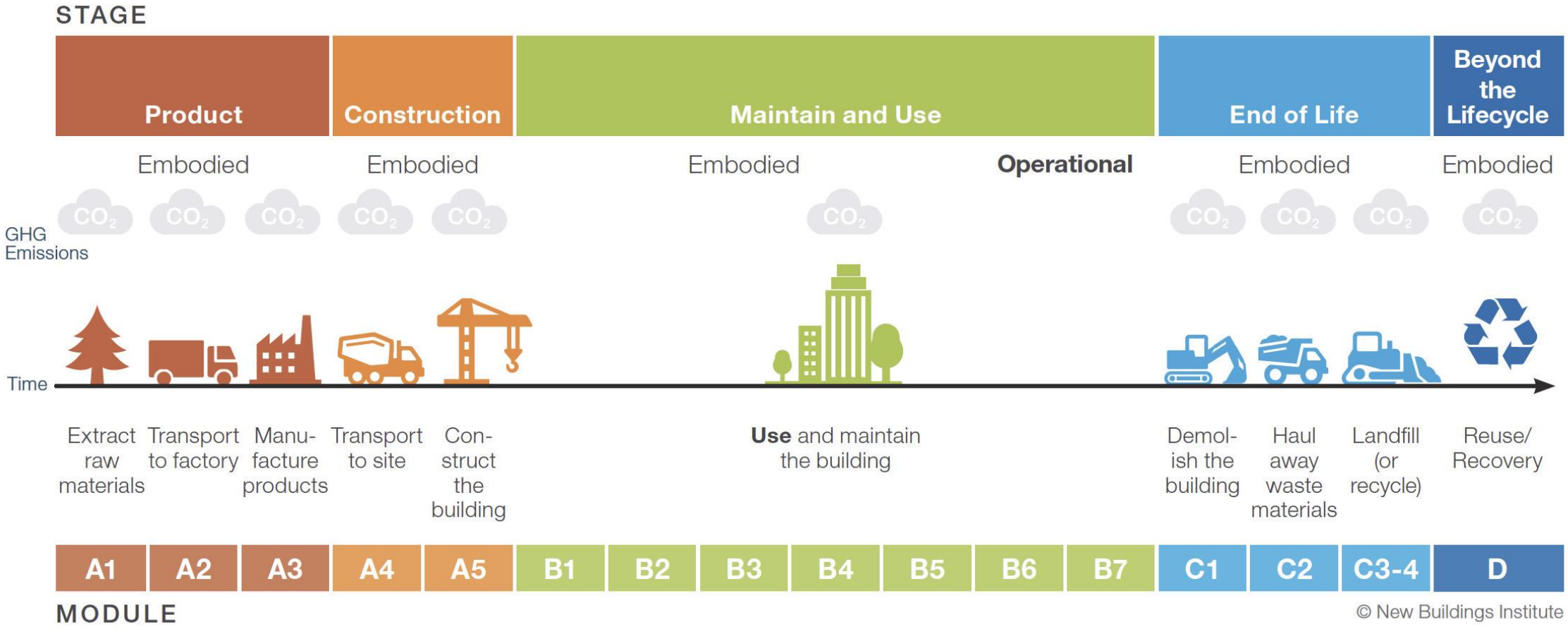
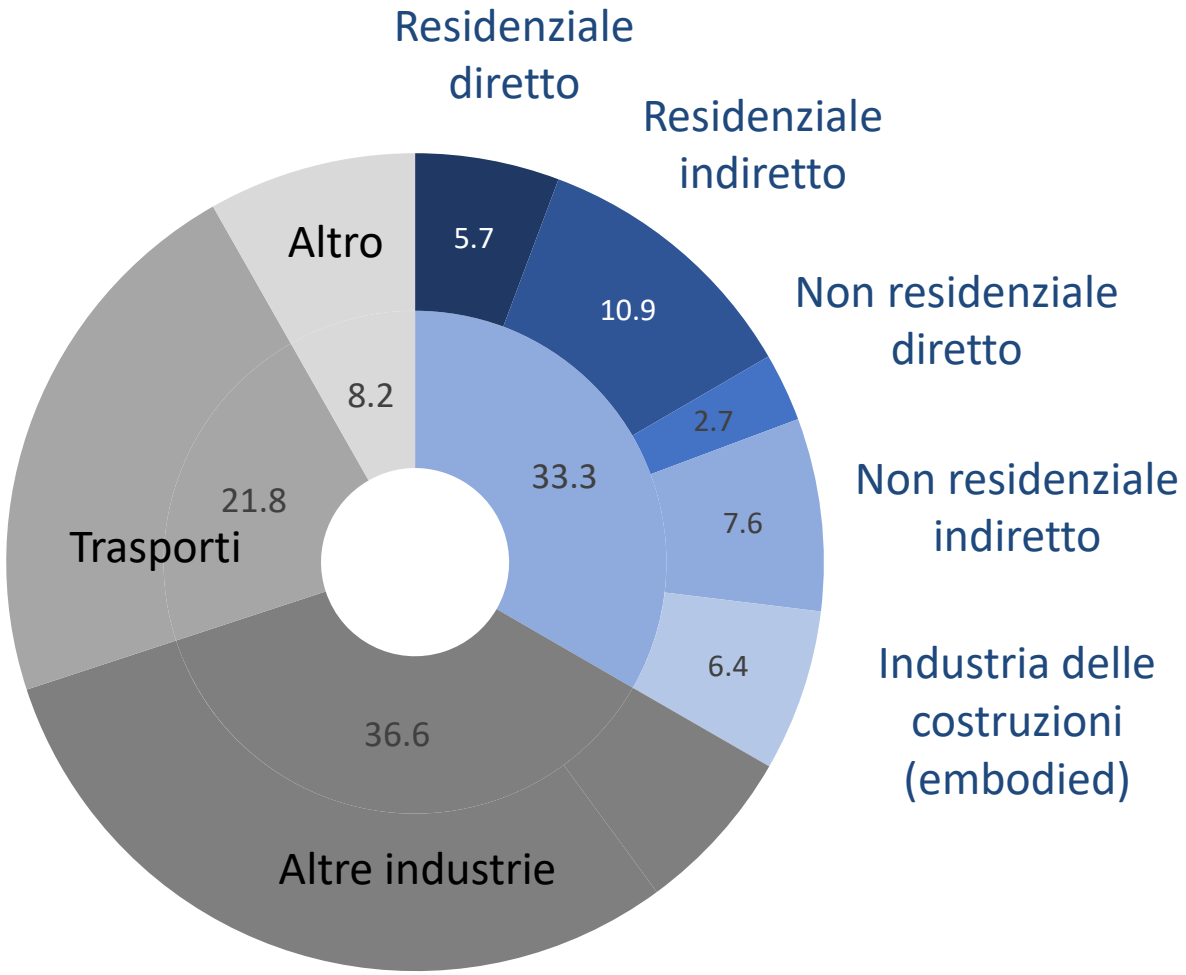
La decarbonizzazione dei sistemi di riscaldamento e del raffrescamento

Andrea Gasparella

Pescara, 11 ottobre 2022



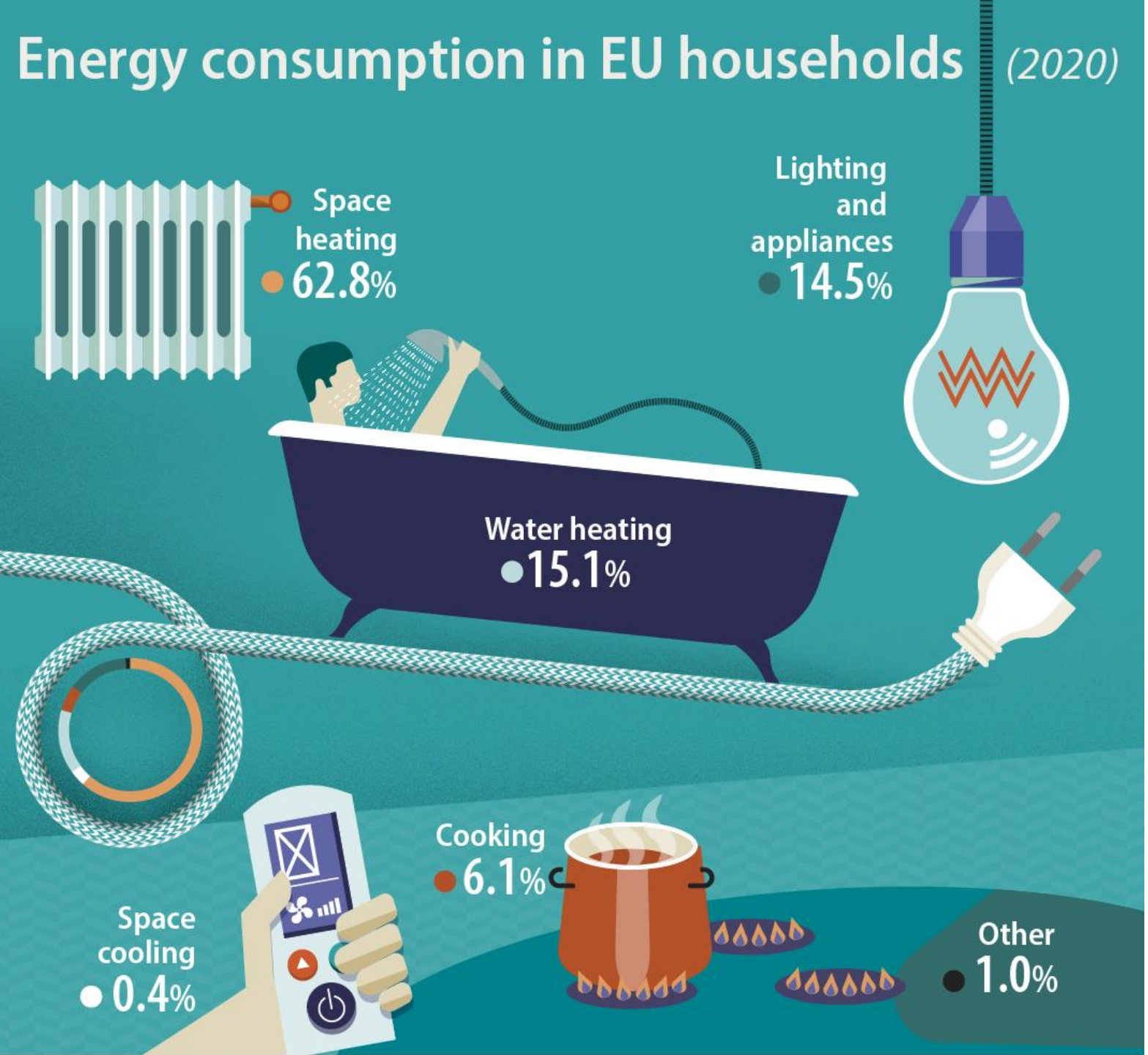


IEA (2022), Buildings, IEA, Paris https://www.iea.org/reports/buildings

Global energy and process emissions from buildings, including embodied emissions from new construction 2021

Direct energy related emissions are from the direct consumption of fossil fuels in buildings, such as natural gas for heating. Indirect energy-related emissions are from electricity generation or during the sourcing, processing, and transportation of fuels attributed to the building

Energy consumption in EU households *(2020)*



Share of final energy consumption in the residential sector by type of end-use, 2020

(%)

	space heating	space cooling	water heating	cooking	lighting and electrical appliances	other end use
EU	**62.8**	**0.4**	**15.1**	**6.1**	**14.5**	**1.0**
Belgium	72.7	0.1	11.7	1.7	13.2	0.6
Bulgaria	54.5	0.5	17.1	8.3	19.7	:
Czechia	68.4	0.1	16.5	6.2	7.2	1.7
Denmark	58.3	:	22.7	1.8	16.7	0.5
Germany	67.1	0.2	16.7	5.9	9.0	1.1
Estonia	72.1	:	11.6	4.9	11.4	:
Ireland	60.8	:	19.7	2.2	16.4	0.9
Greece	57.1	4.2	13.9	8.0	16.7	:
Spain	40.7	:	19.4	7.8	32.1	0.0
France	62.9	0.6	12.0	5.9	18.6	:
Croatia	68.2	1.9	10.2	6.7	13.1	:
Italy	65.4	0.7	12.2	6.8	13.6	1.3
Cyprus	37.2	10.2	22.7	7.9	20.0	2.0
Latvia	64.2	0.0	18.8	7.2	9.1	0.6
Lithuania	69.0	:	9.2	6.4	15.4	:
Luxembourg	81.0	0.5	7.5	3.3	7.8	:
Hungary	63.7	0.2	16.3	6.7	13.2	:
Malta	19.4	12.3	25.1	13.1	29.2	0.8
Netherlands	60.9	0.3	17.4	2.1	19.2	0.1
Austria	69.8	0.0	14.3	2.6	10.2	3.1
Poland	63.3	0.0	17.2	8.6	10.9	:
Portugal	30.5	0.9	17.9	31.4	19.4	0.0
Romania	62.2	0.3	13.8	9.8	13.9	:
Slovenia	62.0	0.6	16.2	4.1	17.2	:
Slovakia	73.1	0.1	12.3	4.3	10.2	0.0
Finland	63.6	0.2	16.4	1.4	12.5	5.8
Sweden	55.6	:	14.1	1.6	20.5	8.2
Norway	65.2	0.1	13.4	1.6	18.9	0.8
North Macedonia	68.7	2.4	8.6	7.3	13.0	:
Albania	32.6	8.0	23.6	31.2	4.6	:
Serbia	66.3	0.4	11.8	7.1	14.4	:
Bosnia and Herzegovina	73.4	0.6	9.4	5.1	11.5	:
Kosovo*	67.8	4.0	7.6	8.4	10.9	1.3
Moldova	68.1	0.1	10.0	13.0	8.9	:
Georgia	56.8	0.3	13.7	17.5	11.7	:

(*)This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

Source: Eurostat (online data code: nrg_d_hhq)

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Bulgaria	54.5	0.5	17.1	8.3	19.7	:
Czechia	68.4	0.1	16.5	6.2	7.2	1.7
Spain	40.7	:	19.4	7.8	32.1	0.0
France	62.9	0.6	12.0	5.9	18.6	:
Croatia	68.2	1.9	10.2	6.7	13.1	:
Italy	65.4	0.7	12.2	6.8	13.6	1.3
Cyprus	37.2	10.2	22.7	7.9	20.0	2.0
Latvia	64.2	0.0	18.8	7.2	9.1	0.6
Lithuania	69.0	:	9.2	6.4	15.4	:
Portugal	30.5	0.9	17.9	31.4	19.4	0.0
Romania	62.2	0.3	13.8	9.8	13.9	:
Slovenia	62.0	0.6	16.2	4.1	17.2	:
Slovakia	73.1	0.1	12.3	4.3	10.2	0.0
Finland	63.6	0.2	16.4	1.4	12.5	5.8
Sweden	55.6	:	14.1	1.6	20.5	8.2
Norway	65.2	0.1	13.4	1.6	18.9	0.8
North Macedonia	68.7	2.4	8.6	7.3	13.0	:
Albania	32.6	8.0	23.6	31.2	4.6	:
Serbia	66.3	0.4	11.8	7.1	14.4	:
Bosnia and Herzegovina	73.4	0.6	9.4	5.1	11.5	:
Kosovo*	67.8	4.0	7.6	8.4	10.9	1.3
Moldova	68.1	0.1	10.0	13.0	8.9	:
Georgia	56.8	0.3	13.7	17.5	11.7	:

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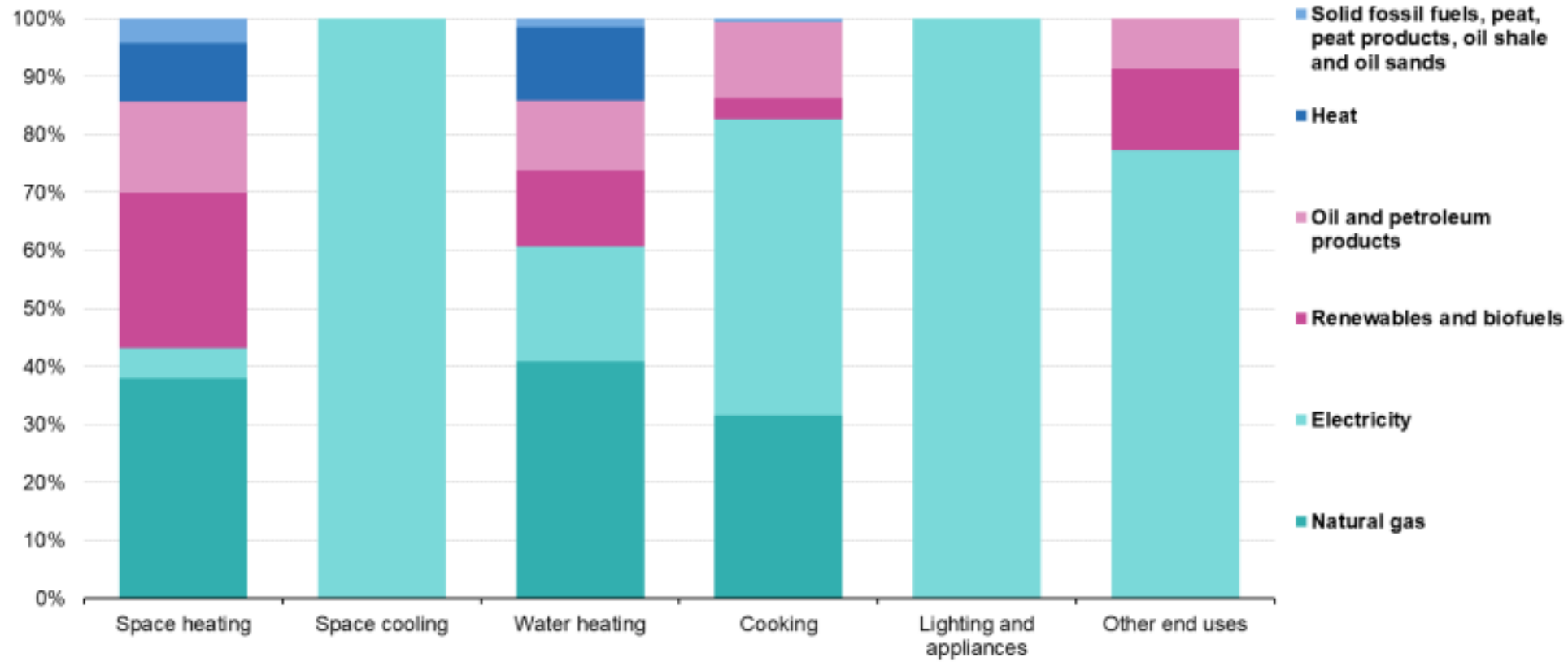
Part of the main energy products in the final energy consumption in the residential sector for each type of end-use, EU, 2020



Source: Eurostat (online data code: nrg_d_hhq)

Share of fuels in the final energy consumption in the residential sector for space heating, 2020

(%)

	Solid fossil fuels, peat, peat products, oil shale and oil sands	Natural gas	Oil and petroleum products	Renewables and biofuels	Electricity	Heat
EU	**4.2**	**38.0**	**15.6**	**26.8**	**5.2**	**10.2**
Belgium	0.6	44.1	41.5	10.5	3.0	0.2
Bulgaria	7.4	6.0	0.1	61.9	8.6	15.9
Czechia	14.2	24.8	0.8	41.9	5.0	13.3
Denmark	:	17.2	3.2	38.0	3.9	37.7
Germany	0.8	43.8	28.0	16.8	1.7	9.0
Estonia	0.1	6.1	0.3	51.5	5.5	36.6
Ireland	17.2	21.9	54.8	2.3	3.7	:
Greece	0.1	16.9	46.7	29.0	5.2	2.1
Spain	0.6	27.4	31.3	32.8	7.9	0.0
France	0.1	35.7	13.6	34.1	12.6	3.9
Croatia	0.1	23.8	4.0	63.4	1.8	6.9
Italy	:	59.9	6.9	28.9	0.4	3.8
Cyprus	:	:	62.6	21.3	16.0	:
Latvia	0.2	8.0	3.3	52.3	0.9	35.3
Lithuania	3.3	11.9	1.9	46.1	1.5	35.3
Luxembourg	0.1	56.8	31.9	4.1	7.1	:
Hungary	1.9	84.2	0.1	:	2.3	11.6
Malta	:	:	21.0	43.5	35.4	:
Netherlands	0.0	83.9	0.6	9.3	2.9	3.2
Austria	0.4	26.8	18.1	35.4	4.7	14.6
Poland	40.3	15.9	0.7	21.0	1.0	21.1
Portugal	:	1.8	6.1	86.8	5.2	0.1
Romania	0.6	32.0	0.0	52.8	0.2	14.3
Slovenia	0.0	11.6	15.9	56.2	7.0	9.4
Slovakia	1.9	45.8	0.2	28.4	7.0	16.7
Finland	0.1	0.6	5.2	40.4	24.8	29.0
Sweden	:	0.3	4.6	19.7	28.7	46.7
Norway	:	0.1	0.2	35.5	60.7	3.5
North Macedonia	0.2	0.0	1.2	51.3	37.2	10.1
Albania	:	:	19.9	27.9	52.2	:
Serbia	11.4	9.6	0.9	53.7	6.2	18.3
Bosnia and Herzegovina	4.4	2.2	2.0	83.6	0.4	7.4
Kosovo*	1.3	:	:	84.3	12.1	2.4
Moldova	4.0	19.7	0.0	64.6	0.5	11.2
Georgia	0.0	73.2	:	24.9	1.9	:

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Share of fuels in the final energy consumption in the residential sector for space heating, 2020

(%)

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EU	**4.2**	**38.0**	**15.6**	**26.8**	**5.2**	**10.2**
Belgium	0.6	44.1	41.5	10.5	3.0	0.2
Bulgaria	7.4	6.0	0.1	61.9	8.6	15.9
Austria	0.4	26.8	18.1	35.4	4.7	14.6
Poland	40.3	15.9	0.7	21.0	1.0	21.1
Portugal	:	1.8	6.1	86.8	5.2	0.1
Romania	0.6	32.0	0.0	52.8	0.2	14.3
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France	0.1	35.7	13.6	34.1	12.6	3.9
Croatia	0.1	23.8	4.0	63.4	1.8	6.9
Italy	:	59.9	6.9	28.9	0.4	3.8
Finland	0.1	0.6	5.2	40.4	24.8	29.0
Sweden	:	0.3	4.6	19.7	28.7	46.7
Norway	:	0.1	0.2	35.5	60.7	3.5
North Macedonia	0.2	0.0	1.2	51.3	37.2	10.1
Albania	:	:	19.9	27.9	52.2	:
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Moldova	4.0	19.7	0.0	64.6	0.5	11.2
Georgia	0.0	73.2	:	24.9	1.9	:

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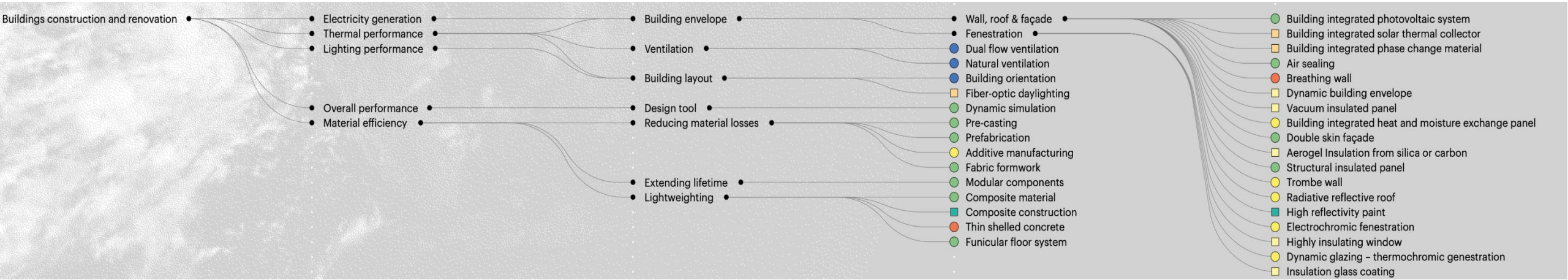

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Basic principles have been defined

2 APPLICATION FORMULATED
Concept and application of solution have been formulated

3 CONCEPTS NEEDS VALIDATION
Solution needs to be prototyped and applied

4 EARLY PROTOTYPE
Prototype proven in test conditions

5 LARGE PROTOTYPE
Components proven in conditions to be deployed

6 FULL PROTOTYPE AT SCALE
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10 INTEGRATION NEEDED AT SCALE
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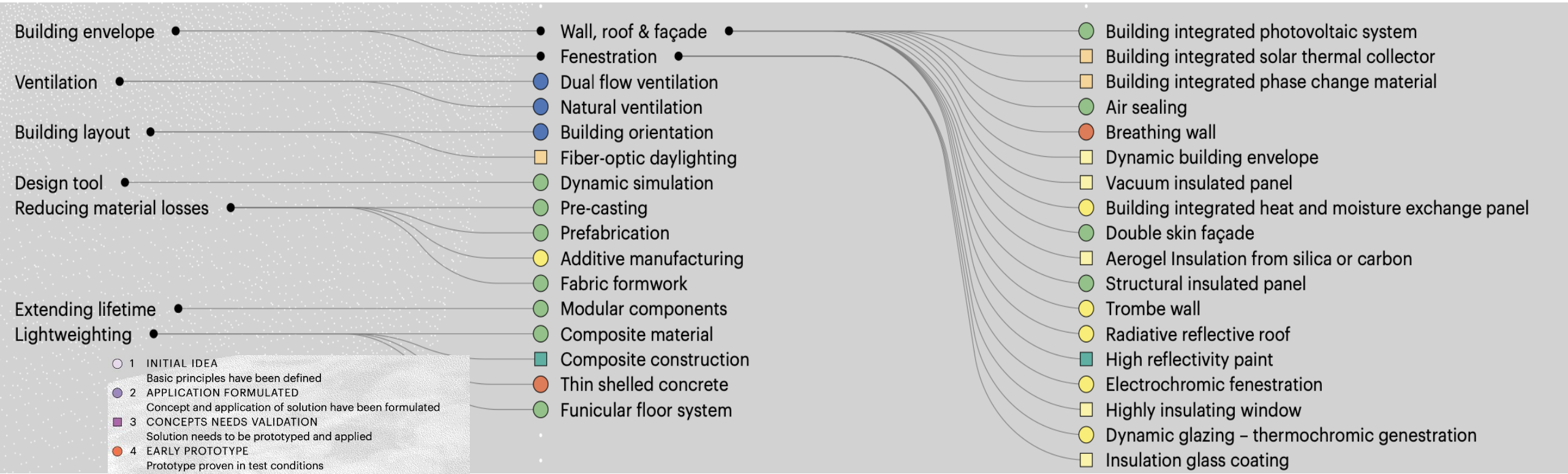
11 PROOF OF STABILITY REACHED
Predictable growth



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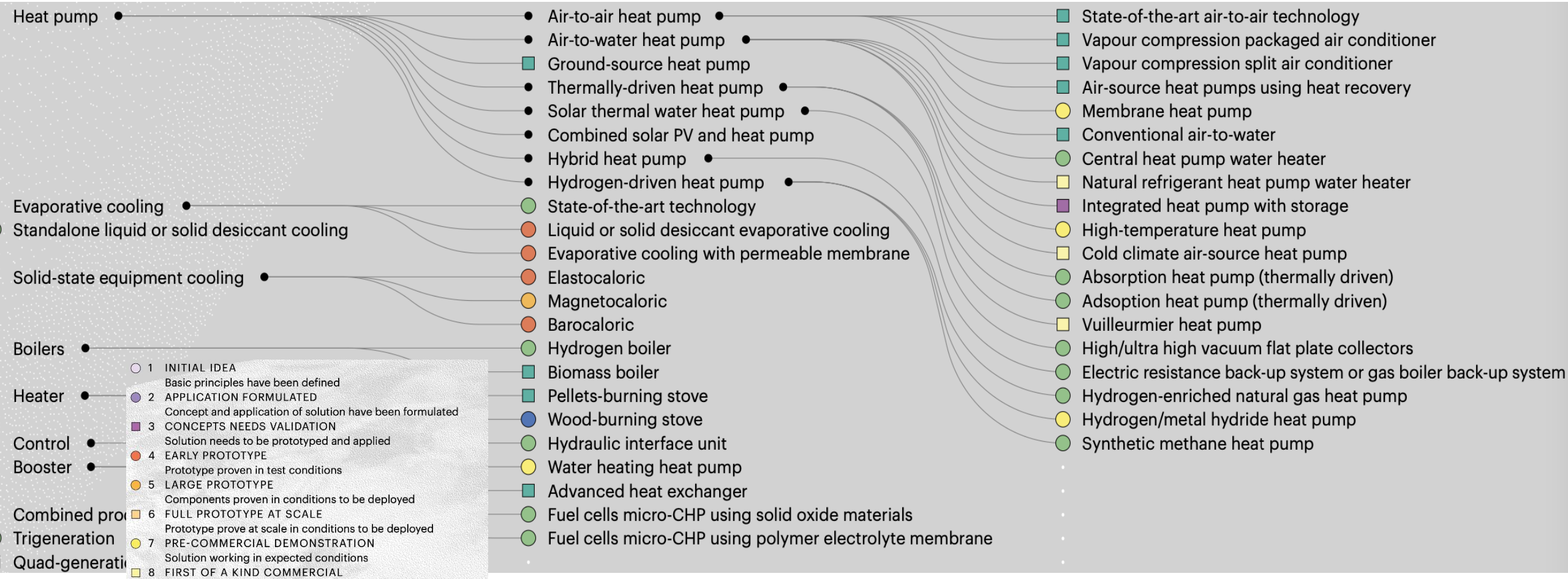
Heat pump
Evaporative cooling
Standalone liquid or solid desiccant cooling
Solid-state equipment cooling
Boilers
Heater
Control
Booster
Combined pro
Trigeneration
Quad-generati
Air-to-air heat pump
Air-to-water heat pump
Ground-source heat pump
Thermally-driven heat pump
Solar thermal water heat pump
Combined solar PV and heat pump
Hybrid heat pump
Hydrogen-driven heat pump
State-of-the-art technology
Liquid or solid desiccant evaporative cooling
Evaporative cooling with permeable membrane
Elastocaloric
Magnetocaloric
Barocaloric
Hydrogen boiler
Biomass boiler
Pellets-burning stove
Wood-burning stove
Hydraulic interface unit
Water heating heat pump
Advanced heat exchanger
Fuel cells micro-CHP using solid oxide materials
Fuel cells micro-CHP using polymer electrolyte membrane
State-of-the-art air-to-air technology
Vapour compression packaged air conditioner
Vapour compression split air conditioner
Air-source heat pumps using heat recovery
Membrane heat pump
Conventional air-to-water
Central heat pump water heater
Natural refrigerant heat pump water heater
Integrated heat pump with storage
High-temperature heat pump
Cold climate air-source heat pump
Absorption heat pump (thermally driven)
Adsoption heat pump (thermally driven)
Vuilleurmier heat pump
High/ultra high vacuum flat plate collectors
Electric resistance back-up system or gas boiler back-up system
Hydrogen-enriched natural gas heat pump
Hydrogen/metal hydride heat pump
Synthetic methane heat pump
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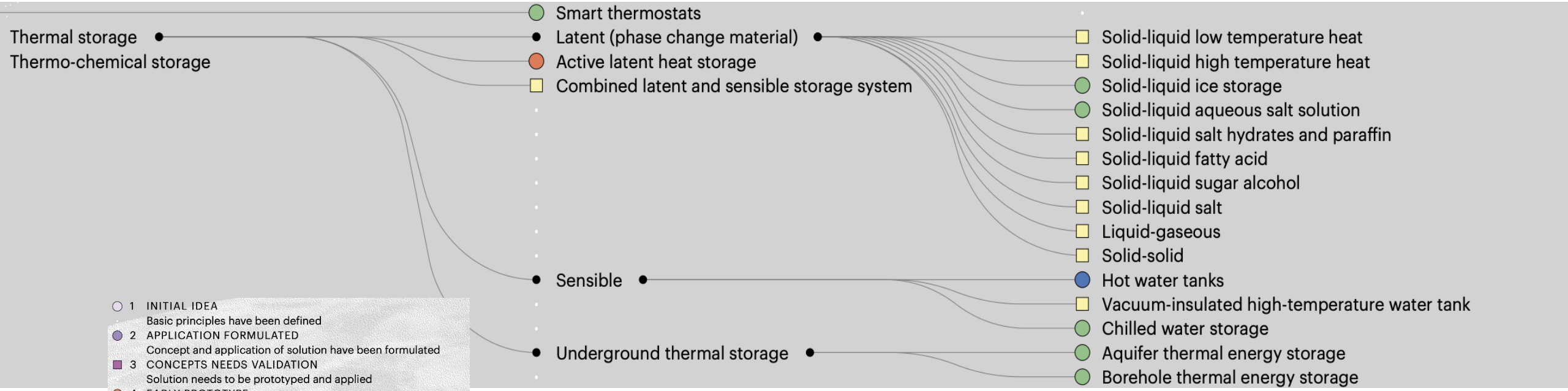

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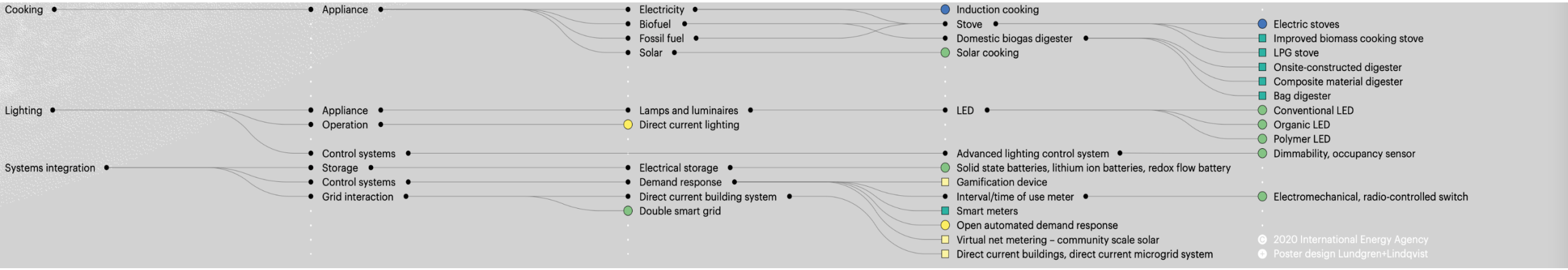

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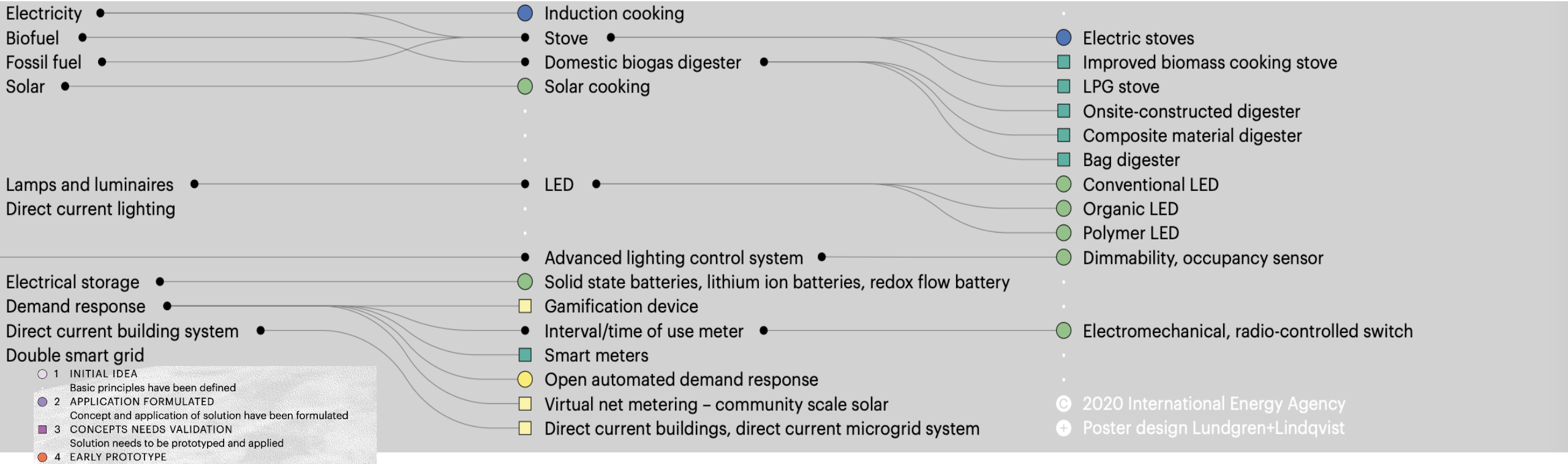

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Area	Technology	
Building Envelope	Wall, roof, façade	BIPV (BIST) (Phase change materials) Double skin facades High reflective paint
	Fenestration	Electrochromic (Thermochromic)
Ventilation	Dual flow Natural ventilation	
Layout	Orientation	
Design tool	Dynamic simulation	
Reducing material losses	Pre-casting Prefabrication (Additive manufacturing)	
Extending lifetime	Modularization	
Lightweight		
Heat pump	Air to air Air to water GSHP Solar thermal Combined solar PV and HP	
Evaporative cooling		
Boilers	(Hydrogen) Biomass/Biogas Pellets Wood	
CHP	Fuel cells micro CHP	
Control/digitalization	Smart thermostats IoT Predictive control	
Thermo-chemical storage	Batteries/electric storage Sensible/Latent heat storage Building mass Ground Aquifers	

1. Ridurre le dispersioni
2. Massimizzare gli apporti (in maniera controllabile)
3. Recuperare dalla ventilazione (pre-riscaldamento/raffrescamento)
4. Elettrificare
5. Utilizzare le fonti rinnovabili
6. Accumulare:
    a. Scambio con la rete
    b. Accumulo elettrico
    c. Accumulo termico (giornaliero, stagionale): buffer, edificio, terreno
7. Automatizzare (IoT, BA, Predictive Control)

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