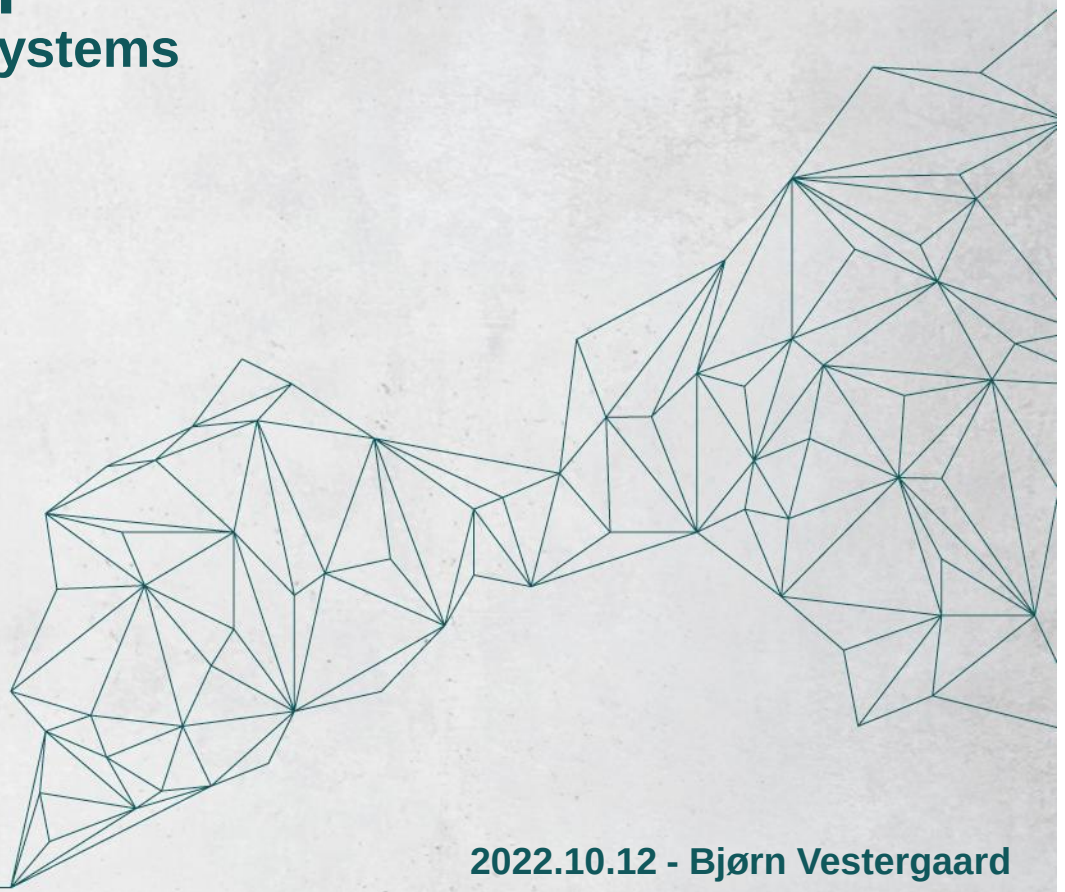
Hydro

Domestic Hot Water Heat Pumps

A new tube solution developed for R-290 systems operating with max. 150 g charge

CONNECTING EXPERTS.



2022.10.12 - Bjørn Vestergaard
Hydro Precision Tubing Tønder

Domestic Hot Water Heat Pump

Content of presentation:

1. Background and parties involved in the Flange-Tube development and testing

2. Market overview – Current technology and options available

3. Flange-Tube features – Larger units using 150 g of R-290 without jeopardizing the COP rating

4. Test results – Existing R-134a unit compared with R-290 units

5. Some design considerations

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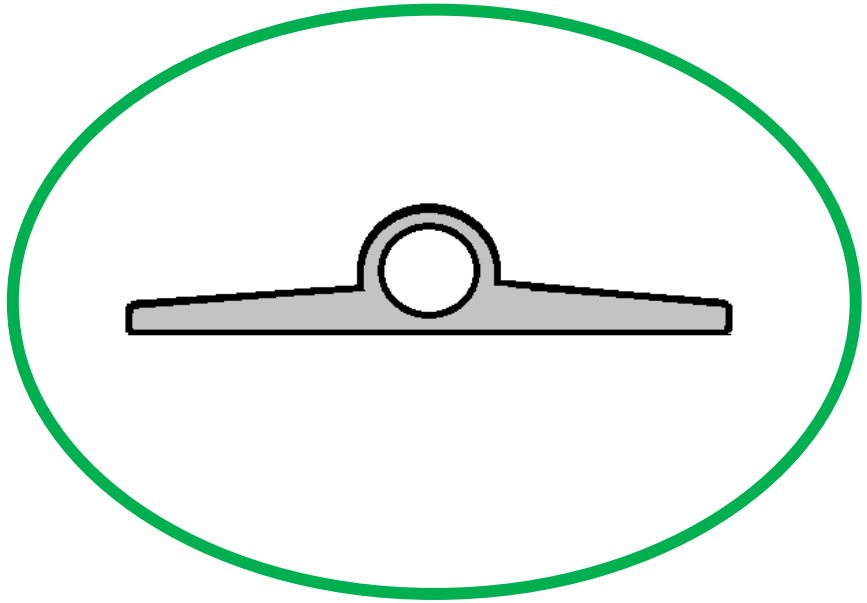
Parties involved in Flange-Tube developement:

Miljøteknologisk udviklings- og demonstrationsprogram (MUDP)
(Danish Environmental Protection Agency)
Financed Testing and reporting to support sustainable refrigerants with low CO_2 footprint

Vesttherm
High End Manufacturer of
Hot Water Heat Pumps
Built a great number of
prototypes to prove concept



TEKNOLOGISK INSTITUT
Accredited Testing Laboratory
System- and tube simulations and
testing of selected prototypes
Reporting

Hydro
Hydro Precison Tubing Tønder
Manufacturer of Flange-Tube

Hydro
Hydro Innovation and Technology
Material- and Heat Transfer simulations
Optimization of heat flow in Flange-Tube

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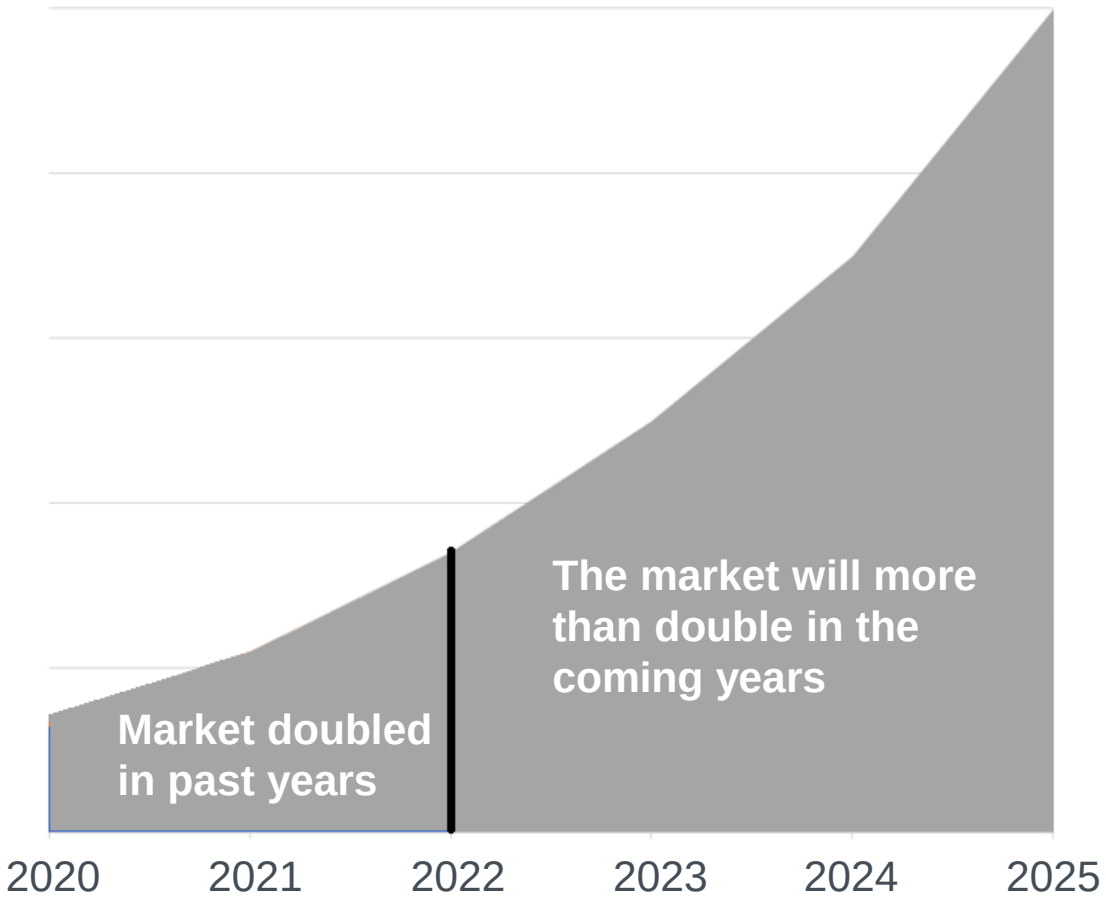
Fast growing market

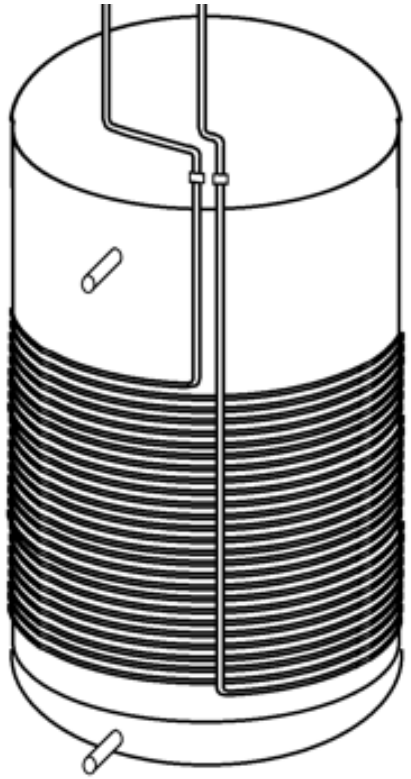


Legislation guarantee market growth

Ban or limitation on electrical boilers in EU

Ban on gas boilers in UK

.....and highly motivated by rapidly increasing energy prices



Source

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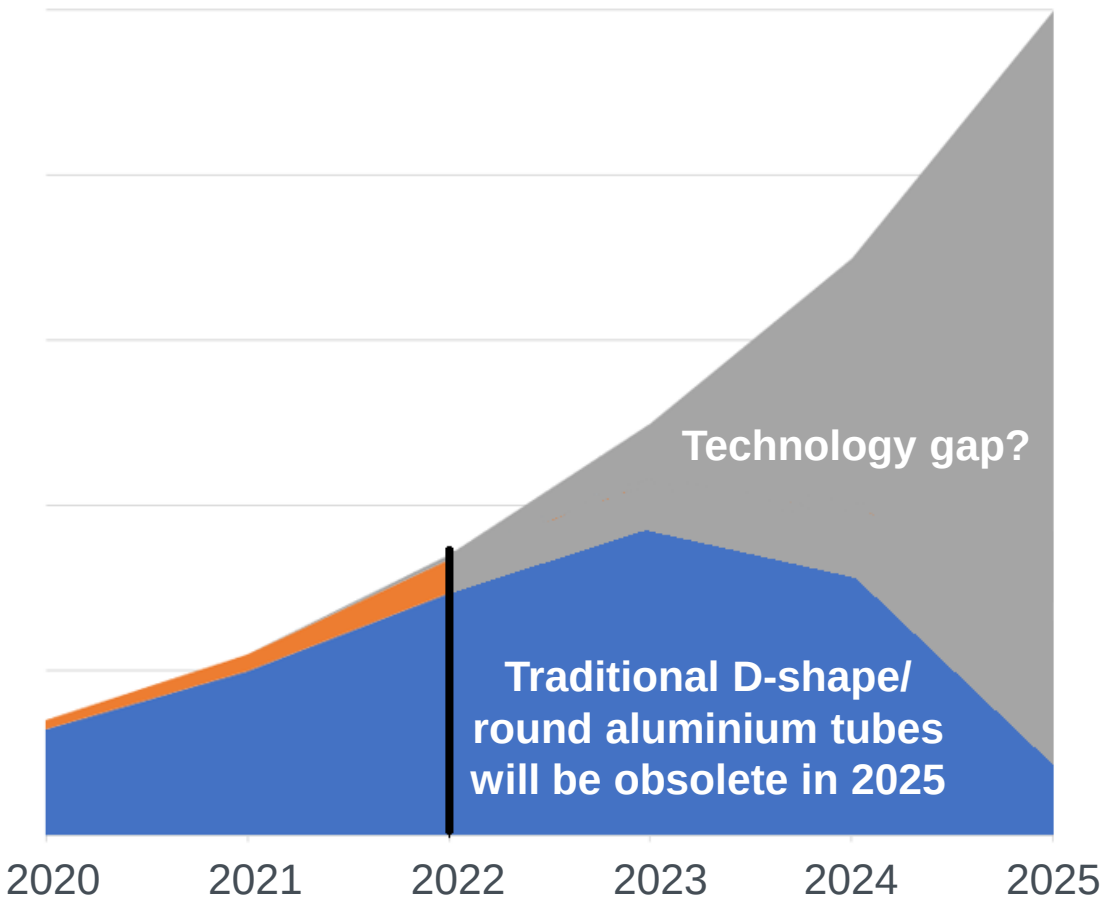
Fast growing market



Source

Legislation guarantee market growth

Ban or limitation on electrical boilers in EU

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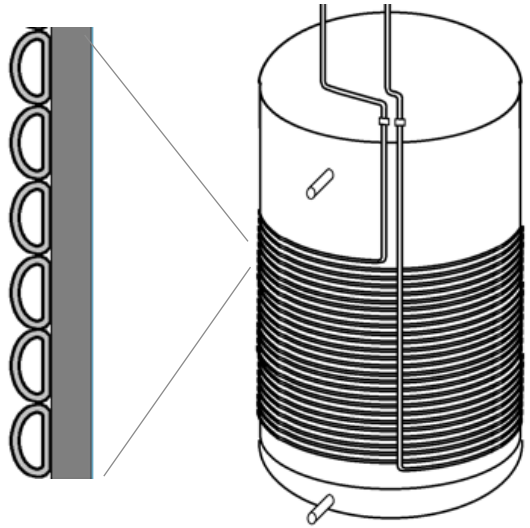
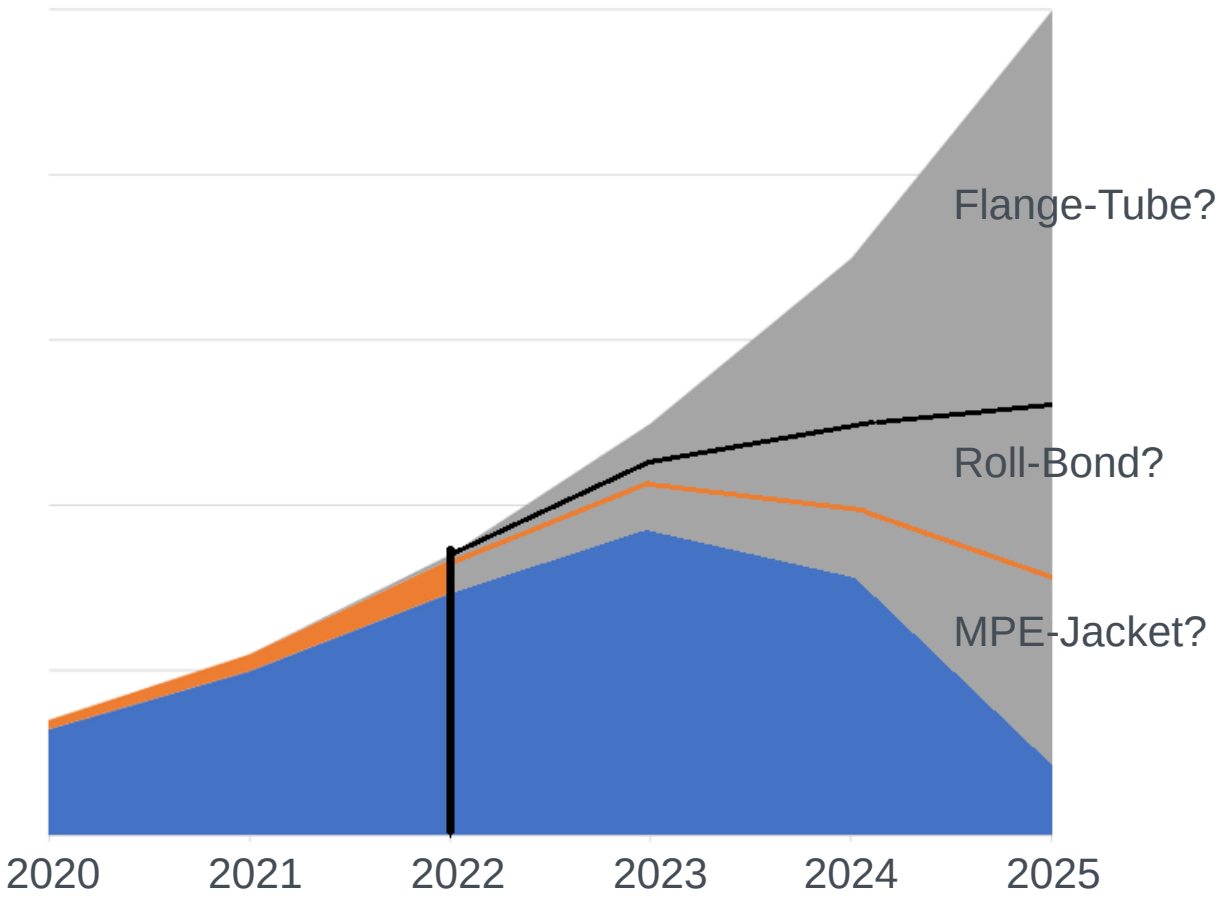
Current technology to be obsolete

HFC-Gas will not be allowed in EU in future (worldwide later)

R-290 (HC-Gas) has strict limitations on max. charge due to safety and can therefore not replace above one-to-one



Domestic Hot Water Heat Pump



Legislation guarantee market growth

Ban or limitation on electrical boilers in EU

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Current technology to be obsolete

HFC-Gas will not be allowed in EU in future (worldwide later)

R-290 (HC-Gas) has strict limitations on max. charge due to safety and can therefore not replace above one-to-one

Which technology to take over/fill the gap?

With R-290 max. 150 g refrigerant charge is acceptable
Energy efficiency (COP) must meet/be better than current status

Source

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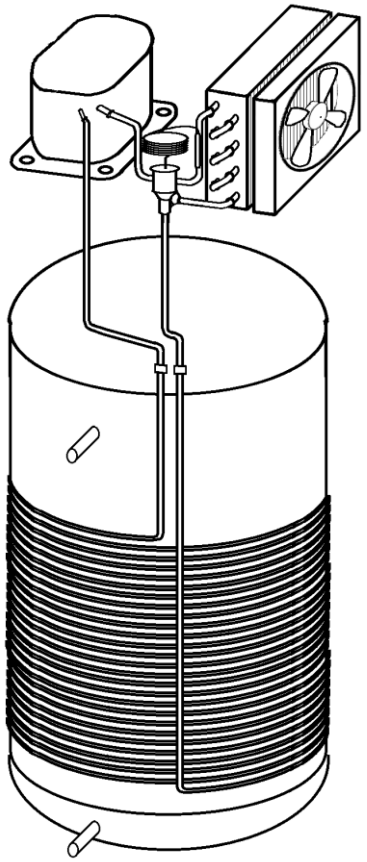
Current Technology



Water tanks below 150-200 liters can shift to R290 in most cases and still use the current D-shape/round tube technology using maximum 150 g of R290

Water tanks above 200 liters usually require more than 150 g of R290 to provide sufficient SCOP – This puts a burden on installers (size of room/ ventilation etc.) and makes those units unattractive in the market

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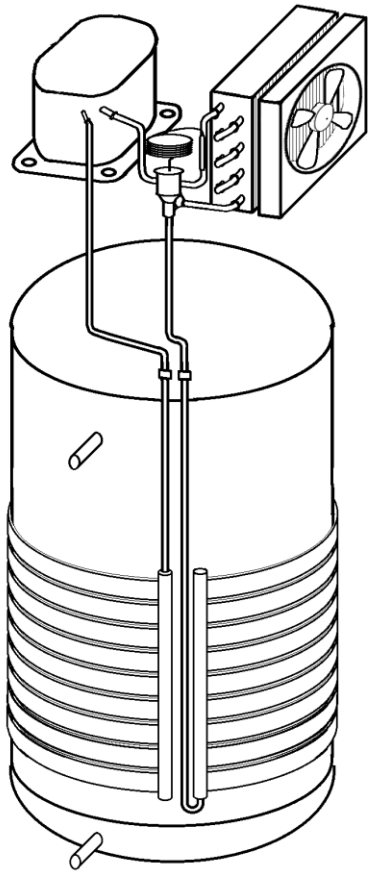
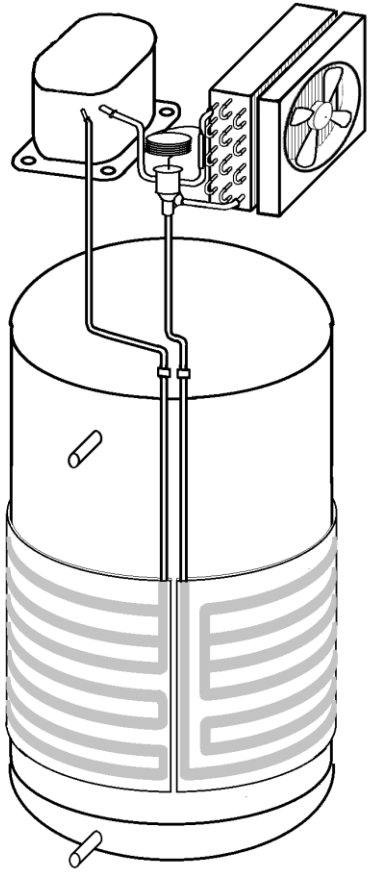
Alternative Technologies



MPE-Jacket



Roll-Bond

Alternatives known in the market today are the ”MPE-Jacket” and the ”Roll-Bond” solutions

Both solutions provide significantly reduced refrigerant charge and the max. 150 g of R-290 can be met for water tanks above 200 liters and provides a great COP

Both the ”MPE-Jacket” and the ”Roll-Bond” solutions are supplied as a ”flat component” to be wrapped around the water tank and fixed

A layout change of the manufacturing site is therefore needed

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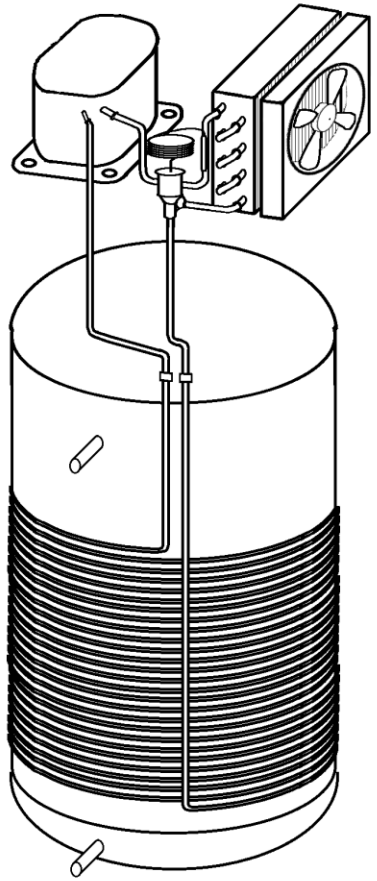
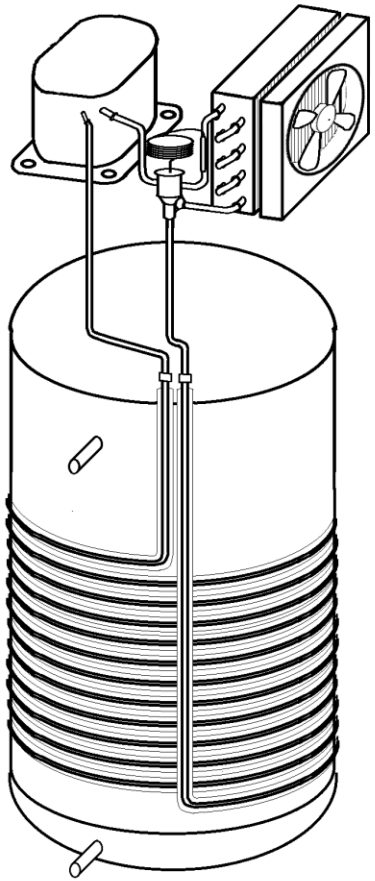
A new alternative - The Flange-Tube

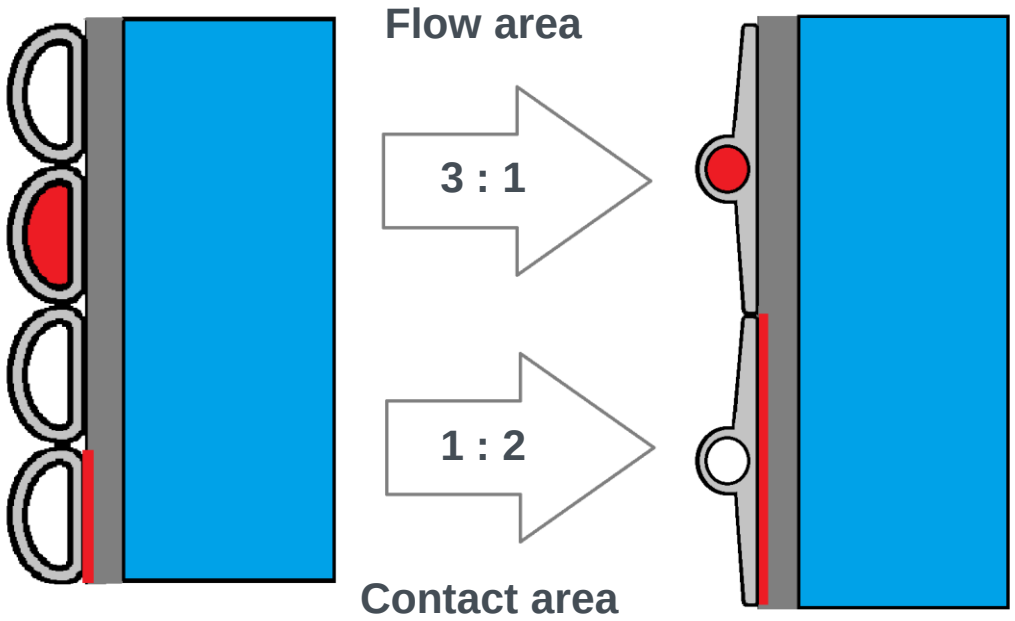


D-shape/round



Flange-Tube

Current D-shape/round compared to Flange-Tube



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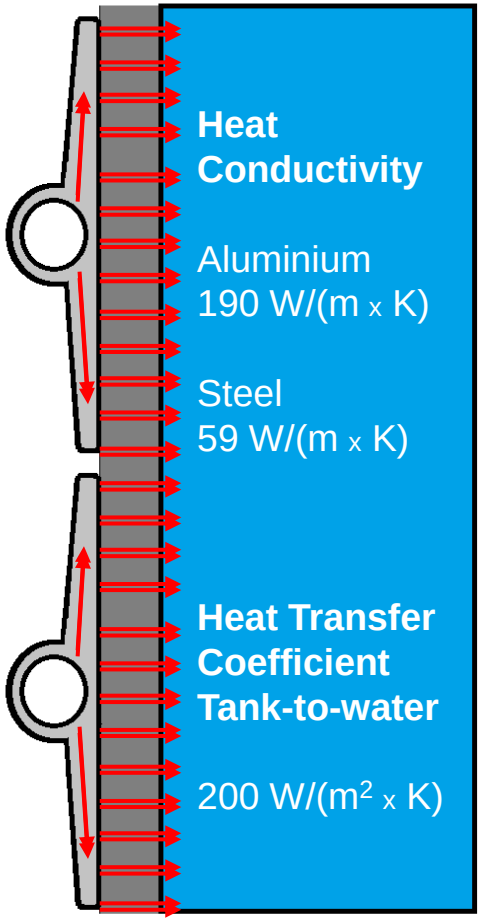
Flange-Tube – A simple solution

- New technology is based on Flange-Tube made of aluminium wrapped around a tank made of steel or stainless steel
- The **good heat conductivity in aluminium** allows the heat to travel from the tubular part to the flange with a minimum of thermal restriction
- The flange of the Flange-Tube **covers a larger area of the tank with full surface contact** and therefore minimizes the effect of the poor heat conductivity in steel/stainless steel
- The **wide flange reduces the number of wraps around the tank, hence significantly reduces the tube length** – Often down to 18-20 meters instead of 50-55 meters
- The shorter tube **allows a great reduction of the flow area without higher pressure drop** in the refrigeration cycle
- The shorter Flange-Tube with smaller inner diameter significantly reduces the refrigerant volume and charge **without compromizing any functional parameters**
- That allows Hydro Carbon gasses such as R290 to be used below the magic 150 g in many applications and the headache arising from HFC or +150 gram Hydro Carbon gas disappears



Domestic Hot Water Heat Pump

Test results according to EN16147:2017 – Existing R-134a unit compared with R-290 units

2014

Hot Water Heat Pump 270 liters
D-shape/round tubes
R-134a - 900 g
COP 3,15 (A+ rating)

2018

Hot Water Heat Pump 270 liters
D-shape/round tubes
R-290 - 350 g
COP 3,52 (A+ rating)

Low sales – Burden to cope with regulations
for room size/ventialtion a.o. and installers refrain

Hot Water Heat Pump 166 liters
D-shape/round tubes
R-290 - 150 g
COP 3,20 (A+ rating)

High sales – Low CO_2 Footprint

2021

Hot Water Heat Pump 270 liters
Flange-Tube 1:0 New Standard
R-290 - 200 g
COP 3,84

Besides the EN16147 test a deep analysis
of the temperatures/pressures during operation
were monitored in order to understand optimi-
zation potentials

2022

Hot Water Heat Pump 270 liters
Flange-Tube 1:2 New Aggressive
R-290 - 150 g
COP 3,63

Inner volume of condenser reduced further

270 liters XL water tapping / 166 liters L water tapping

Domestic Hot Water Heat Pump

Test results according to EN16147:2017 – Existing R-134a unit compared with R-290 units

Hot Water Heat Pump 270 liters
D-shape/round tubes
R-134a - 900 g
COP 3,15 (A+ rating)

2014

Climate impact on energy consumption

R-134a/D-shape/round tubes COP 3,15
Annual Energy Consumption 1298 kW/h/year

R-290/Flange-Tube 1:2 New Aggressive COP 3,63
Annual Energy Consumption 1126 kW/h year

Reduced energy consumption over 10 years 1720 kW/h
Reduced CO2 emission over 10 years 230-575 kg

CO_2 (e)/kW/h from 135 g (DK 2019) to 334 g (EU 2019)

Climate impact shifting from R-134a to R-290

GWP R-134a = 1430 x 0,900 g = 1287,00
GWP R-290 = 3 x 0,150 g = 0,45

GWP reduced to 1:2860

Hot Water Heat Pump 270 liters
Flange-Tube 1:2 New Aggressive
R-290 - 150 g
COP 3,63

2022

https://stateofgreen.com/en/news/new-green-record-for-danish-electricity-lowest-co2-emissions-ever/

https://www.sciencedirect.com/science/article/pii/S0306261921012149#:~:text=In%20the%20European%20Union%2C%20carbon,continue%20in%20the%20coming%20years.

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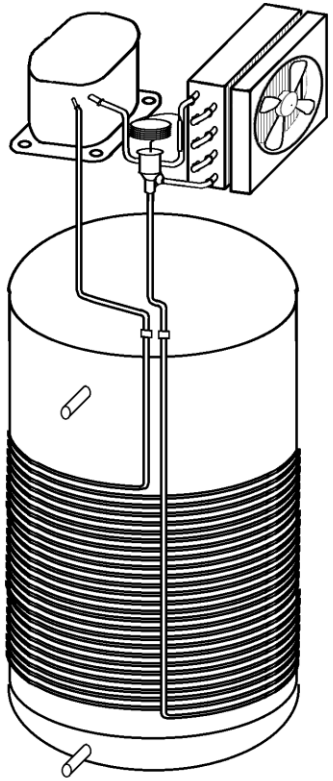
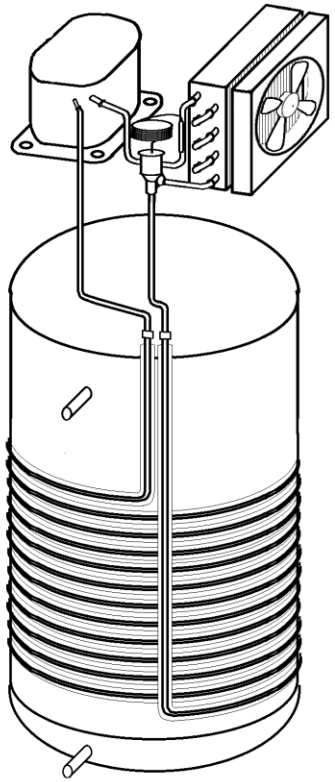
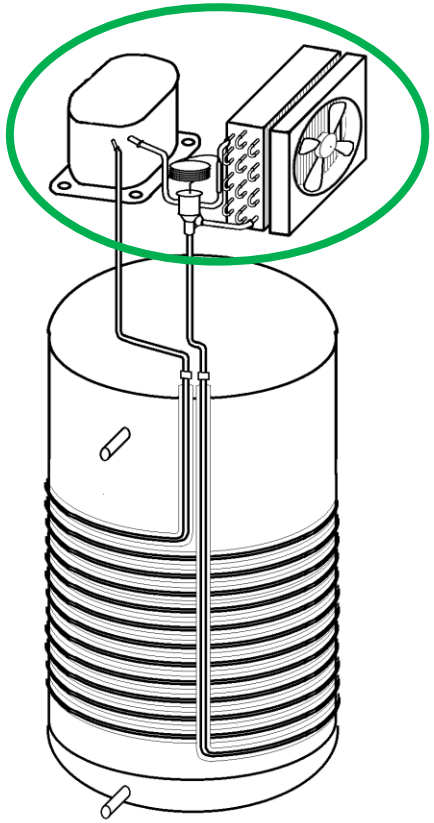
Some design considerations:







Condenser inner volume:

Index 100
D-shape/round

Index 0,28
Flange-Tube 1:0
New Standard

Index 0,23 – 0,18
Flange-Tube 1:2 and 1,6
New Aggressive/Very Aggressive

Reduction of condenser volume has the biggest impact on system refrigerant charge

Aggressive reduction of condenser volume can cause undesired high discharge pressure at start up

A small diameter evaporator (with less internal volume) can reduce refrigerant charge further – The fin area must remain the same to keep a high COP rating

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Flange-Tube

Available Options:

Flange-Tube 1:0 - New Standard

Flange-Tube 1:2 - New Aggressive

Flange-Tube 1:6 - New Very Aggessive

Designed to maximize thermal distribution from tubular part to the flange (Patent Pending)

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Hydro

Thank you very much for your attention

Visit our booth and learn more

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References:

2022 September – MUDP (Danish Environmental Protection Agency) Sagsnummer 2020 – 15378

Title: Brugsvandsvarmepumpe med propan som kølemiddel – Fase 2: Reduktion af kølmiddelfyldning til maks. 150 g.

Authors: Per Henrik Pedersen, Frederik Wulff Winthereik & Preben Eskerod, Teknologisk Institut og Torben Lauridsen, Vesttherm A/S

2022.06.15 – 15th IIR Gustav Lorentzen Conference, Trondheim

Title: Hot water heat pump with low-charge propane refrigerant

Authors: Frederik Wulff Winthereik, Per Henrik Pedersen, Danish Technological Institute and Torben Lauridsen, Vesttherm

2019.10.22-23 – European Heat Pump Summit, Nuremberg

Title: Experimental Research on Micro Channel Heat Exchanger Application for Wall-mounted Heat Pump Water Heater

Authors: ZHANG Haifeng, ZHAO Dengji and GAO Qiang, Hangzhou Sanhua Micro Channel Heat Exchanger

2016.10.10 – Article in International Journal of Refrigeration February 2017

Title: Refrigerant charge optimisation for propane heat pump water heaters

Authors: Redouane Ghoubali, Paul Byrne and Frédéric Bazantay

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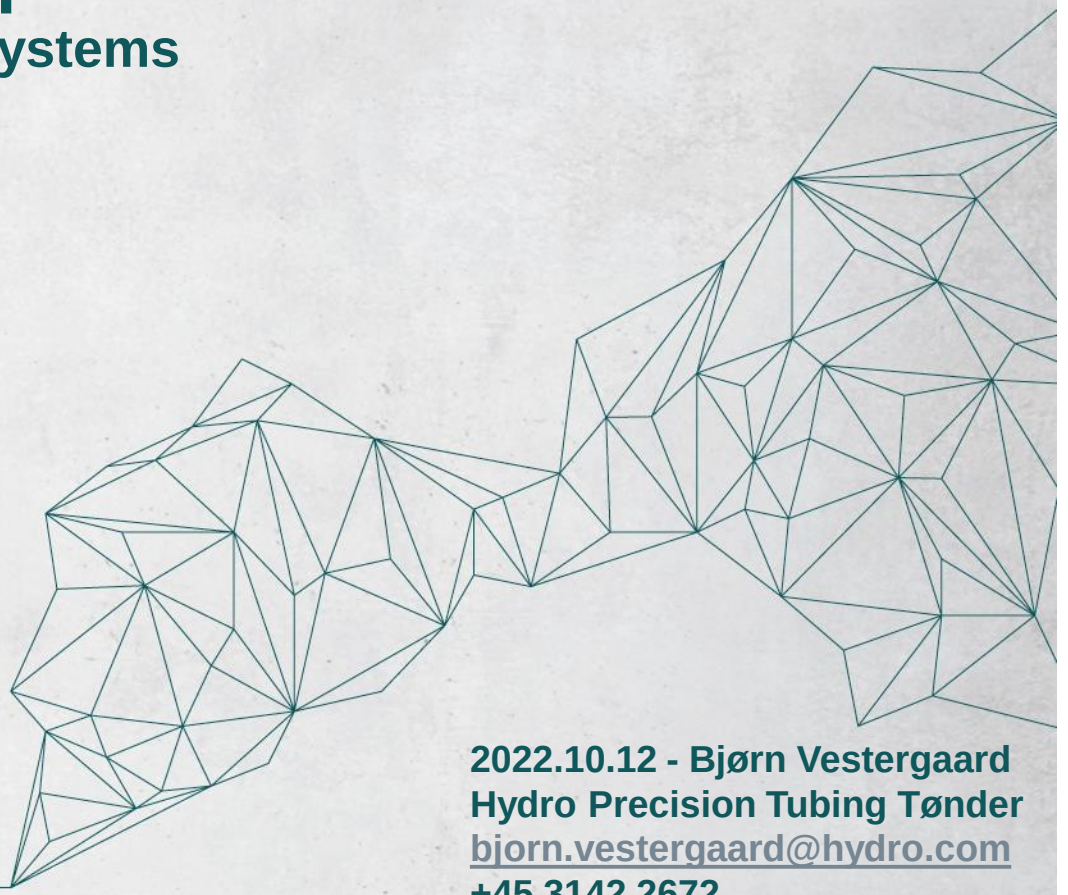
Domestic Hot Water Heat Pumps

A new tube solution developed for R-290 systems operating with max. 150 g charge

CONNECTING EXPERTS.



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