Retrofitting Domestic Heat Pumps – Methods and Lessons Learned

Presented by Paul Kenny

Image: Irish parliamentary delegation to Retrofitted school
Heat Pump Webinar

- Not going to talk about why.
- A little intro to Tipp Energy
- Fundamentals reminder
- Approach from design to warm home
- Results
- Optimisation
- Some myths discussed
Tipperary Energy Agency (TEA)

- 30 Staff, Voluntary Board (experts & local government/development),
- Non-profit Social enterprise
- Profits ring fenced for re-investment in Solutions

- **Tipperary Local Authority Energy Management**
- **Non Residential Energy Management Services** (Consultancy, energy management, upgrades, & M&E)
- **Homes** – Superhomes
- **Community Energy** - In partnership with Community Power
- **Promotion, Awareness and advocacy**
  - Energy in agriculture with TEAGASC, IFA, Tipperary CoCo,
  - Sustainable Tipp local engagement campaign each year.
  - Advocate on a policy level with officials and politicians.
Heat Pump Fundamentals – Heat Sources and Sinks

• Moves heat from Cold to Hot (opposite normal flow)
• Uses 1 unit of energy to move 2-4 other units.
• Lower the temperature difference, lower work required.
• In practice:
  • Low water temperature in Rads/ 150mm UF
  • Achieved by increasing heat transfer area (i.e. rad size)
  • Achieved by lengthening operational temperature time.

<table>
<thead>
<tr>
<th>HVAC System</th>
<th>Heating</th>
<th>1 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiators (high temp)</td>
<td>65°C – 75°C</td>
<td>1.4 x .45 single panel (£62)</td>
</tr>
<tr>
<td>Radiators (HT/Condensing)</td>
<td>45°C – 55°C</td>
<td>1.4 x .45 twin (£95)</td>
</tr>
<tr>
<td>Radiators Low temperature</td>
<td>30°C – 45°C</td>
<td>1.4 x .6 triple panel (£240)</td>
</tr>
<tr>
<td>Underfloor</td>
<td>30°C – 40°C</td>
<td></td>
</tr>
<tr>
<td>Fan Coil</td>
<td>30°C – 70°C</td>
<td></td>
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</table>
Approach

• Setting Expectations – it’s not a boiler, house warm.
• Technical Assessment
• Air leakage reduction & designed ventilation
• Cost effective fabric upgrades
• Radiators designed for low flow temperature
• Domestic hot water (large tank, large coil) – night rate.
• Heatpump sized correctly, no backup (ish)
• Weather compensation to drive down flow temperature
• A heat pump will work in any house, but not sensible to heat a barn, with any fuel.
How we design Heat pump Installations

- Radiators predominantly
  - High volume mass produced steel radiators (Stelrad/Quinn etc)
  - Cheapest heat transfer area per €uro invested.
  - Usually on existing radiator pipe spacing
  - Only replaced if required (<80% of design load)
  - Generally replace sitting room/kitchen radiators
- Sized for -3/21 at 40 Mean water temperature MWT (about 15-20% larger than condensing boilers)
- Room by room heat load calcs
- Allow 2 hours per day for DHW. (immersion for Legionella/backup)
- Demand Curve (flow temperature)
  - 34 Degrees 7 to 15 degrees C. (operational hours increase as temp. drops)
  - 43 Degrees -3
- Only engineers/competent person.
Radiators

- DT50 traditional boiler 75/65
- DT 30 condensing boiler 55/45
- We use DT23 (48/38) for heat pumps (1.25x condensing; 2.5x DT50)
- All radiators sized for Mean water temperature 40-43 at design conditions (-3) Any heat emitter will do provided curves match up
- Standard steel rads just fine
- Triple panel vs Double, up to 700mm high
- Fan coils only when cooling need/ space constraint (kitchen).
- Vast majority can re-use existing spacings.

- Finned = ~1.8 times flat panel area*
- Double panel finned = 3.6 flat panel area*.
- Triple panel 700 high = 2.1* times 500mm double panel
* Heat transfer coeff. drops at lower temp
Retrofit Results (pre & post energy certificate)

- Cost c. €300/m² (£23k/UK home average)
- 26kWh / m² delivered electricity for HP per annum average (60 monitored)
- Energy certificate of 67 KWh/M² Primary energy
- 65% - 80%+ cost savings from buildings.
Optimisation

- Little and often better than blast
- Allows managed down flow temperature in A2W
- Curves should be set at design flowT only for low temperatures
- At milder temperatures avoid cycling by not dropping below min. capacity (c.35 degrees)
- Minimum capacity often c. 30%.
- Control to run steady for long periods to maximise efficiency
- Need to be installed & balanced correctly.
Myth -1: HP not ideal for cold weather

- 1st March 2018 significant weather event (beast from the east)
- 7 days below zero, 300mm snow
- Not a single complaint – several positive emails & texts.
COP (16 houses)- 2 weeks of exceptionally cold weather
COP Oct ‘17- May ‘18 for 16 Superhomes
Overall Average = 3.1 (pre optimization)
Myth 2: Backup heaters – Not in UK/Ireland

- 250 homes – no backup heater
- No immersion for space heating
- Some stoves – but largely unused
- Histogram of heat loads is surprisingly low.
- Extra Cap-ex into radiators instead of backup heaters

- Detailed analysis of output per hour based on bins of hours, 2 hour periods, 4 hour periods, daily.
- 5kW heat pump – sufficient for 99.6% of days.
- 8kW heat pump – sufficient for 99.8% of 4 hour periods.
- 11.5kW heat pump installed.

<table>
<thead>
<tr>
<th>kW</th>
<th>Hourly</th>
<th>2-Hourly</th>
<th>4-Hourly</th>
<th>Daily average</th>
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<td>12.7%</td>
<td>15.0%</td>
<td>20.6%</td>
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<tr>
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<td>14.4%</td>
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<td>15.1%</td>
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<td>18.9%</td>
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Myth 3: Grid can’t cope.

- House load Vs external temperature
- Grid average design Ireland = 2.5.
- In cold weather HP operate steady state
- 52 GW based on 2.1 kW for 25M homes
- UK homes are 85m2 average; say 1 kW/home: 25GWth ~ 75GWth
- Watson, 2019 suggests 170GW total heat
- COP 2.5 ~ 68GW (COP3 is 56GW)

20 homes 2 years; r² = 0.988

Fixed!!
Summary and Key Take-Outs

• Well sized and designed Heat pumps perform wonderfully in retrofits with radiators.
• Need to be designed, installed and commissioned properly.
• Best done while retrofitting, with ventilation & AT key components.
• Only feasible way to decarbonise homes
• Alternates promoted by fossil asset owners will lead to additional householder & exchequer costs and poorer outcomes
• Policy Lessons:
  • Protect people from snake oil and silver bullets
  • Focus on training & upskilling SMEs & Awareness
  • Regulations for new build
  • Policy signals in the future
  • Subsidise/tax to increase investment
Specification & Design of Heating Systems with Heat Pumps

Online Course

Overview
The course aims to enhance the knowledge base of the construction sector in Ireland with respect to heat pumps in homes and commercial buildings. The construction sector have to change their method and type of specifications and designs for heating systems from predominately high carbon heating systems to low carbon heating systems. There are a large number of different types of heat pump heating systems available with a myriad of emitters and controls that require more knowledge than before in appliance selection and design as part of an integrated design of renovations and low energy buildings.

Cost: €95
When: Complete the course in your own time

For full details and to register, visit tipenergy.ie.

https://tipenergy.ie/event/hpcourse/