

Single house low-carbon heating systems for UK detached and semi-detached homes retrofit

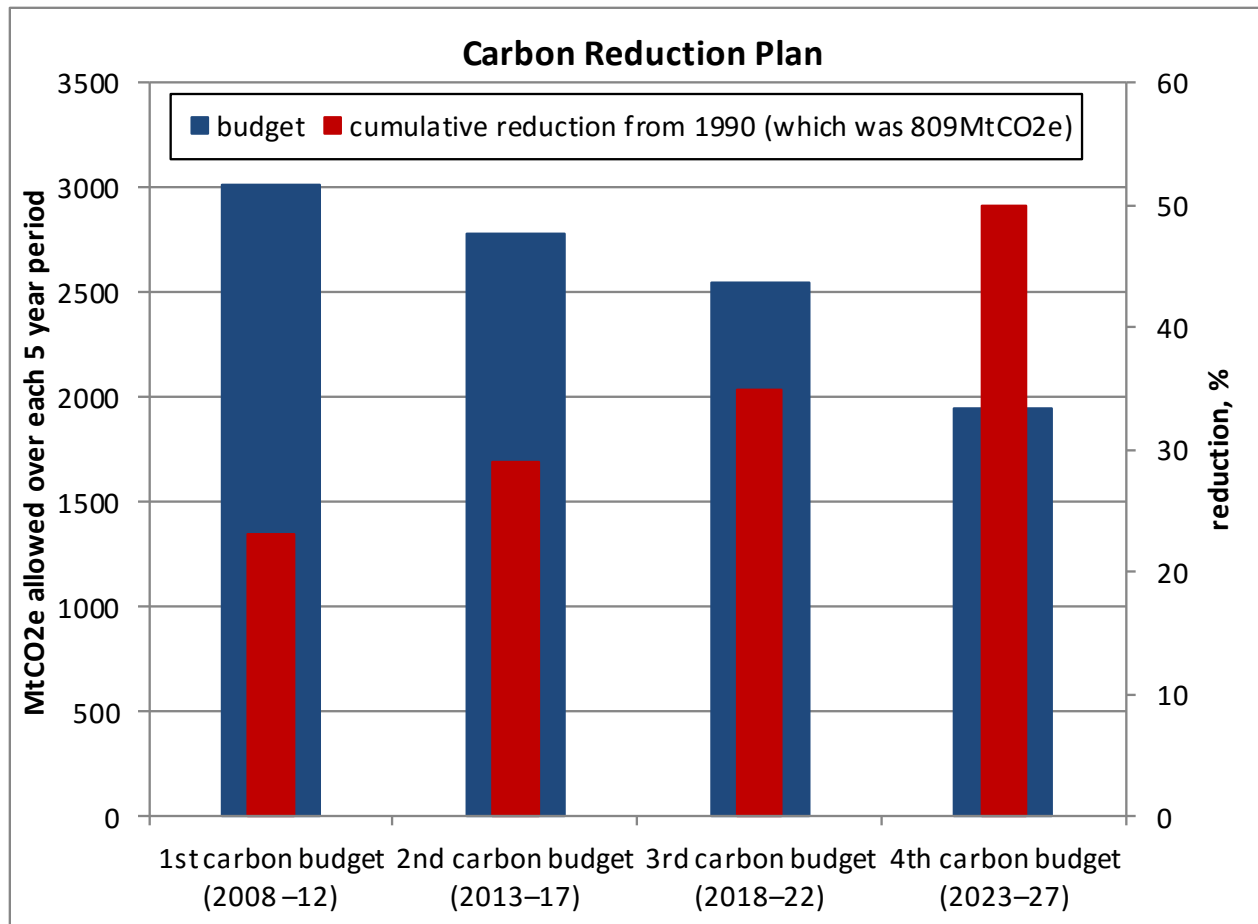
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Summary

- UK Targets
- Marginal Abatement Curves
- UK Carbon price forecasts
- MAC curve to 2020
- Heating System Stakeholders & Requirements
- Heating Subsystems: many possible combinations
- SOURCE Subsystems: first filter by requirements
- DELIVERY Subsystems: first filter by requirements
- Heating Subsystems: Revisited
- Heating System Configurations
- Next Steps include

UK Targets

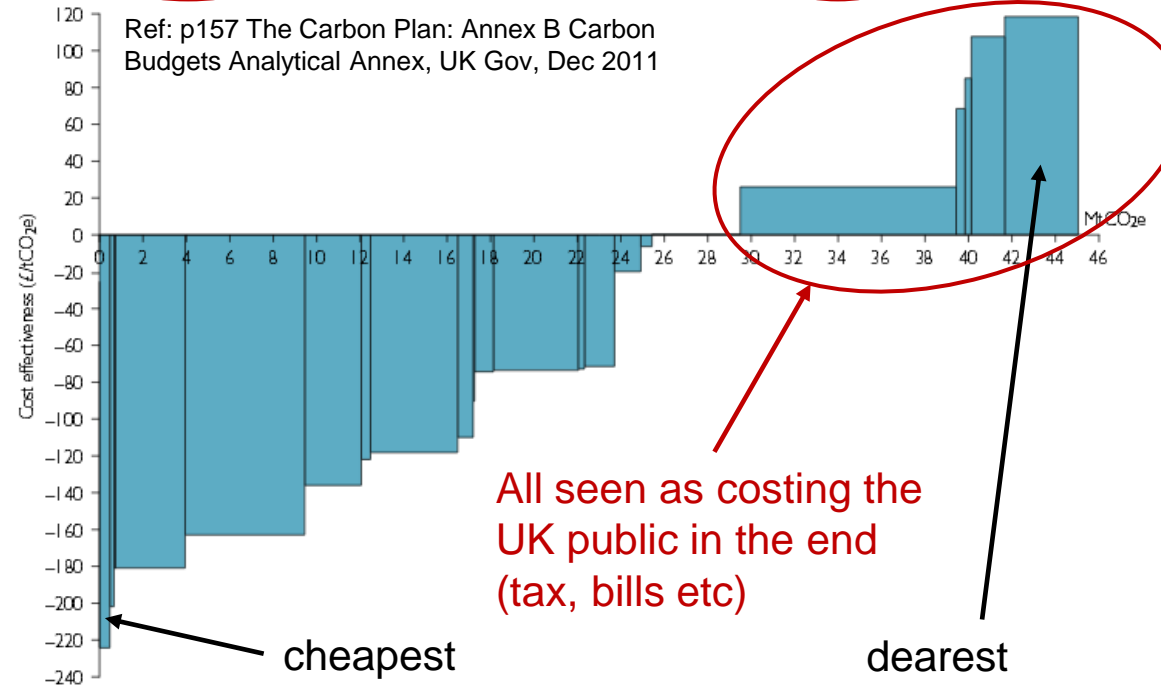
-80% by 2050, -34% by 2020 i.e. 533MtCO₂e/year



Marginal Abatement Curves (MACs)

- Least-cost ranking of decarbonisation measures
- Whole economy

Chart B6: Non-traded emissions policy marginal abatement cost curve, 2020



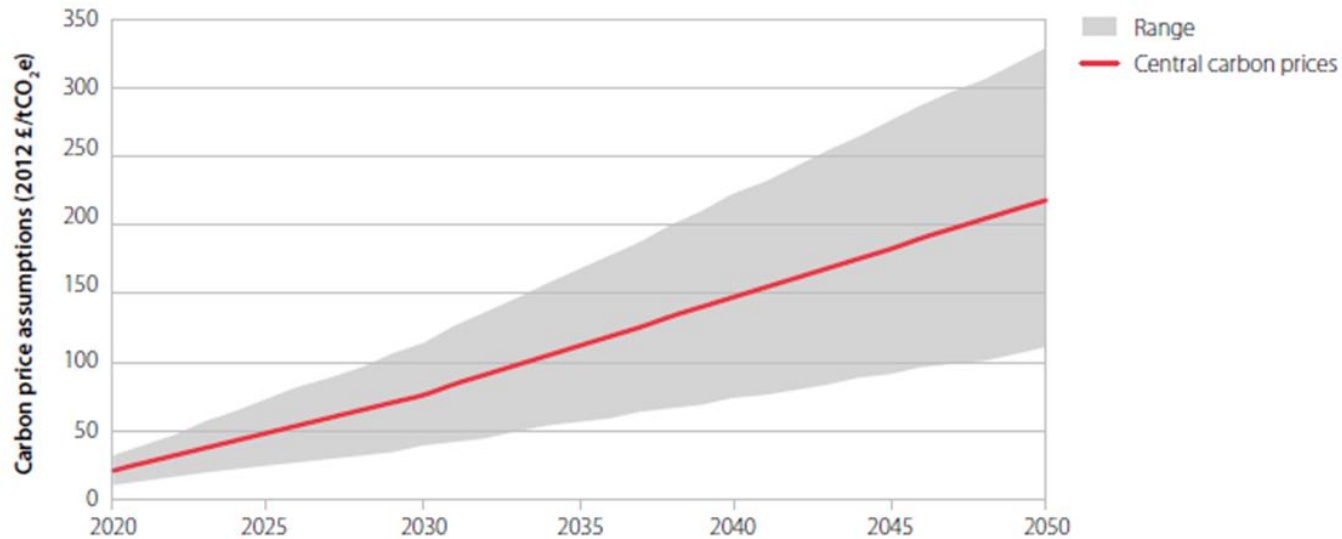
Key

0.0 – 0.5	Local Sustainable Transport Fund
0.5 – 0.7	Rail electrification
0.7 – 0.7	Carbon Trust
0.7 – 3.9	Agriculture Voluntary Action Plan
3.9 – 9.4	Carbon Emissions Reduction Target (CERT)
9.4 – 12.2	EU new car average fuel efficiency standards (130gCO ₂ /km)
12.2 – 12.7	HGV technology measures
12.7 – 16.7	CERT extension
16.7 – 17.4	HGV low rolling resistance tyres
17.4 – 17.5	Community Energy Savings Programme
17.5 – 18.3	Non-Domestic Green Deal

18.3 – 22.2	Building Regulations 2010 part L
22.2 – 22.5	Low carbon emission buses
22.5 – 23.9	Carbon Reduction Commitment
23.9 – 25.1	Energy Company Obligation (ECO) and Domestic Green Deal
25.1 – 25.7	EU new van CO ₂ regulation
25.7 – 30.0	8% transport fuel from renewable sources by 2020
30.0 – 40.0	Renewable Heat Incentive
40.0 – 40.4	Zero Carbon Homes
40.4 – 40.7	Energy Performance of Buildings Directive
40.7 – 42.2	EU new car complementary measures
42.2 – 45.8	Further new car efficiency improvements to 95 gCO ₂ /km

UK Carbon price forecasts

Figure B3.1: Carbon prices used for the Fourth Carbon Budget Review analysis



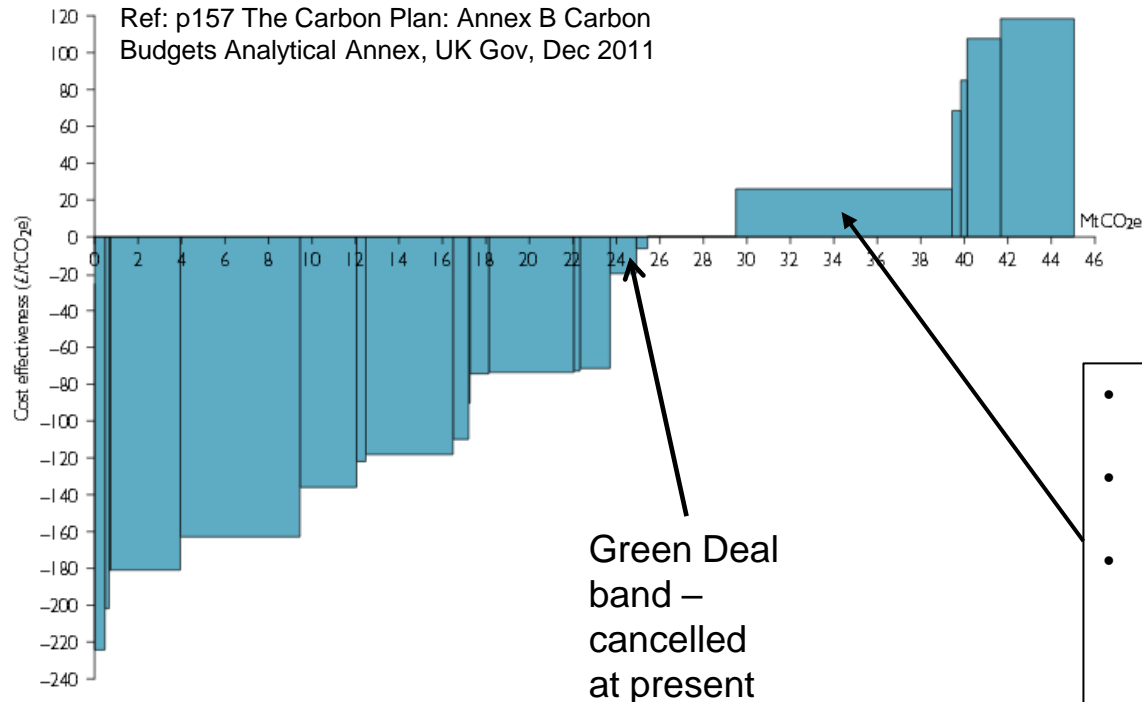
Source: DECC (2009) Carbon Valuation in UK Policy Appraisal: A Revised Approach; EC (2011) Low-Carbon Roadmap.

Notes: Linear interpolation assumed between the EC point for 2020 and the DECC point for 2030, as in DECC methodology post-2030.

- based partly on an assessment of the MAC beyond 2020 to meet UK targets
- UK (or perhaps global) context for heating system costs and CO₂ savings - if it's too expensive, perhaps some other sector should be de-carbonised
- these carbon prices, or broadly similar, seem to be what UK will use in designing policy
- not the be-all and end-all, e.g. some expensive measures required to enable later action

MAC curve to 2020

Chart B5: Non-traded emissions policy marginal abatement cost curve, 2020



- large RHI band totalling 10MtCO₂e, costing £25/tCO₂e
- this supports for solar thermal, biomass, GSHP, ASHP?
- 10MtCO₂e is only 7% of the domestic emissions (as of 2009), so just a start – seems to be non-domestic RHI

Key

0.0 – 0.5 Local Sustainable Transport Fund
 0.5 – 0.7 Rail electrification
 0.7 – 0.7 Carbon Trust
 0.7 – 3.9 Agriculture Voluntary Action Plan
 3.9 – 9.4 Carbon Emissions Reduction Target (CERT)
 9.4 – 12.2 EU new car average fuel efficiency standards (130gCO₂/km)
 12.2 – 12.7 HGV technology measures
 12.7 – 16.7 CERT extension
 16.7 – 17.4 HGV low rolling resistance tyres
 17.4 – 17.5 Community Energy Savings Programme
 17.5 – 18.3 Non-Domestic Green Deal

18.3 – 22.2 Building Regulations 2010 part L
 22.2 – 22.5 Low carbon emission buses
 22.5 – 23.9 Carbon Reduction Commitment
 23.9 – 25.1 Energy Company Obligation (ECO) and Domestic Green Deal
 25.1 – 25.7 EU new van CO₂ regulation
 25.7 – 30.0 8% transport fuel from renewable sources by 2020
 30.0 – 40.0 Renewable Heat Incentive
 40.0 – 40.4 Zero Carbon Homes
 40.4 – 40.7 Energy Performance of Buildings Directive
 40.7 – 42.2 EU new car complementary measures
 42.2 – 45.8 Further new car efficiency improvements to 95 gCO₂/km

Heating system stakeholders & requirements

to provide low-carbon space and water heating in a large proportion of detached and semi-detached homes

STAKEHOLDERS
house occupiers
house owners - incl bank
insurance companies
manufacturer of system
installer of system
maintainer of system
LV network owner/operator
electric utility retail company
gas supply owner/operator
gas utility retail company
government
neighbours

Functional Requirements

accept/gather energy and/or heat
 emit heat to living space and DHW
 control energy or heat flows, living spacetemperature and DHW temperature
 contain energy and/or heat
 store energy and/or heat
 convert energy to heat
 store energy and/or heat

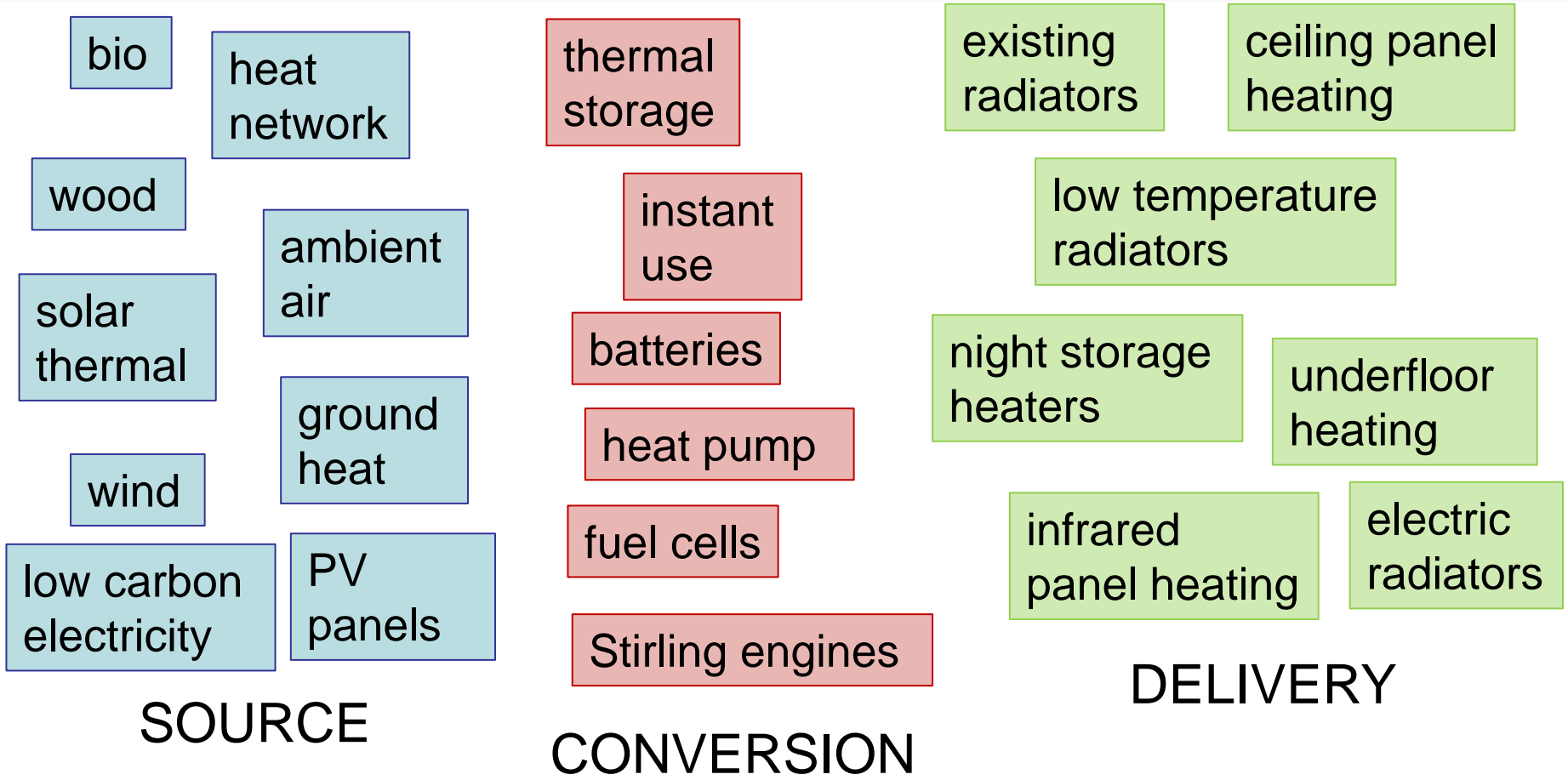
Non-functional Requirements

P=performance, S=system, I=implementation

S rate of tech adoption
 S 80% reduction in CO2
 S market potential \geq 20% of total UK houses heat energy use
 S commercialised by 2015
 S <1 week to install and no vacate
 S not use a lot of useful space
 S limited noise
 S cost-effective i.e. market potential fits into UK-wide MAC
 P \leq 20 minute response time for space and DHW temperature demand
 S yearly service \leq 2 hours; MTBF 4 years; trade-maintainable in home
 S aesthetics
 S adaptable to future resident demands
 S easily scaled for differing house sizes, types, energy efficiencies
 S easy to use
 S be safe

These are not just for the technology, they are also for any technology development

Heating Subsystems: many possible combinations



reduce count by eliminating weakest subsystems

SOURCE Subsystems: first filter by requirements

type	Non-functional Requirements	energy/heat sources									
		onsite					offsite				
		wind turbine	various bio-waste digestion etc	solar thermal panels	PV panels	ground heat loop/piles	ambient air	natural gas micro-CHIP	bio	low-carbon electricity	area heat network
S	80% reduction in CO2							5	8		
S	market potential >= 20% of total UK houses heat energy use	1	3			6					
S	commercialised by 2025		4						9		
S	not use a lot of useful space										
S	cost-effective i.e. market potential fits into UK-wide MAC	2									7
S	<1 week to install and no vacate										
S	good rate of tech adoption										
S	limited noise										
P	<= 20 minute response time for space and DHW temperature demand										
S	yearly service <=2 hours; MTBF 4 years; trade-maintainable in home										
S	aesthetics										
S	adaptable to future resident demands										
S	easily scaled for differing house sizes, types, energy efficiencies										
S	easy to use										
S	be safe										

P=performance, S=system, I=implementation

Notes

1. most houses don't have several acres of land required (approx 2W average/m² of land)
2. small wind turbines very expensive
3. not enough waste in average garden and occupancy
4. multi-waste conversion unclear
5. transition only
6. most houses don't have garden big enough
7. too costly at detached and semi-detached densities
8. wood: industry, CHP, power station competing for resource, all arguably higher priority
9. algae/other crops/biofuels etc: not practical /optimal for conversion at house scale

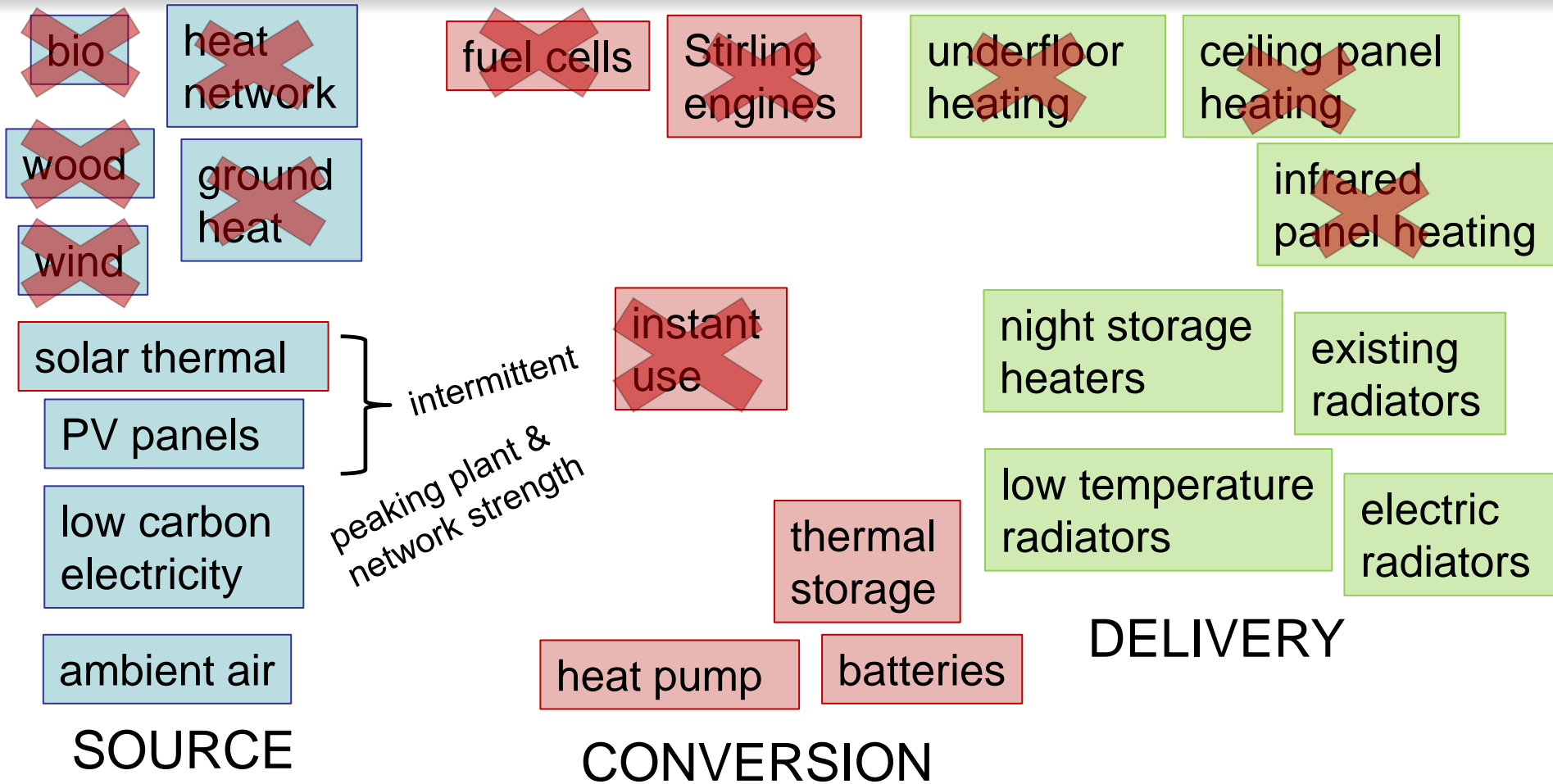
DELIVERY Subsystems: first filter by requirements

type	Non-functional Requirements	energy/heat delivery						
		existing radiators	ceiling panel radiators	low temperature radiators	night storage heaters	underfloor heating	infrared panel heating	electric panel
S	80% reduction in CO2							
S	market potential >= 20% of total UK houses heat energy use							
S	commercialised by 2025							
S	not use a lot of useful space							
S	cost-effective i.e. market potential fits into UK-wide MAC		2			2		
S	<1 week to install and no vacate		1			1		
S	good rate of tech adoption		3			3		
S	limited noise							
P	<= 20 minute response time for space and DHW temperature demand						4	
S	yearly service <=2 hours; MTBF 4 years; trade-maintainable in home							
S	aesthetics							
S	adaptable to future resident demands							
S	easily scaled for differing house sizes, types, energy efficiencies							
S	easy to use							
S	be safe							

Notes

1. can't fit large size ceiling or roof panels without furniture, carpets etc removal
2. labour intensive
3. unusual technology for UK
4. comfort levels too reliant on positioning, so impractical as main heating

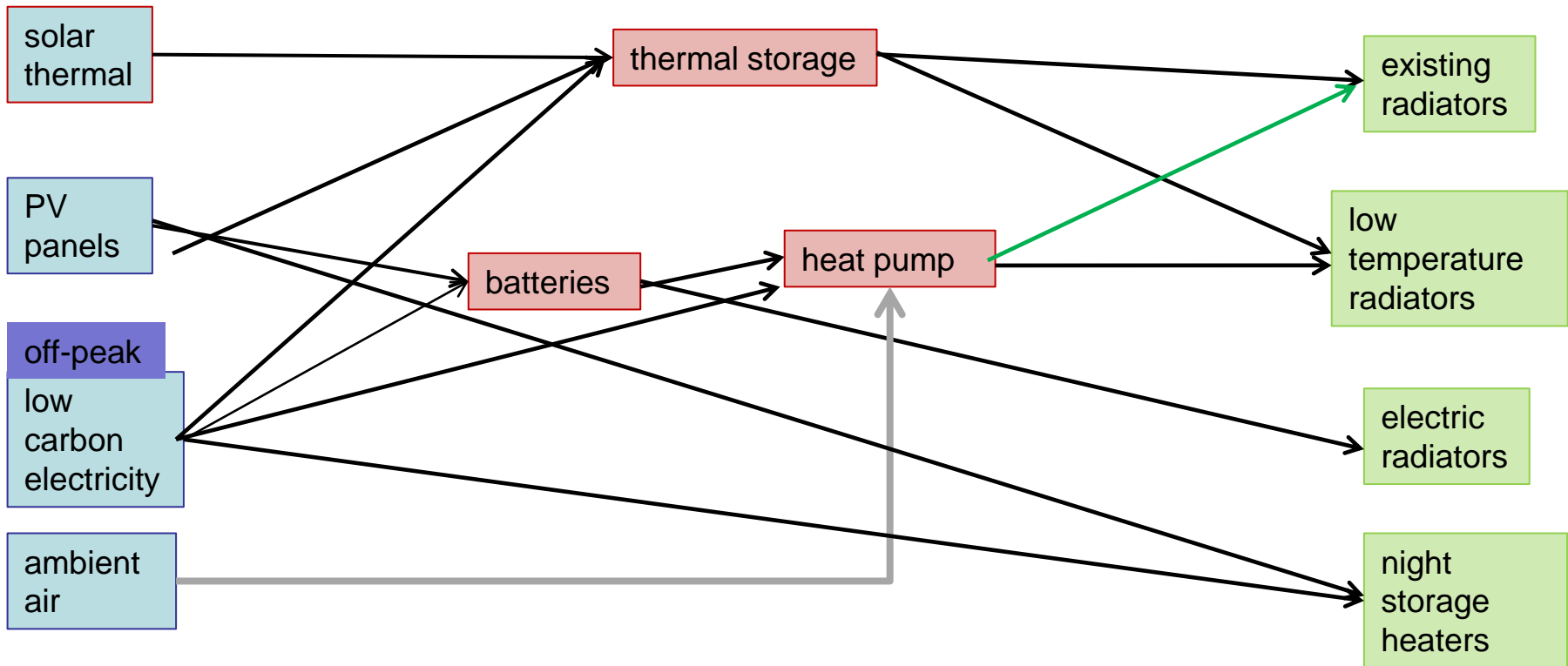
Heating Subsystems: Revisited



reduced count by eliminating weakest subsystems, and related subsystems

Heating System Configurations

“simplest”: 1 source + 1 storage + 1 delivery



18 configurations

Next Steps include

- further characterise the 18 simple system configurations e.g. LCOH, physical detail
- ranking based on this, against requirements
- seek to discard very weak configurations (18 is too much)
- identify primary factors influencing the remainders' fit to requirements
- set factors for best case of each candidate system at nominals
- ranking with refined candidate systems
- identify if the ranking is robust to variations
- identify technology needs and value for top systems