Building Technology Graduation Studio
P5 presentation, October 2022

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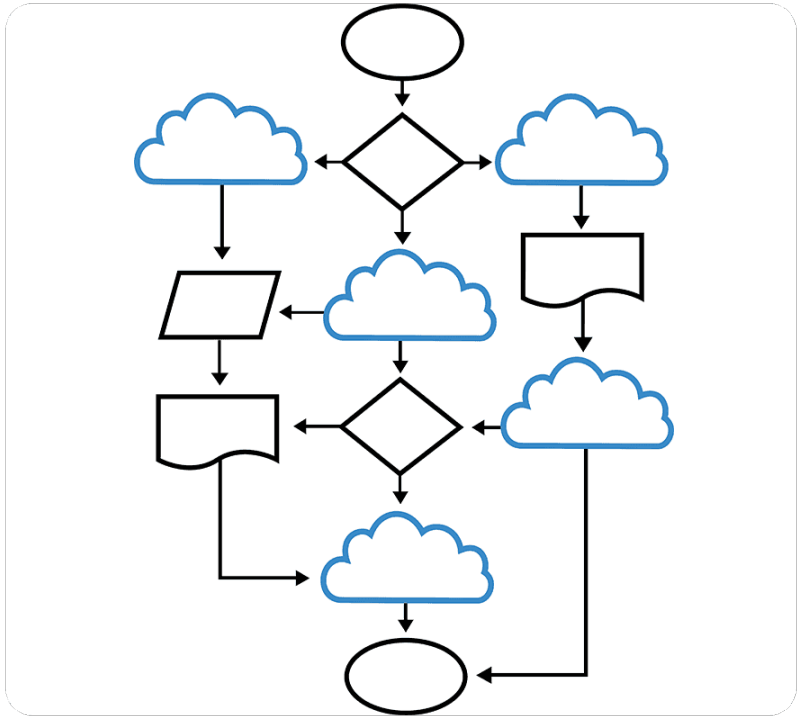
John (Delegate)



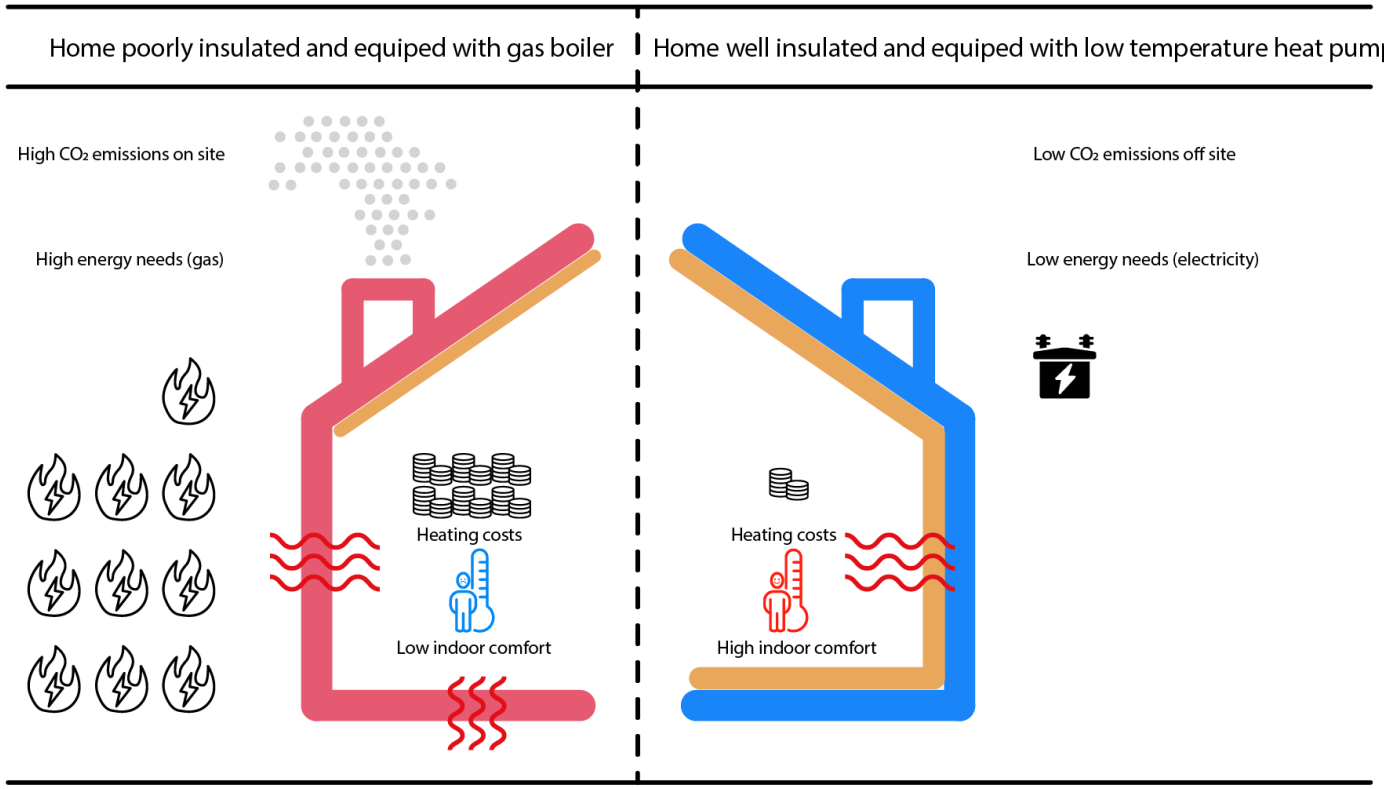
Flowchart. From https://www.imindq.com/decision-making

A heat pump decision tool for homeowners

An advise leading to the benefits of the homeowner and a contribution to the energy transition of the built environment

Background

Energy transition: 7 million households transformed



Background

Energy transition: consequences

Earthquakes

Emissions

Climate change

Background

Economic developments: reasons for homeowners to change

Gas price

War

Terschellingenergie.nl

ISDE
InvesteringsSubsidie
Duurzame Energie

Grants

Background

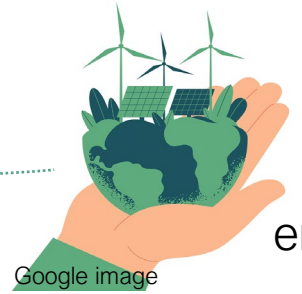
Development educational tool

Heat pump key technology

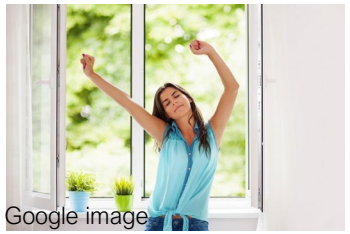
Fall short

Thesis goal

Independent heat pump decision tool


Google image

Advise that: contributes to energy transition


Google image

Advise that: contributes to the comfort of the homeowner


Google image

Advise that: contributes to cost savings for the homeowner

Literature research

Potential renewable energy sources for space heating

Individual (focus)

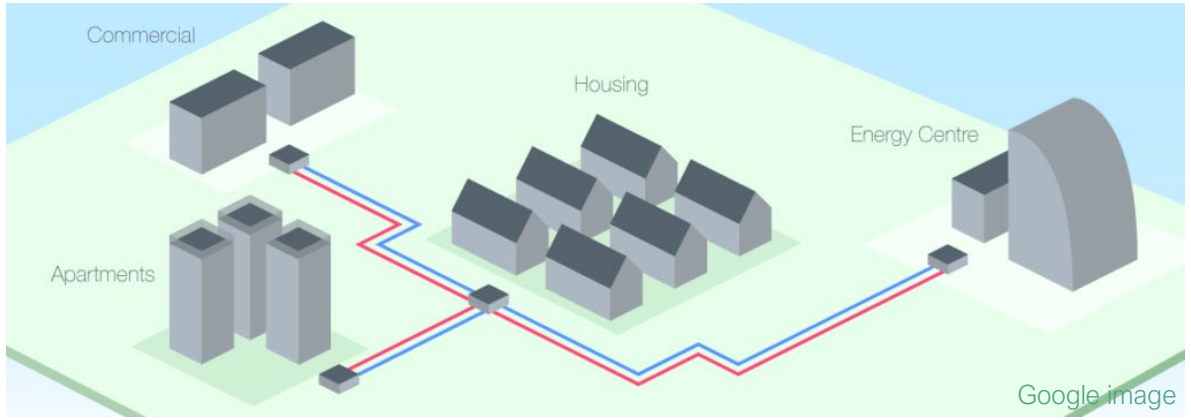
Biomass

Biogas

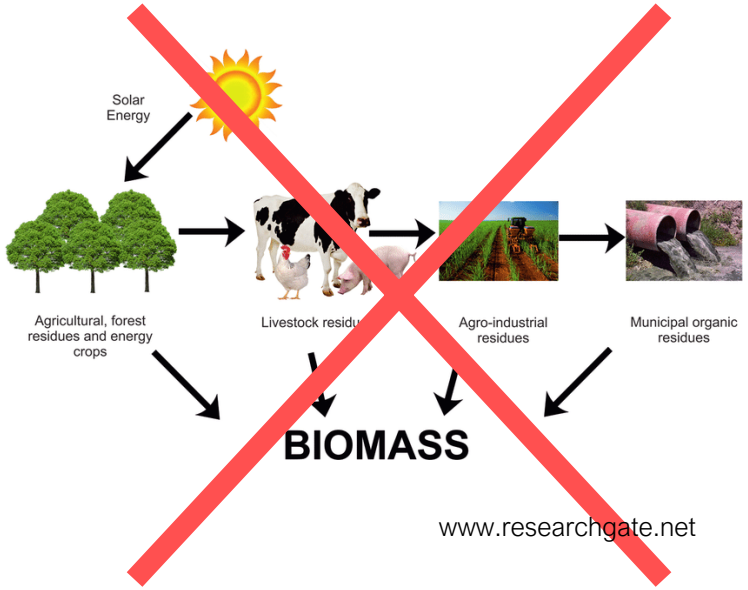
vs

All-electric

Collective(excluded)

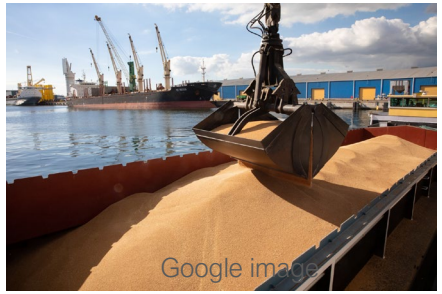


Biomass



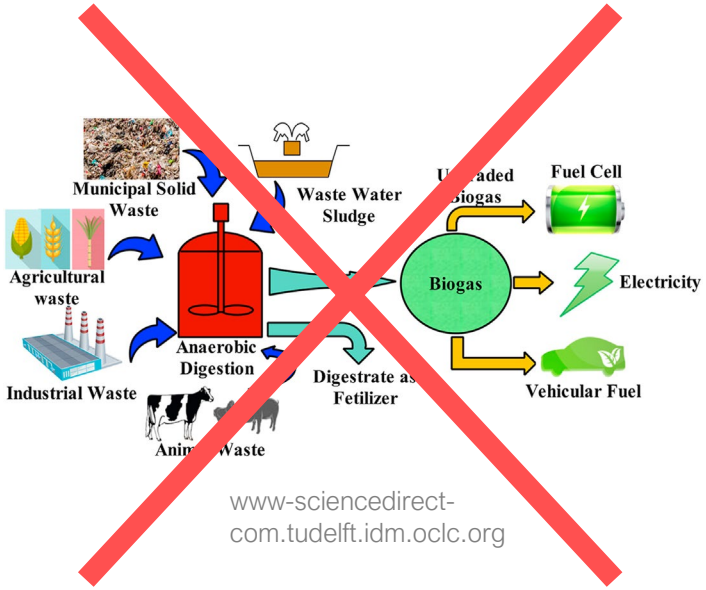
Low contribution to energy transition of built environment

Wood is scarce in NL



Importing causes lot of CO2 emissions

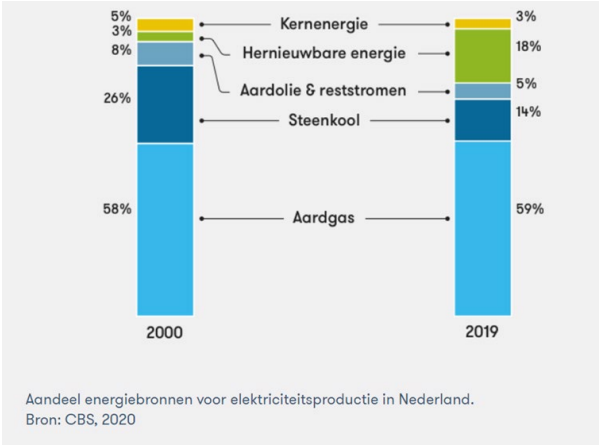
Biogas



www-sciencedirect-com.tudelft.idm.oclc.org

- Limited production
- Production expensive
- Too expensive in the future

All electric

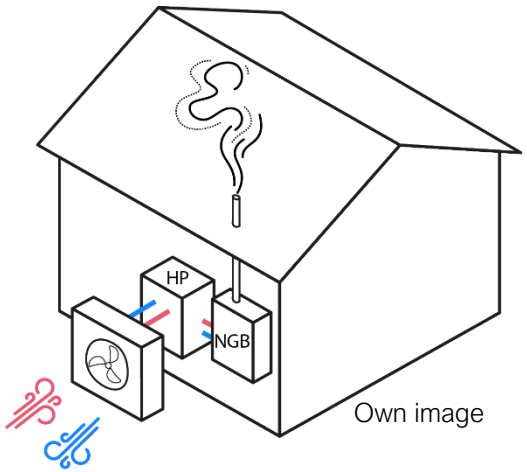


Aandeel energiebronnen voor elektriciteitsproductie in Nederland.
Bron: CBS, 2020

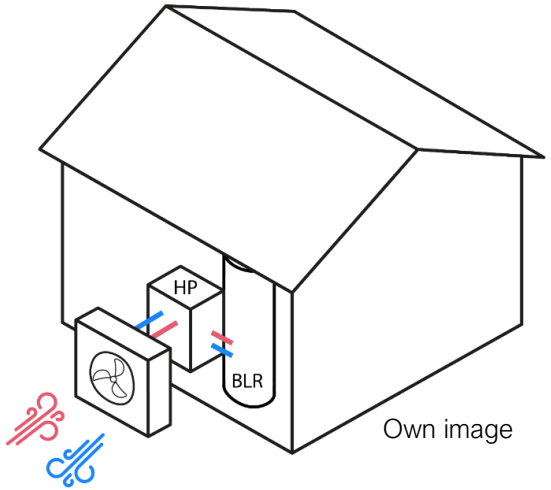
Literature research/Desk research

Potential heat pump systems space heating

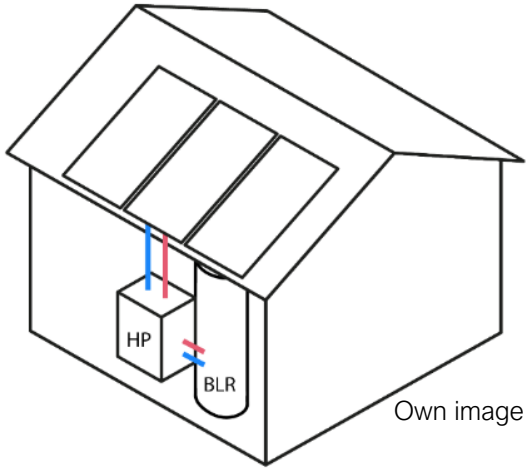
Hybrid air source heat pump



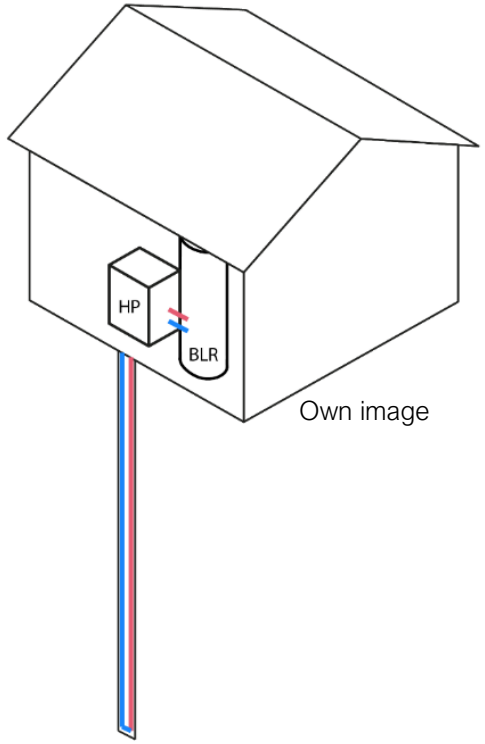
All electric air source heat pump



All electric/hybrid PVT heat pump



All electric ground source heat pump



Empirical research

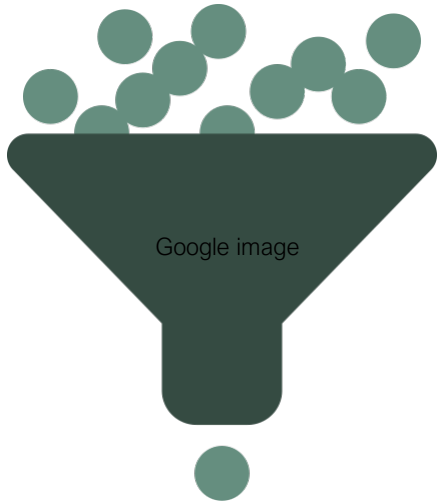
The analysis of existing heat pump decision tools

1. https://www.milieucentraal.nl/energie-besparen/duurzaam-verwarmen-en-koelen/volledige-warmtepomp/
2. https://www.samangroep.nl/keuzehulp-warmtepompen/
3. https://www.warmhuis.be/start
4. https://groenpand.nl/warmtepomp/#check
5. https://warmtepompcheck.ithodaalderop.nl/warmtepomp/afa71df8-b136-41cc-a69b-115e88473f30
6. https://www.panasonicproclub.com/NL_nl/tools/aquarea-designer/
7. https://www.vaillant.nl/consument/kennis-en-advies/keuze-advies/ketelkiezer/

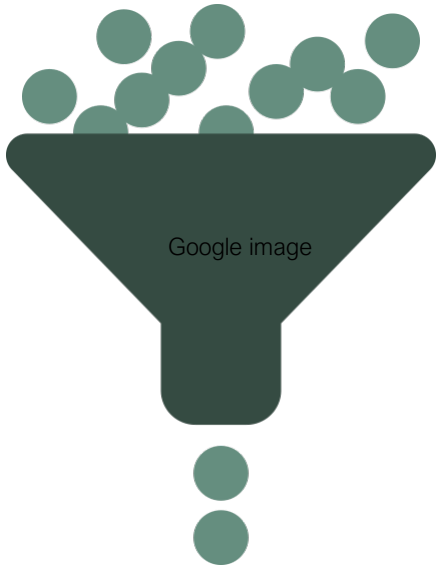
Empirical research

The analysis of existing heat pump decision tools

Most existing tools



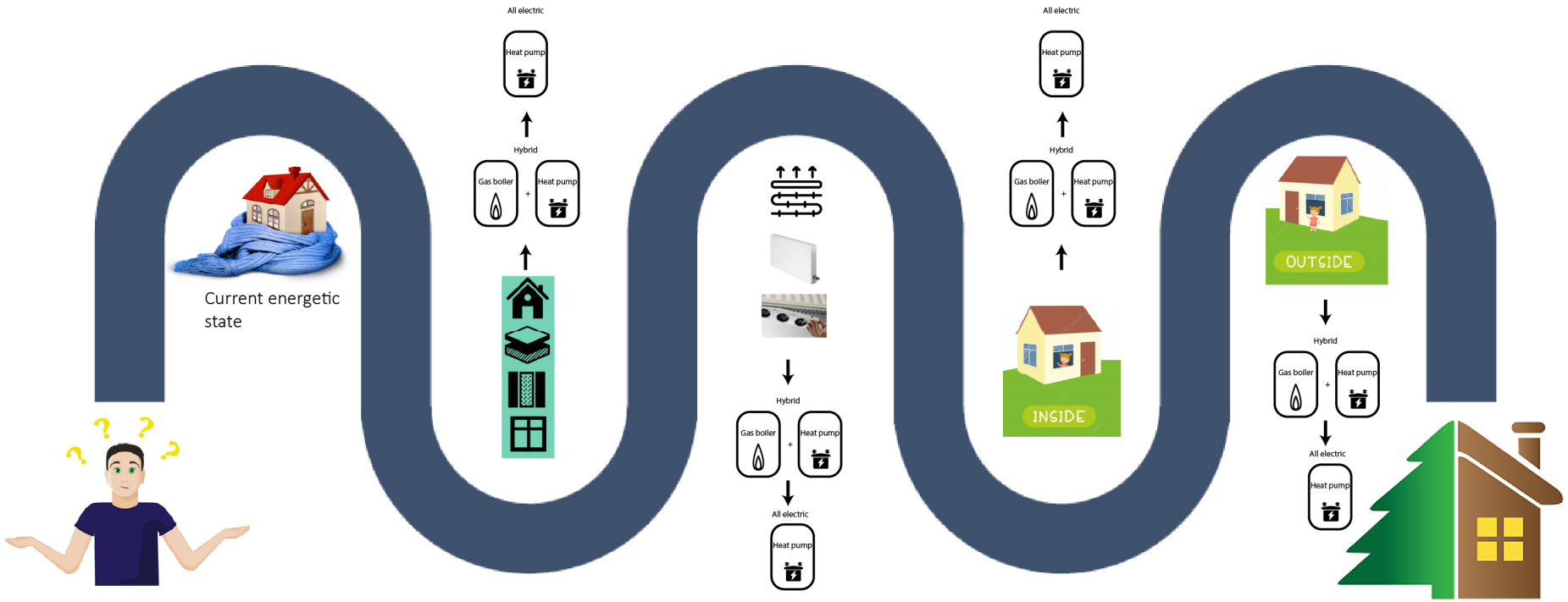
Only 1 existing tool



Empirical research

The analysis of existing heat pump decision tools

Guided path missing in existing tools



Own image (composed from google images)

Empirical research

Tool boundaries: target group

Owner-occupied home

Empirical research

Tool boundaries: building type

Terraced home

Google image

Semi-detached home

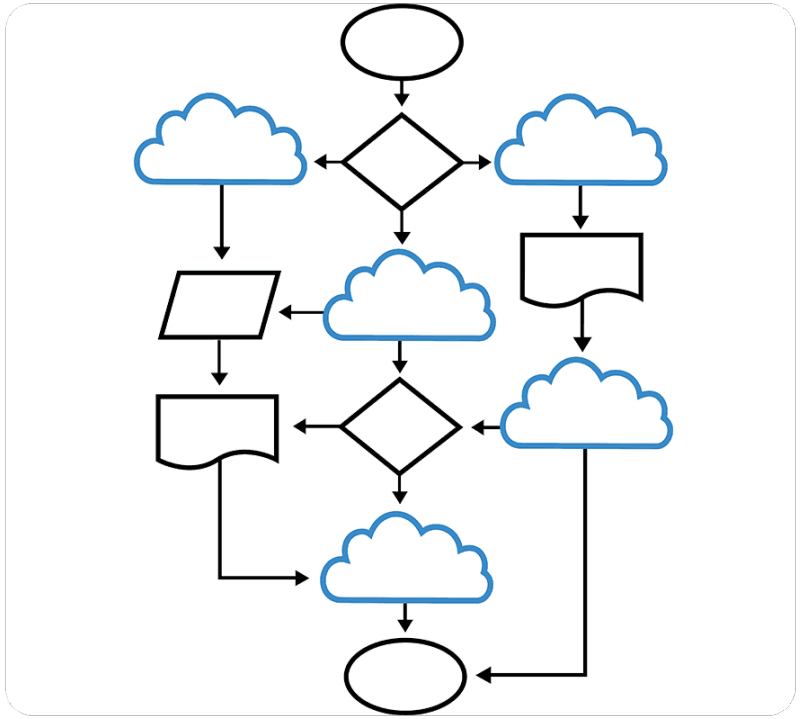
Google image

Detached home

Google image

Research by design

Building the final tool



https://www.imindq.com/decision-making

Different flowcharts for:

- Energetic state
- Insulation improvements
- Heat emitter improvements
- Spatial aspects outdoors
- Spatial aspects indoors

2 example cases

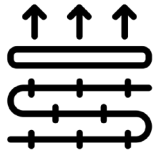
An advice given with the final tool

Detached home 1998

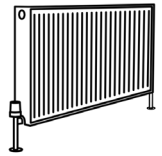
Terraced home 1940

The heat pump decision tool

1st example: detached home 1998



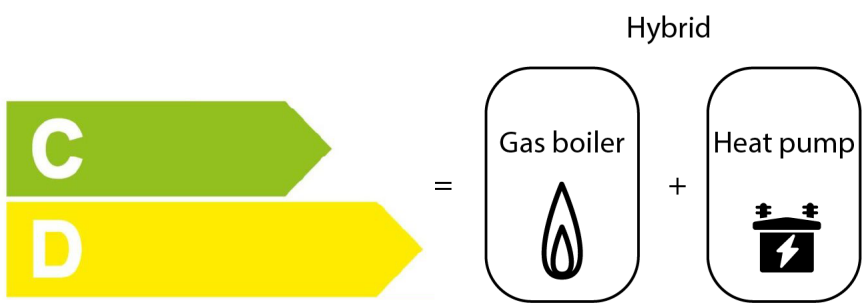
Underfloor heating ground floor



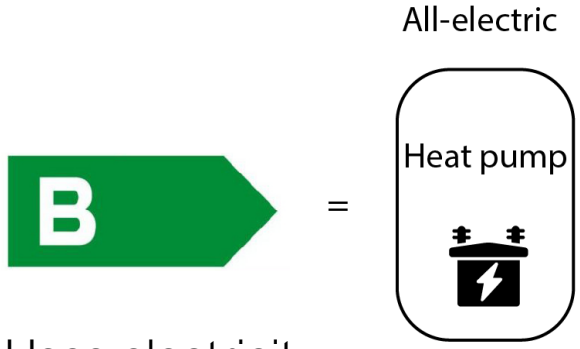
Radiators upstairs in bedrooms

Information obtained by the tool

Hybrid and all electric both applicable



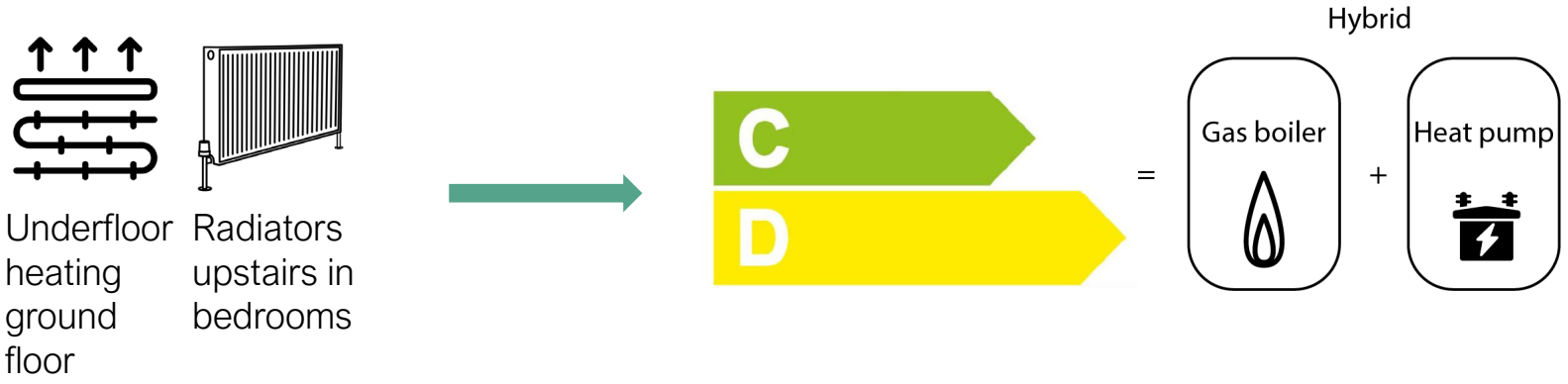
Uses gas and electricity
Reduction heating cost
Reduction in Co2 emissions



Uses electricity
Higher reduction in heating costs
Higher reduction in Co2 emissions

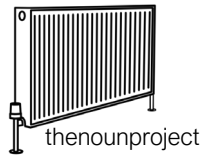
Information obtained by the tool

Emitter directly suitable for hybrid



Information obtained by the tool

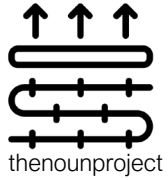
Emitter needs to be improved for all-electric



Radiators upstairs in bedrooms

Low temperature Radiators upstairs in bedrooms

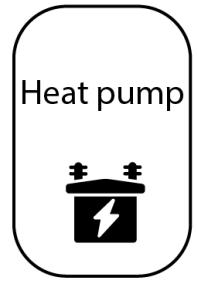
OR



Underfloor heating

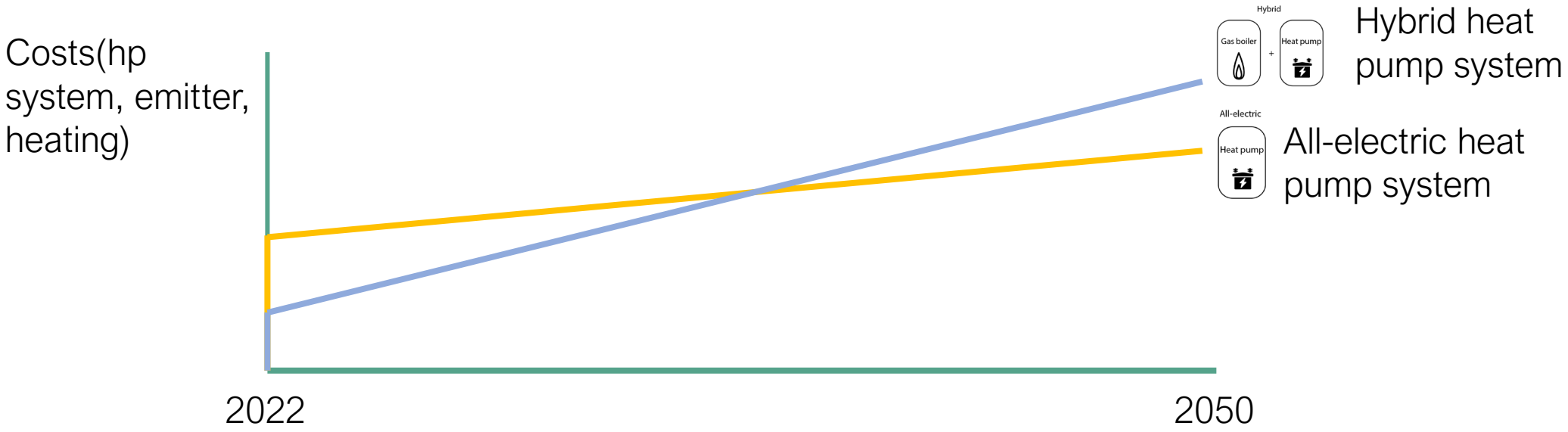
=

All-electric



Information obtained by the tool

Cost education



Own image

Final decision made by homeowner

The tool provides all the information to support the decision

I just want to get rid of that widely varying gas price.
I take the extra installation measures and investment costs for granted.

=

All-electric

Heat pump

The heat pump decision tool

Spatial aspects

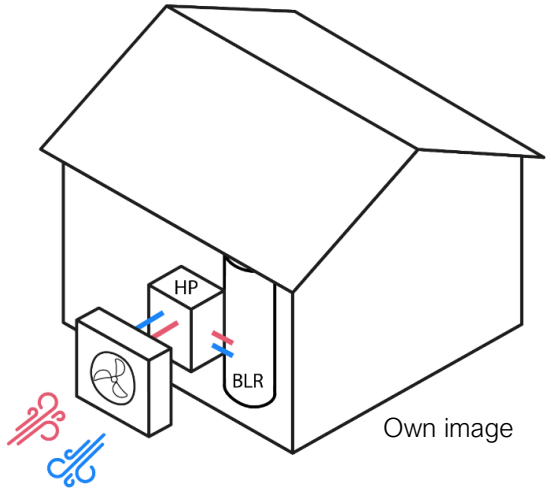
Outdoor spatial aspects

Indoor spatial aspects

Heat pump systems applicable

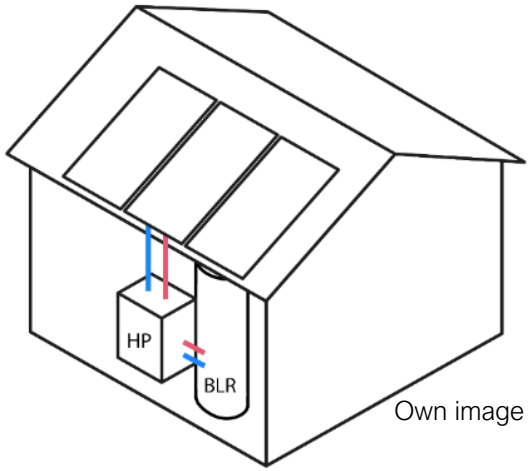
Based on spatial aspects indoors and outdoors

All electric air source heat pump



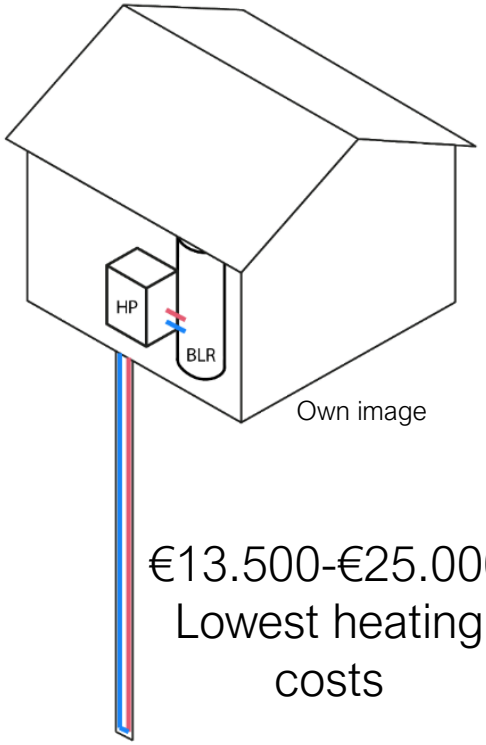
€7.500-€12.500
Highest heating costs
Noise production

All electric/hybrid PVT heat pump



€15.000-€25.000
Medium heating costs

All electric ground source heat pump

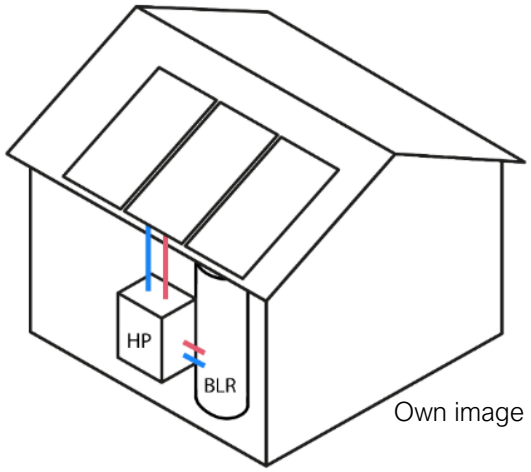


€13.500-€25.000
Lowest heating costs

Final decision made by homeowner

The tool provides all the information to support the decision

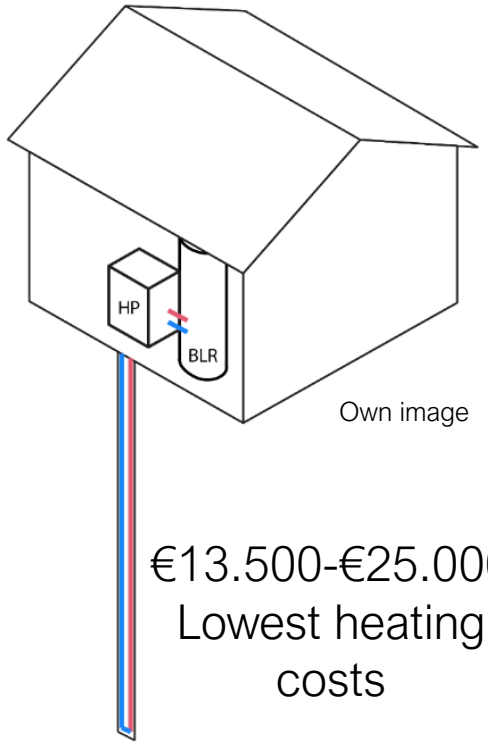
All electric PVT heat pump



€15.000-€25.000
Medium heating costs

OR

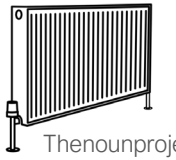
All electric ground source heat pump



€13.500-€25.000
Lowest heating costs

Request quotes from installers

The homeowner is provided with al the needed information and can search for an installer



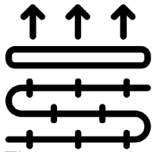
Thenounproject

Radiators upstairs in bedrooms

Google image

Low temperature Radiators upstairs in bedrooms

OR

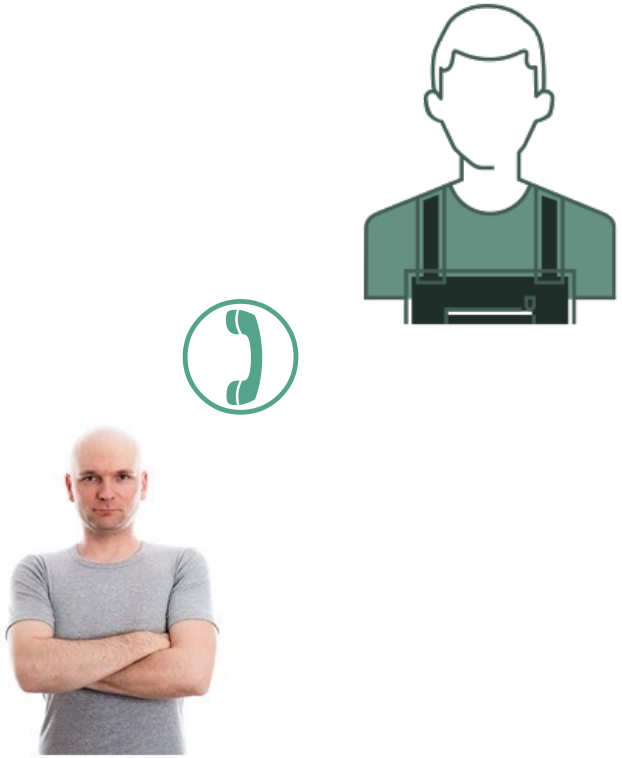


Thenounproject

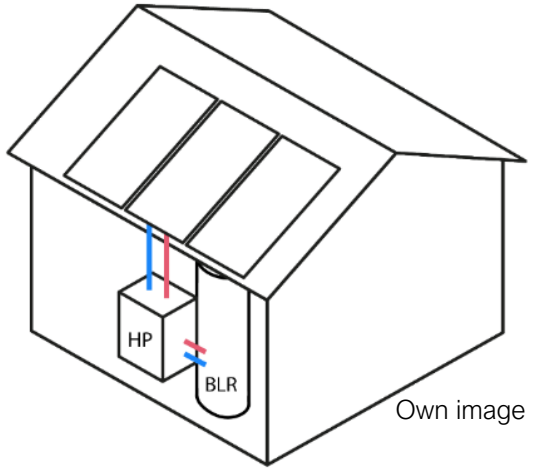
Underfloor heating

Request quotes from installers

The homeowner is provided with al the needed information and can search for an installer



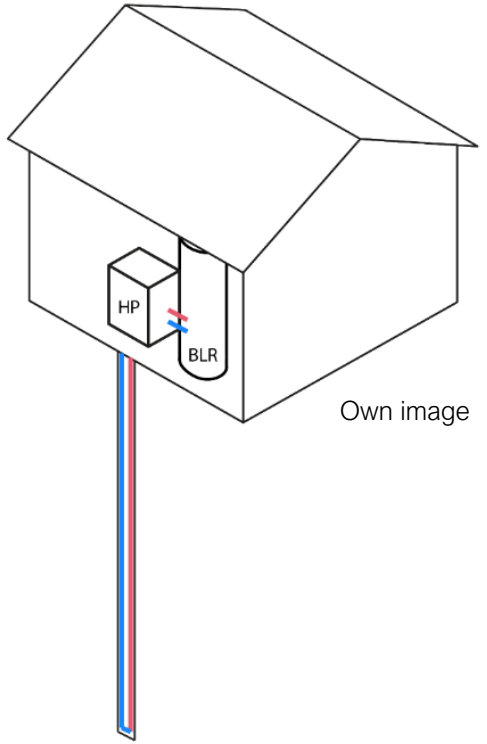
All electric PVT heat pump



Own image

OR

All electric ground source heat pump

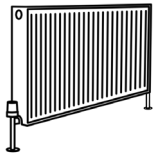


Own image

The heat pump decision tool

2nd example: terraced home 1940

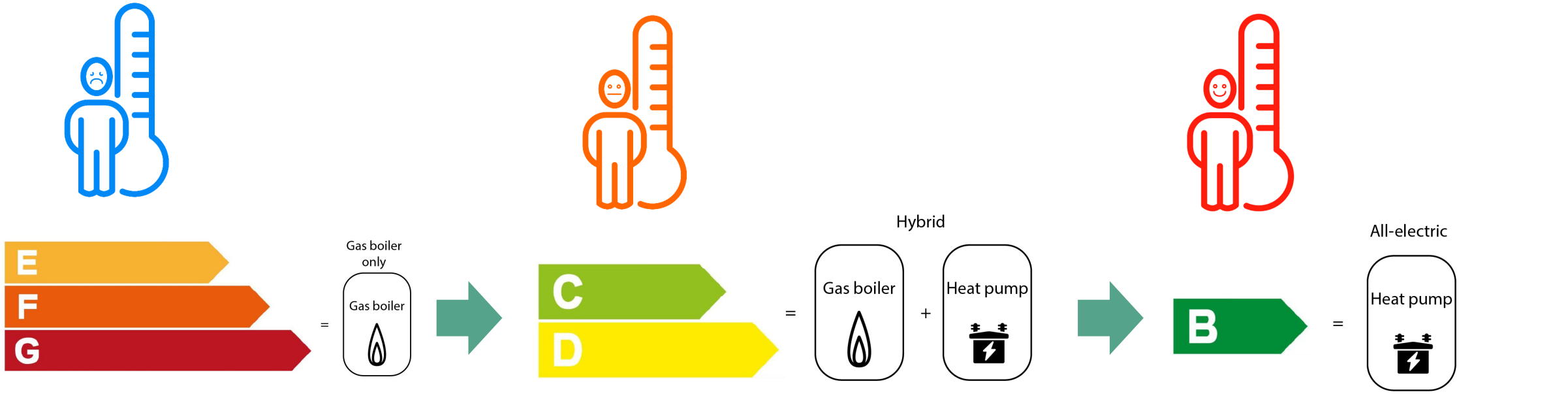
Gas usage for heating 3453 m3.yr
Floor area: 102



Radiators on all floors

Information obtained by the tool

Insulate first



Heat emitter can be remained

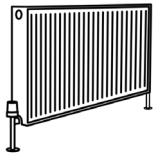
Heat emitter can be remained

Own images

The heat pump decision tool

2nd example: terraced home 1940 insulating

Gas usage for heating 3453 m3.yr
Floor area: 102

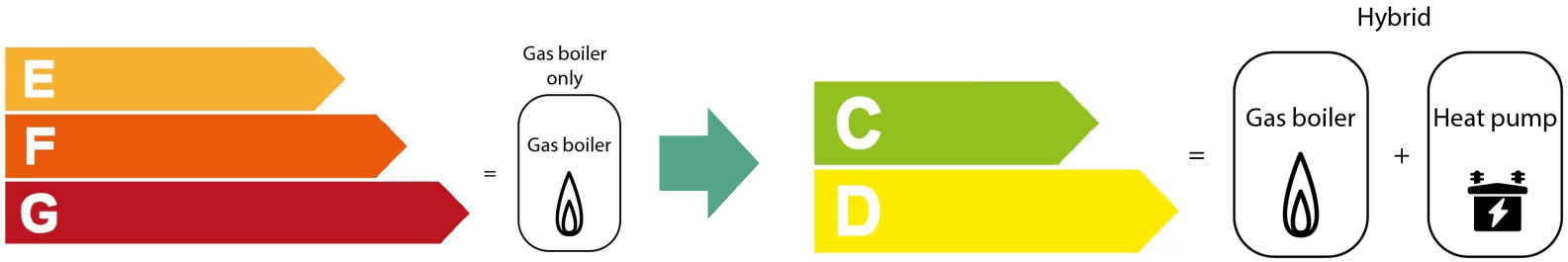


Radiators on all floors

Decision making by homeowner

First insulate to (C-D)

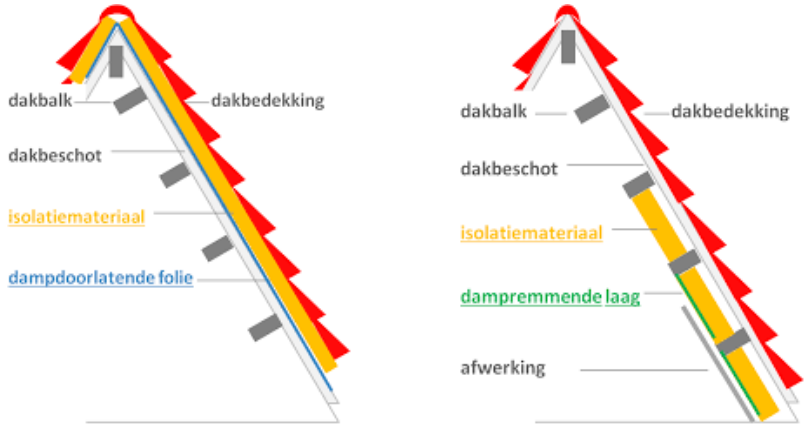
We are starters and want a step-by-step approach in order to spread costs



Information obtained by the tool

Roof needs to be insulated according to insulation standard

Roof: min Rc 3,5 (15cm) ‘standard’, max Rc 8 (35cm) ‘target value’



Google images

The contractor determines how this can be carried out

Request quotes from contractor

The homeowner can search for a contractor to insulate the roof

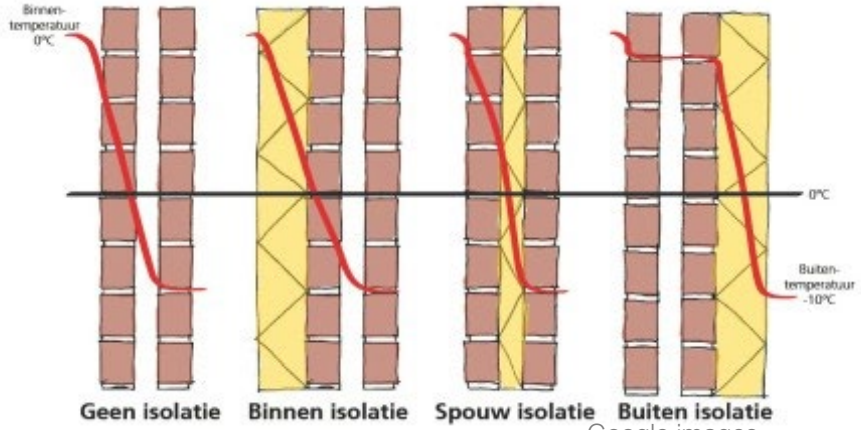
Roof: min Rc 3,5 (15cm) ‘standard’, max Rc 8 (35cm) ‘target value’

Currently not obliged by the government: homeowner must only agree if the contractor adheres to the standard

Information obtained by the tool

Roof needs to be insulated according to insulation standard

Façade: min Rc 1,7 (highest quality cavity insulation) ‘standard’, max Rc 6 (26cm) ‘target value’



Google images

The contractor determines how this can be carried out

Request quotes from contractor

The homeowner can search for a contractor to insulate the façade

Façade: min Rc 1,7 (highest quality cavity insulation) ‘standard’, max Rc 6 (26cm) ‘target value’

Currently not obliged by the government: homeowner must only agree if the contractor adheres to the standard

Decision making by homeowner

Insulation turned out to be expensive, budget is gone

- Indoor comfort has increased
- Heating costs decreased

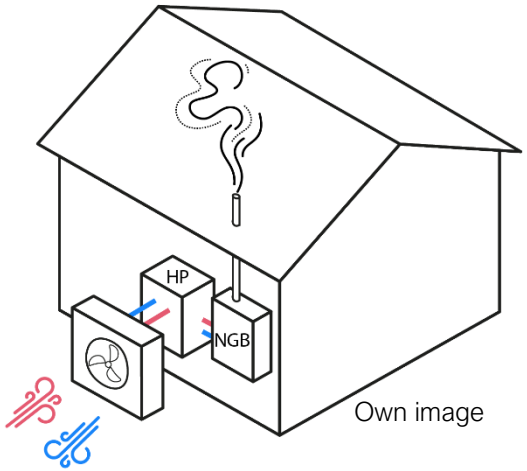
The heat pump decision tool

5 years later: Gas boiler is broken, hybrid heat pumps are obliged

Heat pump system applicable

Based on spatial aspects

Hybrid air source heat pump



€4.500-€6.000

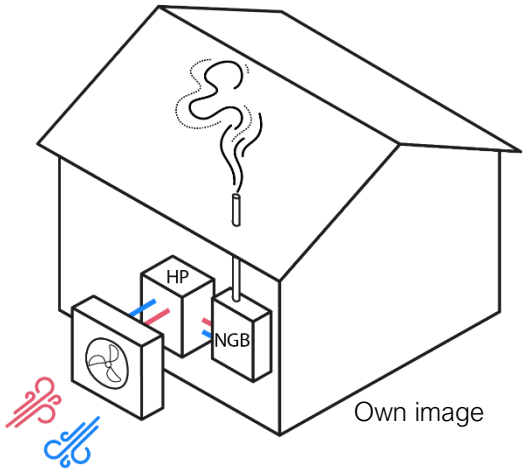
AND

Sound proof casing

Request quotes from installers

The homeowner is provided with al the needed information and can search for an installer

Hybrid air source heat pump



AND

Sound proof casing

The heat pump decision tool

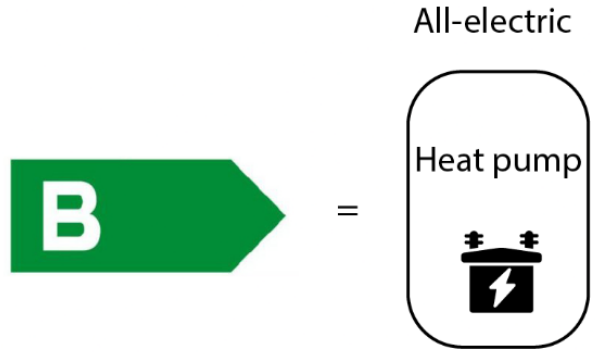
5 years later: budget available, look at options to prepare their home for all-electric

- Roof already insulated according to standard
- Façade already insulated according to standard

Insulating another 2 building parts at once will give you 30% grants.

1. Floor insulation according to 'Standard' resulting in 14 cm insulation
2. Replacing all glass by HR++ glass

This will result in a home with a label (B or lower) and a all-electric heat pump is now applicable. The heat emitter should be changed to a low temperature one. But the higher investments will pay for themselves in the long term and the indoor comfort will increase.



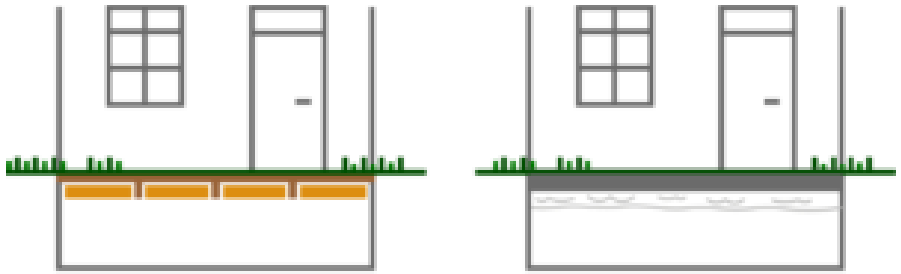
Heat emitter

The existing radiators have enough overcapacity after insulating so underfloor heating isn't necessary needed, but in some cases it can be needed to install add-on fans on the existing radiators.

Information obtained by the tool

Ground floor needs to be insulated according to insulation standard

Floor: min Rc 3,5 (15cm) ‘standard/target value’



Google images

The contractor determines how this can be carried out

Information obtained by the tool

Glass needs to be replaced by HR++

Google images

The contractor determines how this can be carried out

Request quotes from contractor

The homeowner can search for a contractor to insulate the ground floor

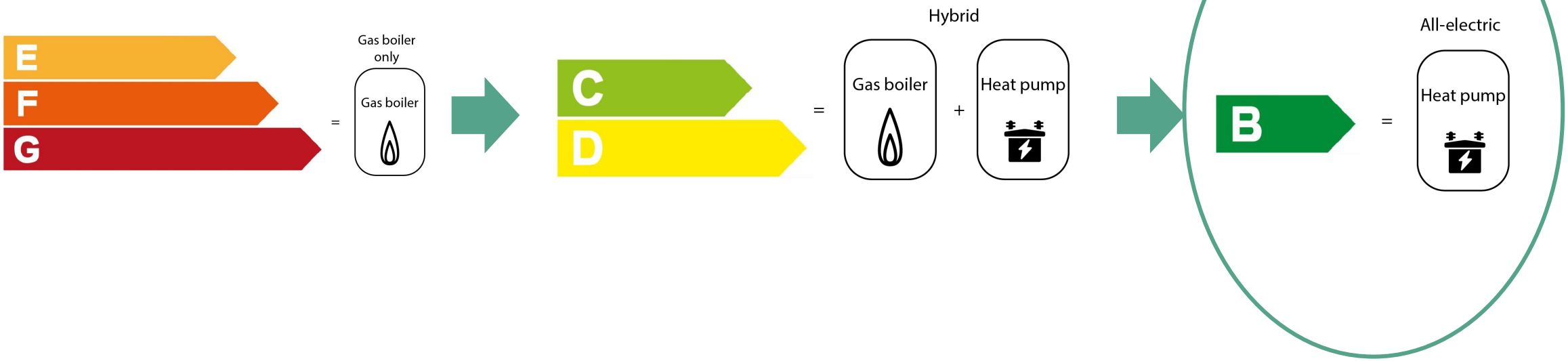
Glass HR++

Floor: min Rc 3,5 (15cm) ‘standard/target value’

Currently not obliged by the government: homeowner must only agree if the contractor adheres to the standard

Progress

Current state



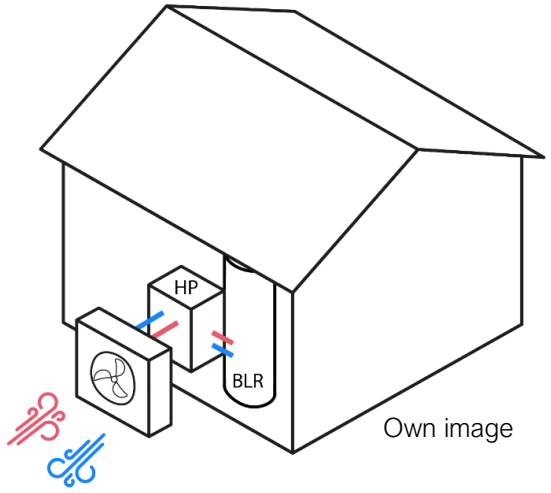
The heat pump decision tool

Hybrid heat pump broken, time for all electric

Heat pump system applicable

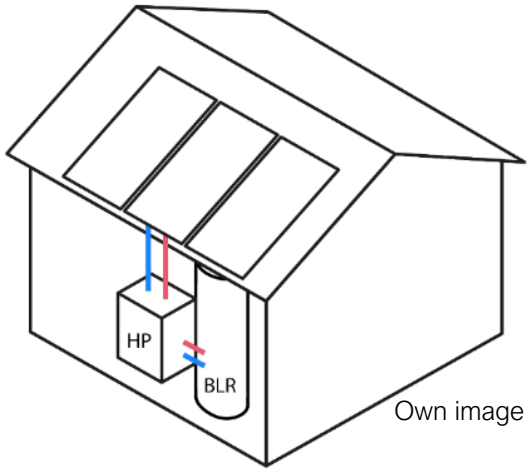
Based on spatial aspects outdoors

All electric air source heat pump



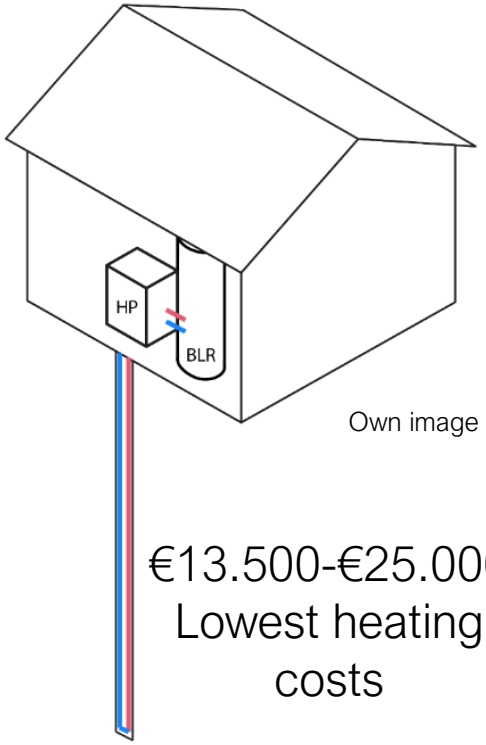
€7.500-€12.500
Highest heating costs
Noise production

All electric PVT heat pump



€15.000-€25.000
Medium heating costs

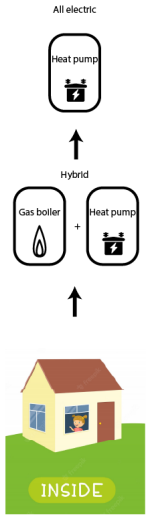
All electric ground source heat pump



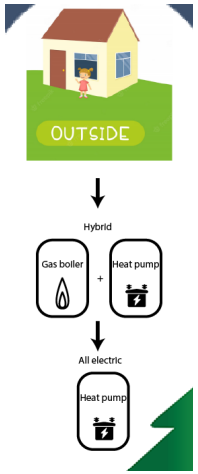
€13.500-€25.000
Lowest heating costs

Heat pump system applicable

Based on spatial aspects indoors



No all-electric heat pump applicable based in indoor spatial aspects



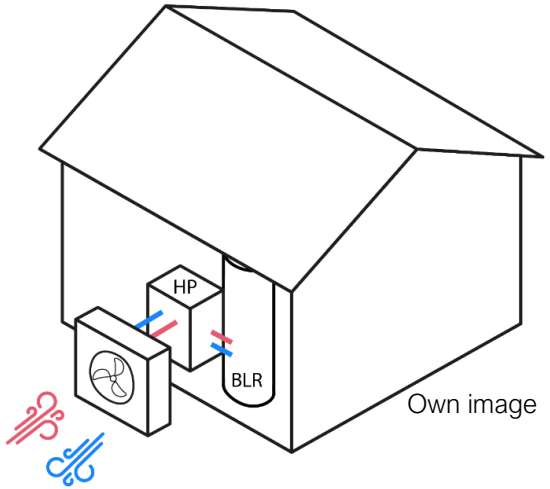
Outdoor spatial aspects are leading

Decision making by homeowner

The tool provides all the information to support the decision

We'll take the system with the lowest investment costs because our budget allows it. We were satisfied with our current hybrid air source heat pump system and we already have a sound proofing casing.

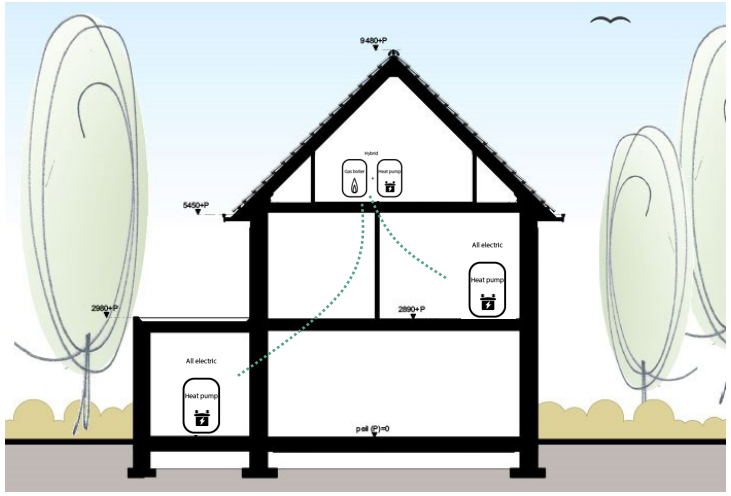
All electric air source heat pump



Own image

Request quotes from installers

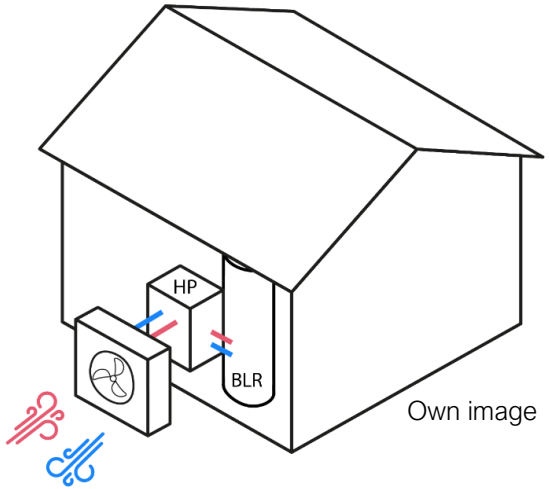
The homeowner is provided with al the needed information and can search for an installer



Google image composed

New system location

All electric air source heat pump



Own image

Weak point

Conflict between the tools advise and the installer’s thoughts

The tool

Installer

Weak point solution

Have the tool reviewed by leading installer companies

Google images

Advertise that the tool is backed by leading companies

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwarmerhuis.nl%2Fwarmtepomp-merken&psig=AOvVaw388EnehB4FlLQyIqFD7Prt&ust=1666959542507000&source=images&cd=vfe&ved=0CA0QjRxqFwoTCIiz2qyygPsCFQAAAAAdAAAAABAE

Weak point solution

Tool gains trust by both homeowners and installers

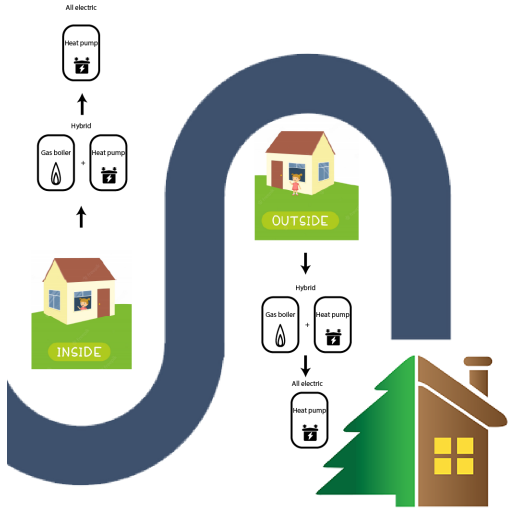
Discussion

Innovative heat pump techniques that can be added in the future

Google image

Only if:

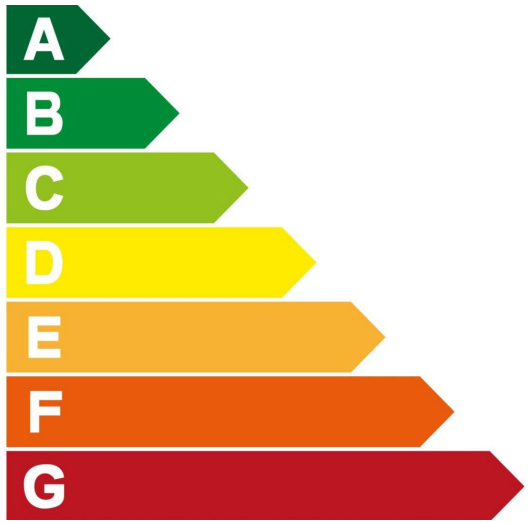
- Supply temp < 55°C
- SCOP (efficiency) better than current ones



Tools spatial aspects need to be readdressed. Or should be left entirely to the installer.

Discussion

More home types next to: Terraced home, Semi-detached home & Detached home



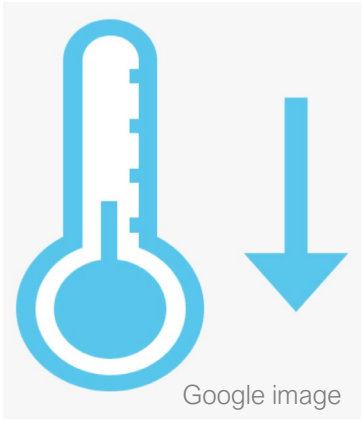
The energy label is not a perfect energetic indicator for all home types

As long as the home meets the insulation standard as described in the tool, you will always meet the insulation values for a heat pump

Discussion

Indoor comfort

Add-on fans are advised in severe winters based on calculations to maintain the same indoor temperature



No add on fans in case the homeowner settles for a lower indoor temperature for a short period of time

Link to the dummy heat pump decision tool

https://ztree.ai/684865704