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WPs 2.1, 2.2
Retail refrigeration

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WP 2.1 and 2.2 Retail refrigeration

Background

- 40-70% of energy in supermarkets used for refrigeration
- UK retail refrigeration ~ 9-10 TWh/year
- 1.5% of UK energy used by retail
- Indirect (energy) and direct (refrigerant loss) effects
- ~7.3 Mt CO_2 (~26% direct, ~74% indirect)

Deliverables

- Refrigeration road map
- Improved current cabinet
- State of the art display cabinet

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WP 2.1 Retail chilling and freezing

WP2.1.1 – Technologies will be initially investigated and sifted

WP2.1.2 – In parallel with WP2.1 technologies will be investigated with a proof of concept prototype

WP2.1.3 – Non technical barriers preventing uptake, will be assessed i.e. customer reaction, implementation, cost-benefit, incentives

WP2.1.4 –A trial of the prototype in-store

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Road map

- Road map updated (specific to baseline store)
- 81 display cabinet/refrigeration technologies (plus some discounted)
- Also:
  - HVAC
  - Cooking
  - Building technologies
- Application to an baseline store
- 6290 m^2

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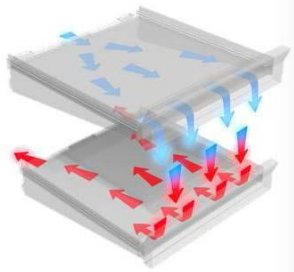
Technologies

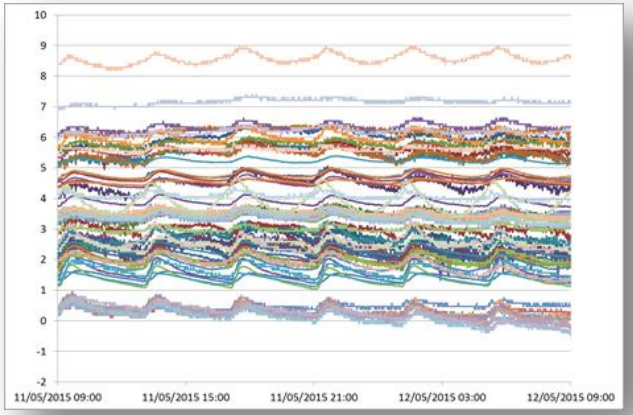
1. Air deflectors/guides
2. Anti-fogging glass
3. Anti-sweat heater control
4. Boreholes and ground sink condensers
5. Cabinet air flow
6. Cabinet lighting controls – dimming/switching using occupancy sensors
7. Cabinet loading
8. Cabinet location
9. Cabinet selection
10. Cabinet temperature control
11. Centralised air distribution
12. DC electronically commutated (EC) permanent magnet motors for condenser fans
13. DC electronically commutated (EC) permanent magnet motors for evaporator fans
14. Defrost drain traps
15. Defrosts
16. Electric defrost
17. Hot/cool gas defrost
18. Reverse cycle defrost
19. Warm liquid defrost
20. Heat bank defrost
21. Thermo-siphon defrost
22. Defrost controls (on demand)
23. Ultrasonic defrosting of evaporators
24. Diagonal compact fans
25. Distributed refrigeration system
26. Doors on cabinets
27. Dual port TEV
28. Dynamic demand
29. Economisers
30. Ejectors
31. Electronic expansion valves
32. Expansion machines (e.g. turbines, not including vortex tubes)
33. Fan motor outside of cabinet
34. Floating head pressure control
35. Flooded evaporators
36. Glazing
37. Heat exchanger design
38. Evaporator optimisation
39. Micro-channel heat exchangers
40. Heat exchange rifling
41. Enhanced internal heat transfer (micro-fins)
42. Evaporative condensers
43. Heat from light outside cabinet
44. Heat pipes
45. Hydrophilic and hydrophobic coating on evaporator
46. Improved axial fans
47. Internet shopping
48. Inverter Drives and Motor Efficiency Controllers
49. Lighting – cabinets
50. Lighting – store
51. Liquid pressure amplification (LPA
52. Loading (food) temperature and duration of loading
53. Low emissivity packaging
54. Magnetic refrigeration
55. Nanoparticles in refrigerant
56. Night blinds and covers
57. Novel building fabric
58. Peltier cooling
59. Pipe insulation
60. Pipe pressure drops
61. Radiant reflectors
62. Recommissioning
63. Refrigerants - HFC retrofit with lower GWP HFC
64. Refrigerants - HFC retrofit with hydrocarbons
65. Refrigerants - HFC retrofit with HFO
66. Refrigerant – R744
67. Risers and weir plates
68. Secondary systems
69. Short air curtains
70. Store dehumidification
71. Store temperature control
72. Strip curtains
73. Suction-liquid heat exchangers (SLHE) or liquid-suction heat exchangers (LSHE)
74. Suction pressure control
75. Tangential fans
76. Thermostatic flow control (TFC)
77. Training and maintenance
78. Trigeneration
79. Two stage compression
80. Vacuum insulated panels (VIP)
81. Water loop systems

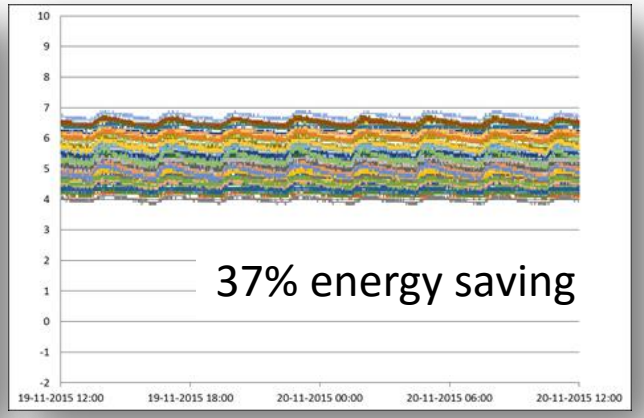
Technologies

- New information available
- Work on technologies where information limited e.g.
  - Short air curtains
  - Aerofoils
  - PCMS
  - VIPs
  - Thermo siphon defrost
  - Heat pipes
  - Refrigerants
- Plus detailed calculations where possible

17% energy saving







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Technologies - papers

1. FOSTER A., ORLANDI M., BROWN T., EVANS J. (2015). Use of phase change materials in retail display cabinets to reduce the effect of defrosts. The 24th IIR International Congress of Refrigeration, 2015, Yokohama, Japan.
2. FOSTER A., CAMPBELL R., DAVIES T., EVANS J. (2015) a novel passive defrost system for a frozen retail display cabinet with a low evaporator. The 24th IIR International Congress of Refrigeration, 2015, Yokohama, Japan.
3. EVANS, J.A. and FOSTER, A.M (editors). (2015). Retail refrigeration. Edited book (Blackwell Publishing).
4. EVANS, J.A. (2015). Emerging refrigeration and freezing technologies for food preservation. In: Innovation and future trends in food manufacturing and supply chain technologies. Woodhead Publishing
5. HAMMOND E.C. and EVANS, J.A. (2014). Application of vacuum insulation panels in the cold chain – analysis of viability. International Journal of Refrigeration. Volume 47, November 2014, Pages 58–65.
6. FOSTER, A., MCANDREW, P. AND EVANS, J. Novel aerofoils used for reducing energy consumption and improving temperature performance for multi-deck refrigerated display cabinets. 3rd IIR International Conference on Sustainability and the Cold Chain, London, 2014.
7. FOSTER, A., ORLANDI, M. AND EVANS, J. (2014). Use of heat pipes to improve temperature performance of a chilled refrigerated display cabinet. 3rd IIR International Conference on Sustainability and the Cold Chain, London, 2014.

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Technologies

Quality of information	5 independent peer review papers in general agreement = 5* 3 independent peer review papers in general agreement =4* General agreement between Independent reports or 1 peer reviewed publication=3* General agreement between Web based and sales literature =2* Personal communication only = 1*
Barriers to staff/customers	H=major barrier M=partial barrier L=no barrier
Availability barriers	H=prototype/demonstrator only M=limited availability L=available
Limits to commercial maturity	H=lack of maturity M=intermediate L=mature
Ease of use of installation	H=major issues M=partial L=simple
Technology independence	H=high (i.e., interaction with another technology) M=some L=none
Maintainability	H=major issue M=some problems L=no issues
Legislative concerns	H=major (issue now) M=could be an issue in near future L=no impact
Energy savings (confidence)	**% or actual savings (High, Medium, Low)**
Scope of application	Range of applications
Direct emissions (confidence)	**% emissions from technology (High, Medium, Low)**
Cost (payback)	Cost of technology, ROI (time)

Minimum/maximum

Minimum/maximum

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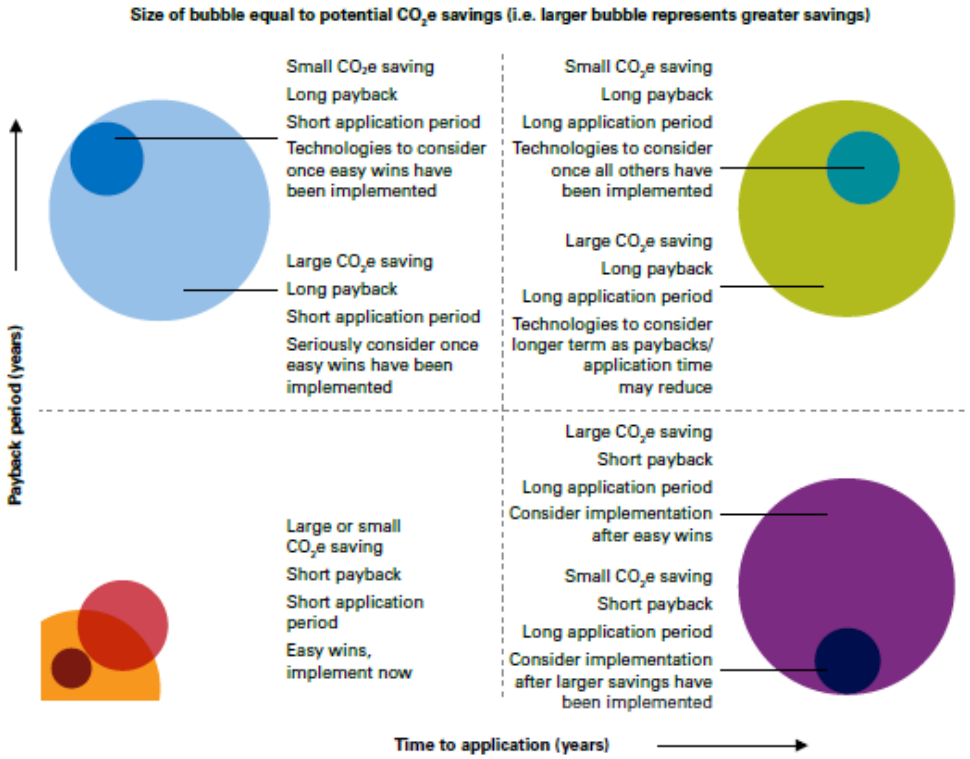
The model

- Supermarket model applied to baseline store
- Carbon savings in road map qualified and applied directly to the baseline store
- Results divided into
  - Technologies that can be applied to current cabinets/refrigeration system
  - Future technologies that could be applied to new cabinets/refrigeration system
  - Other technologies and initiatives (current/future)
- Bubble maps to show best options



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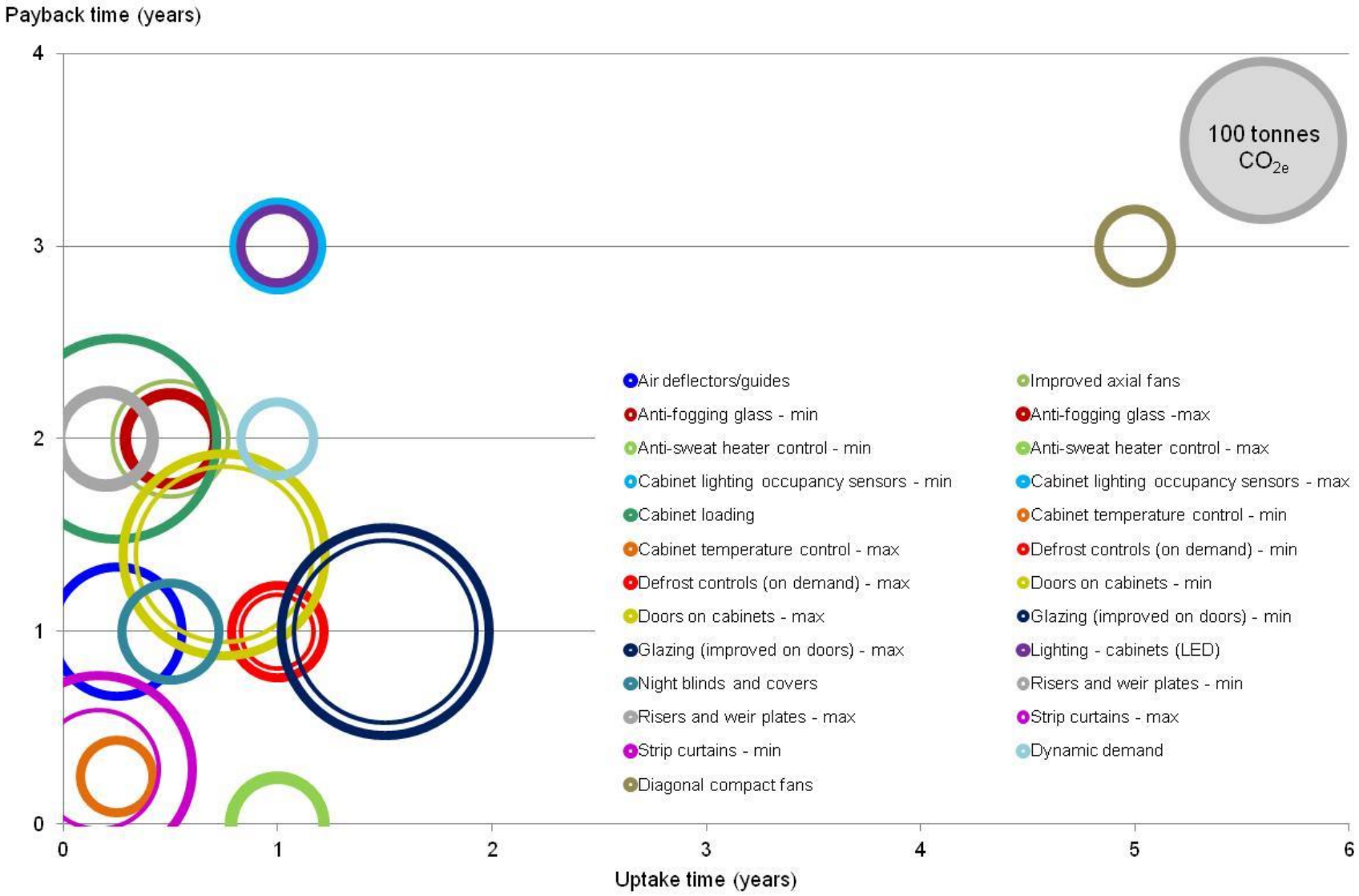
Carbon savings – current cabinet



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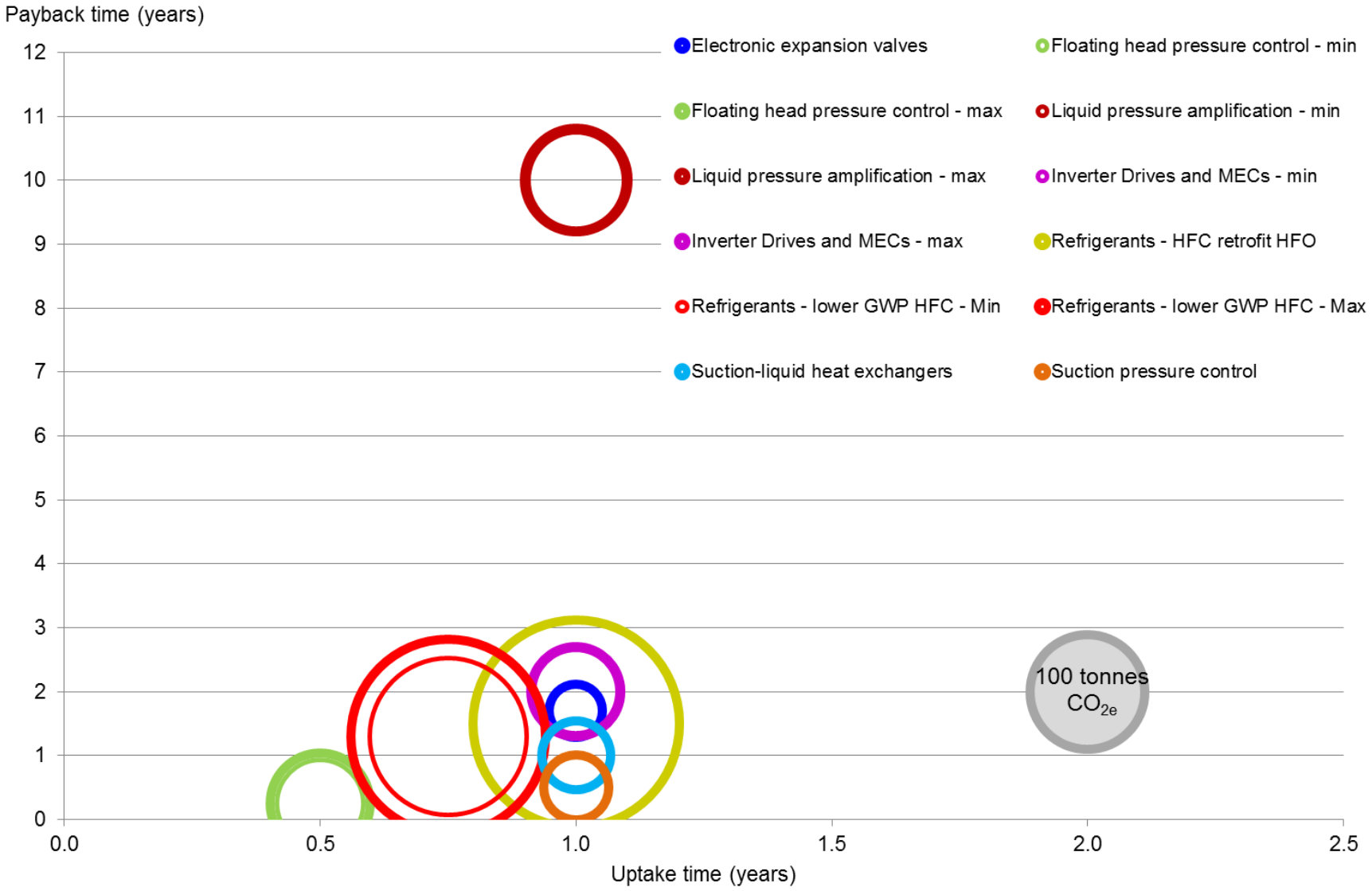
Carbon savings – current refrigeration



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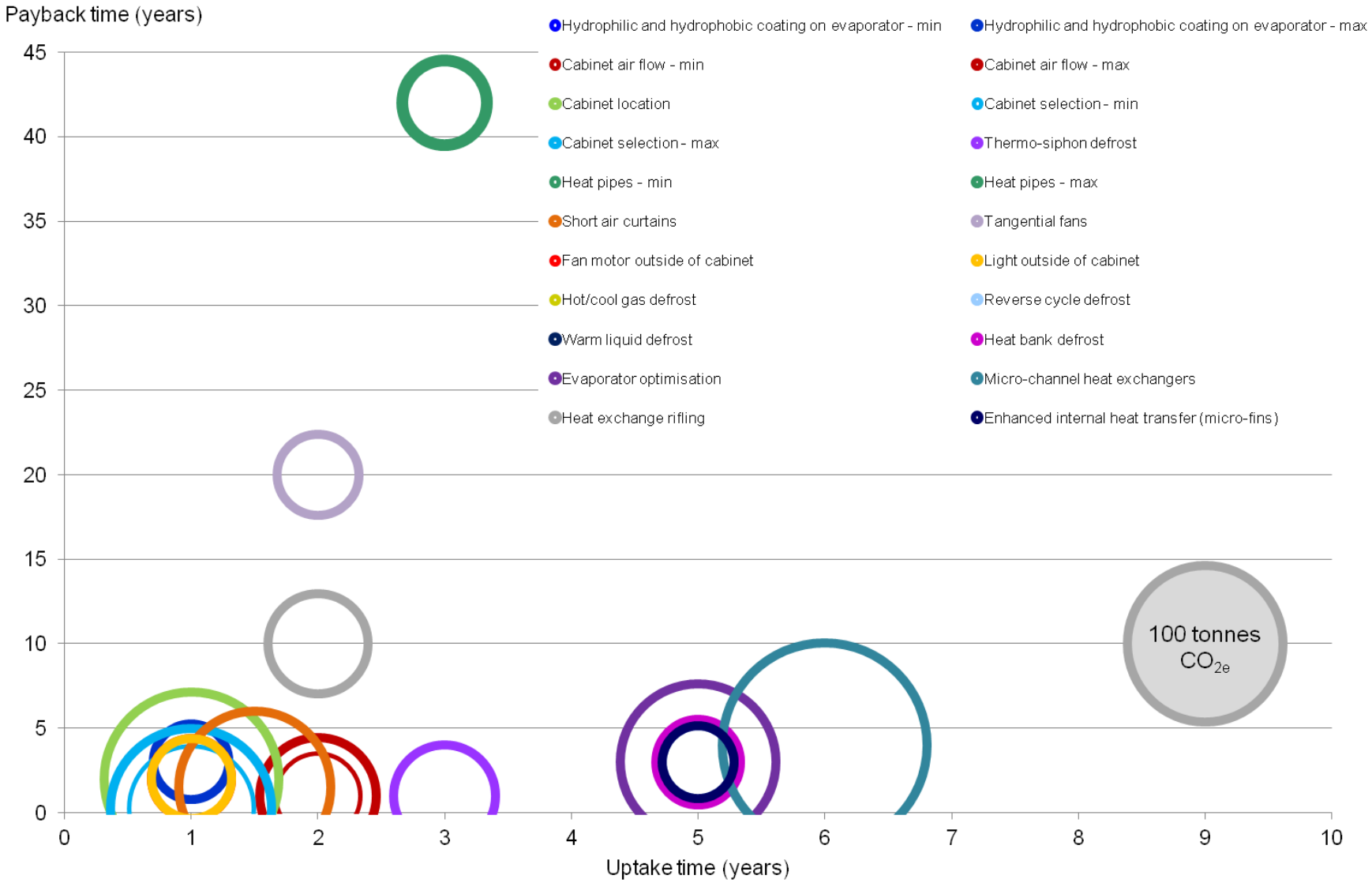
Carbon savings – future cabinet



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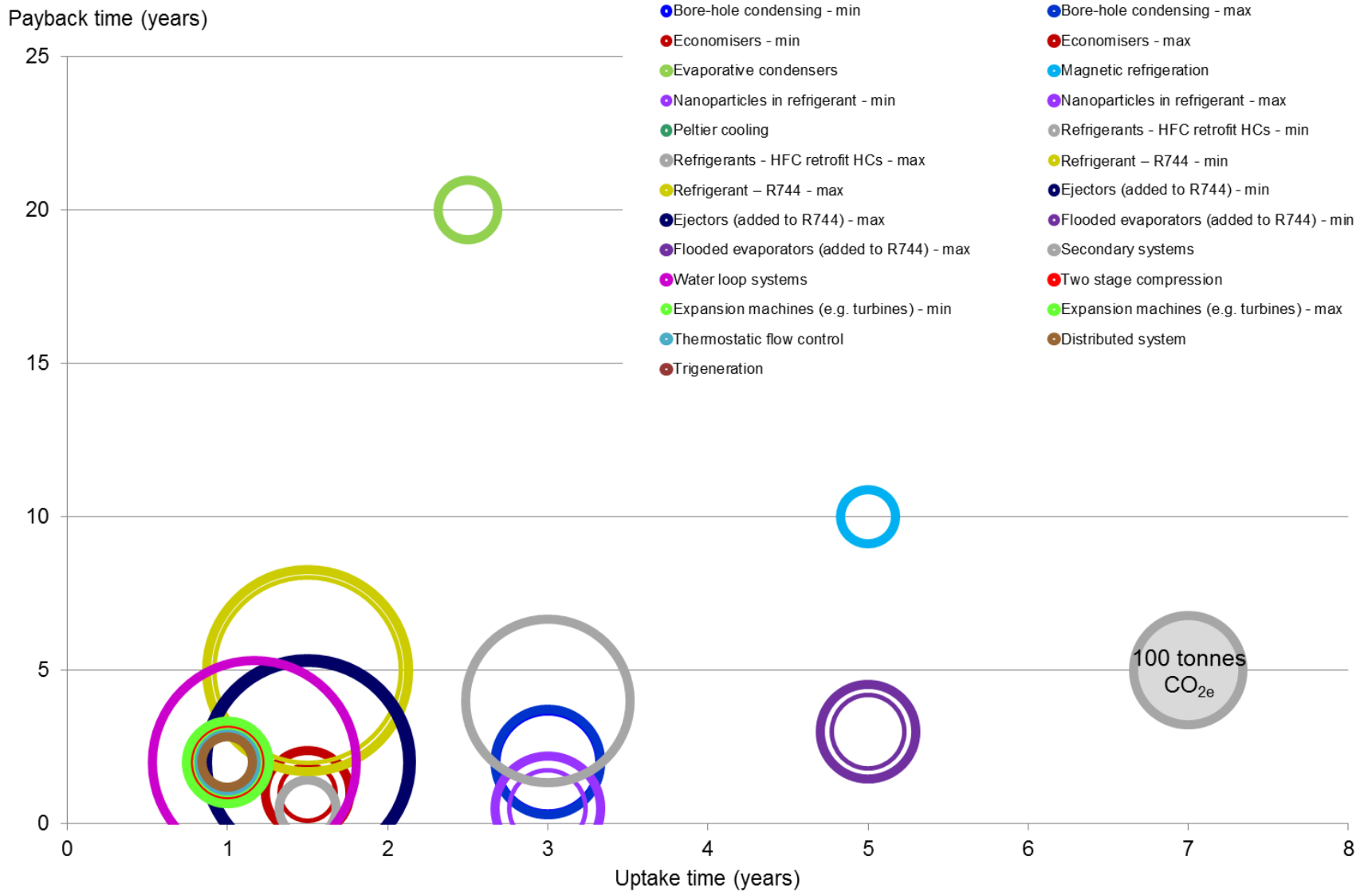
Carbon savings – future refrigeration



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Prototype cabinet

- Open fronted multi-deck
- Typically used in baseline store
- Test to EN23953 (2015)
- Adapt using selected technologies
- Select from road map (link technologies), not always additive effect
- Retest
- Calculate/apply new technologies for low carbon cabinet

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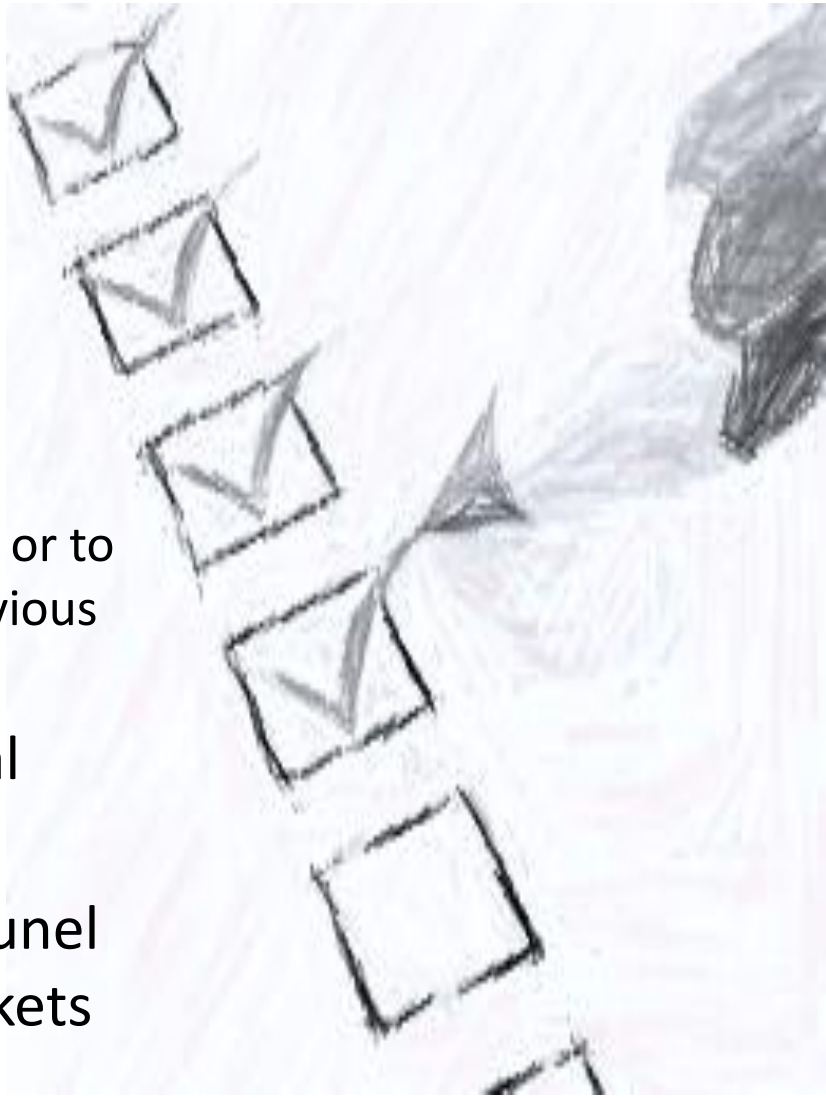
WP2 Deliverables

- Joint paper with CSEF on modelling and road map (IOR, March)
- Paper at ICCC in New Zealand
- Publication of road map as IIR publication
  - Peer review of publication
  - Potential for Carbon Trust to be involved or to publish compact version (update on previous work)
- Peer reviewed paper on technological options in development (IJR)
- Joint project in development with Brunel and UCL on benchmarking supermarkets



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THANK YOU