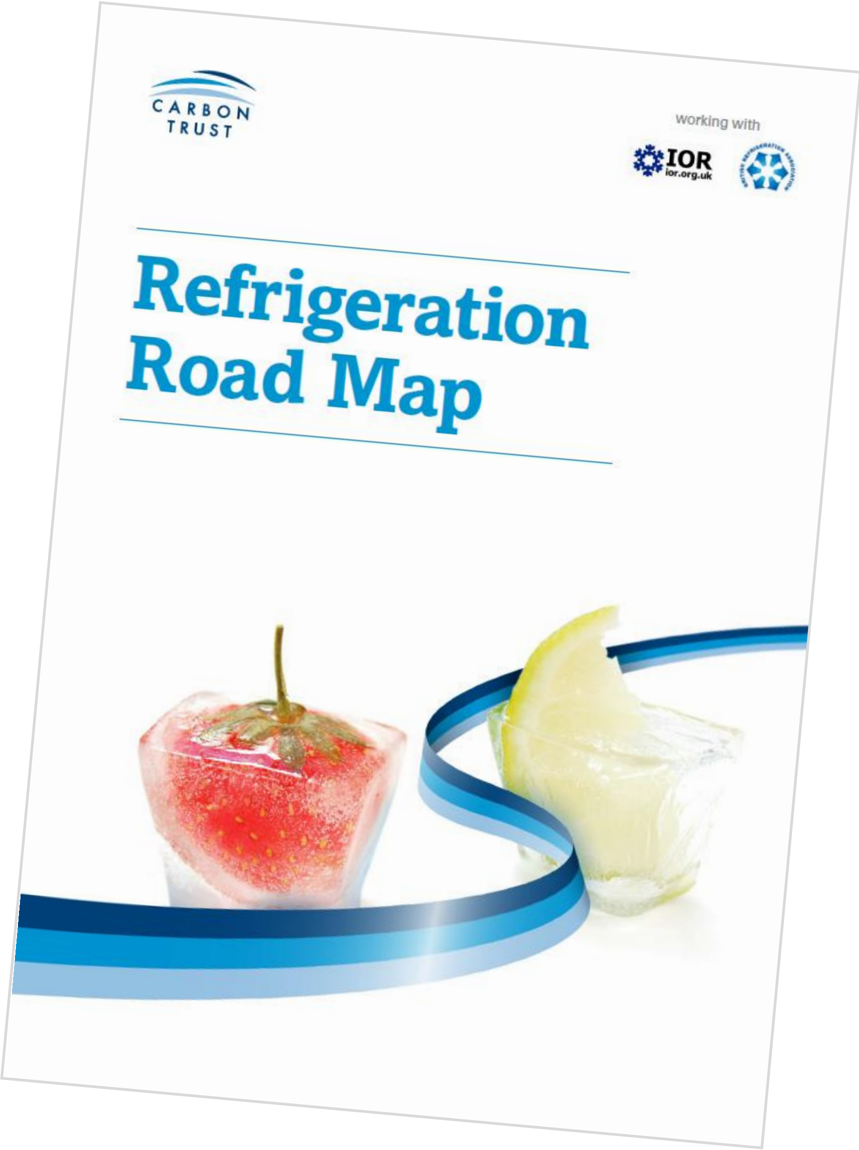
RETAIL ROAD MAP

i-STUTE

London South Bank University

Background

- Carbon Trust/IOR/BRA road map (2012)
- Update
- More detailed review of literature
- Application to a baseline store



Baseline store

- UK
- Intermediate age (1999)
- Medium size (6290 m^2)
- 2 LT packs
- 4 MT packs
- Condensing units for cold stores
- R404A

Store audit and info gathering

- Compressor pack specifications
- Duty of cabinets connected to each pack (store design spec)
- Length of each type of cabinet
- Integral cabinets
- Energy consumption from store (sub metered)
- Power of fans, lights, trim heaters, defrost heaters and schedule
- Energy savings predicted only those from refrigeration system
- Steady state (averaged over a year)

Split into cabinets and components

- Cabinet types from EN23953
- Each type of cabinet contains associated energy consumption of all its components

Remote chilled multi-deck (VC2) → Compressors, Condenser fan, Evaporator fans, Defrost heaters, Trim heaters, Lights

Remote chilled roll-in (VC3) → Ditto

Remote frozen HGD/well (VF1) → Ditto

Remote FGD (VF4) → Ditto

Integral chilled (VC2+HC1,4) → Ditto

Professional (catering) cabinets → Ditto

London South Bank University

i-STUTE

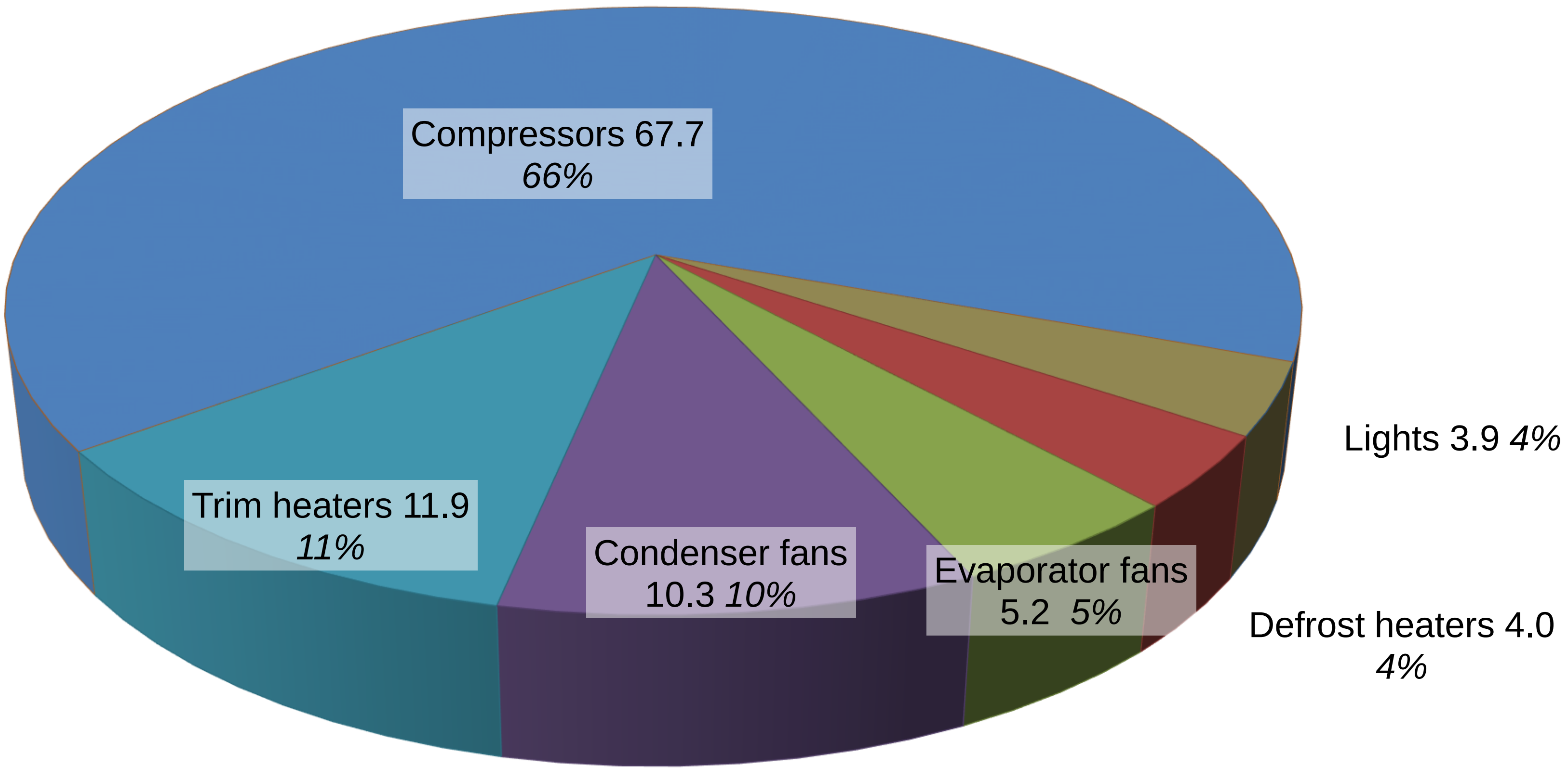
Determining average power (integral)

- Total energy consumption from manufacturers specs or estimated
- Component split same as remote of same type
- Professional all chilled

London South Bank University

i·STUTE

Total component average power (kW) %



Validation

- Refrigeration energy
  - Estimated at 1186 MWh p.a.
  - Measured at 1309 MWh p.a.
  - 9% lower than measured
- Small difference considering uncertainties
  - Store did not know exactly what was connected to each sub meter
  - Design data not likely to be exact

London South Bank University

i-STUTE

Emissions

Energy

- CO_{2e} conversion factor of 0.46219

Leakage

- GWP based on UNEP 100 year horizon
- Divided into LT/MT packs, integral/remote
- Leakage from:
  - Remote plant = 6.1 %/year
  - Integral cabinets = 1.5 %/year

R404A (remote cabinets) 867 kg (GWP=4,200)

R404A (integral cabinets) 18 kg (GWP=4,200)

R134a (integral cabinets) 3 kg (GWP=1,360)

R600a (integral cabinets) 1 kg (GWP=20)

Other information

- Cost for application of technologies from industry sources
- Implementation time scale from industry
- Payback = extra cost of technology/savings per year
- Energy cost £0.12/kW.h

London South Bank University

i-STUTE

Technology assessment

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

Technologies assessed

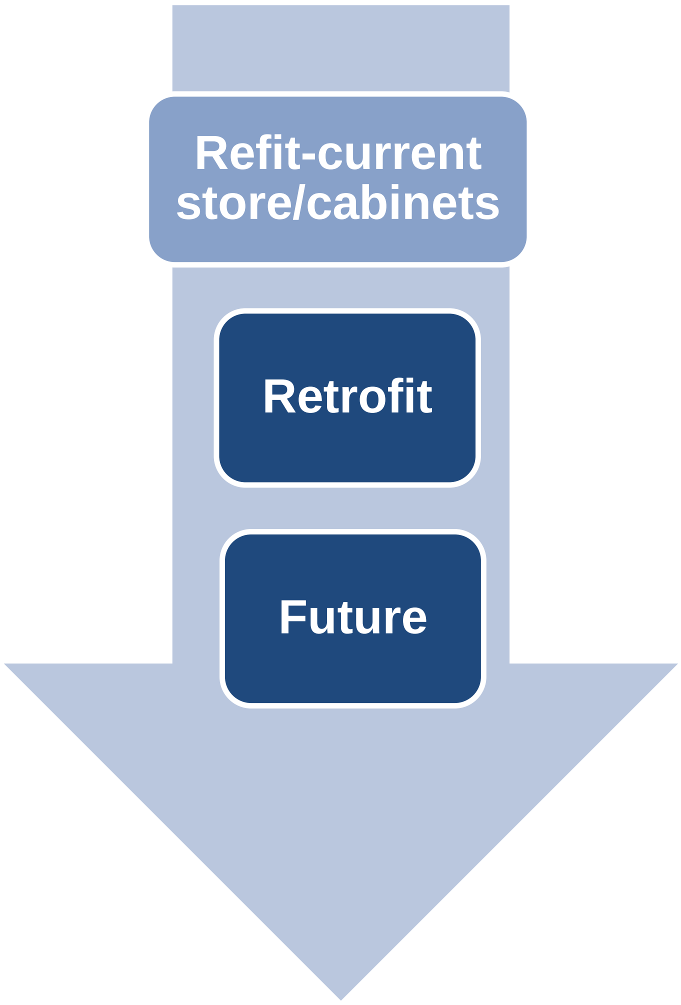
1. Air deflectors/guides
2. Anti-fogging glass
3. Anti-sweat heater control
4. Boreholes and ground sink condensers
5. Cabinet air flow
6. Cabinet lighting controls – dimming/switching using occupancy sensors
7. Cabinet loading
8. Cabinet location
9. Cabinet selection
10. Cabinet temperature control
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

London South Bank University

i-STUTE

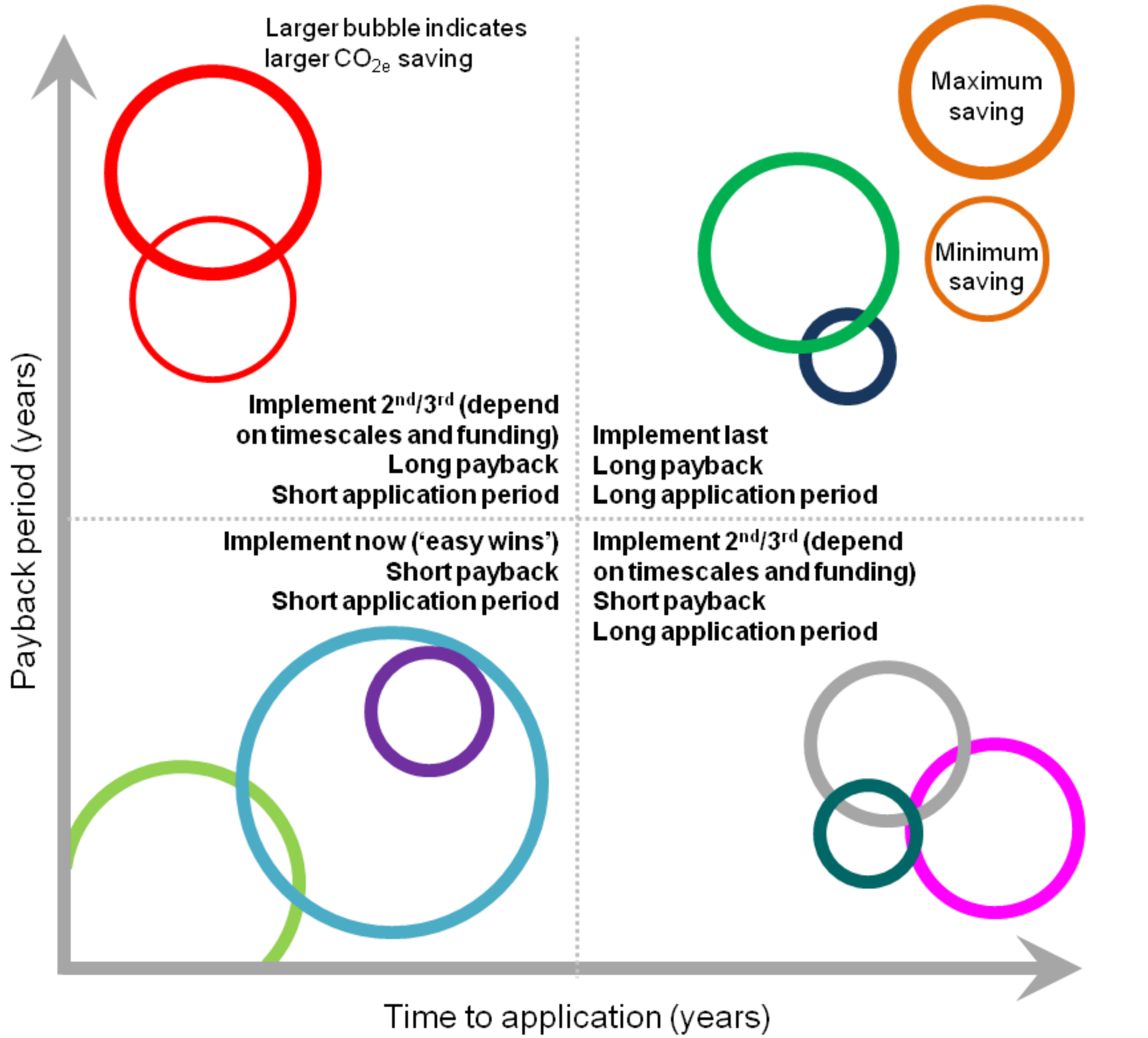
Results

- 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)



Presentation

- Graphs:
  - Direct
  - Indirect
- Bubble maps



London South Bank University

i-STUTE

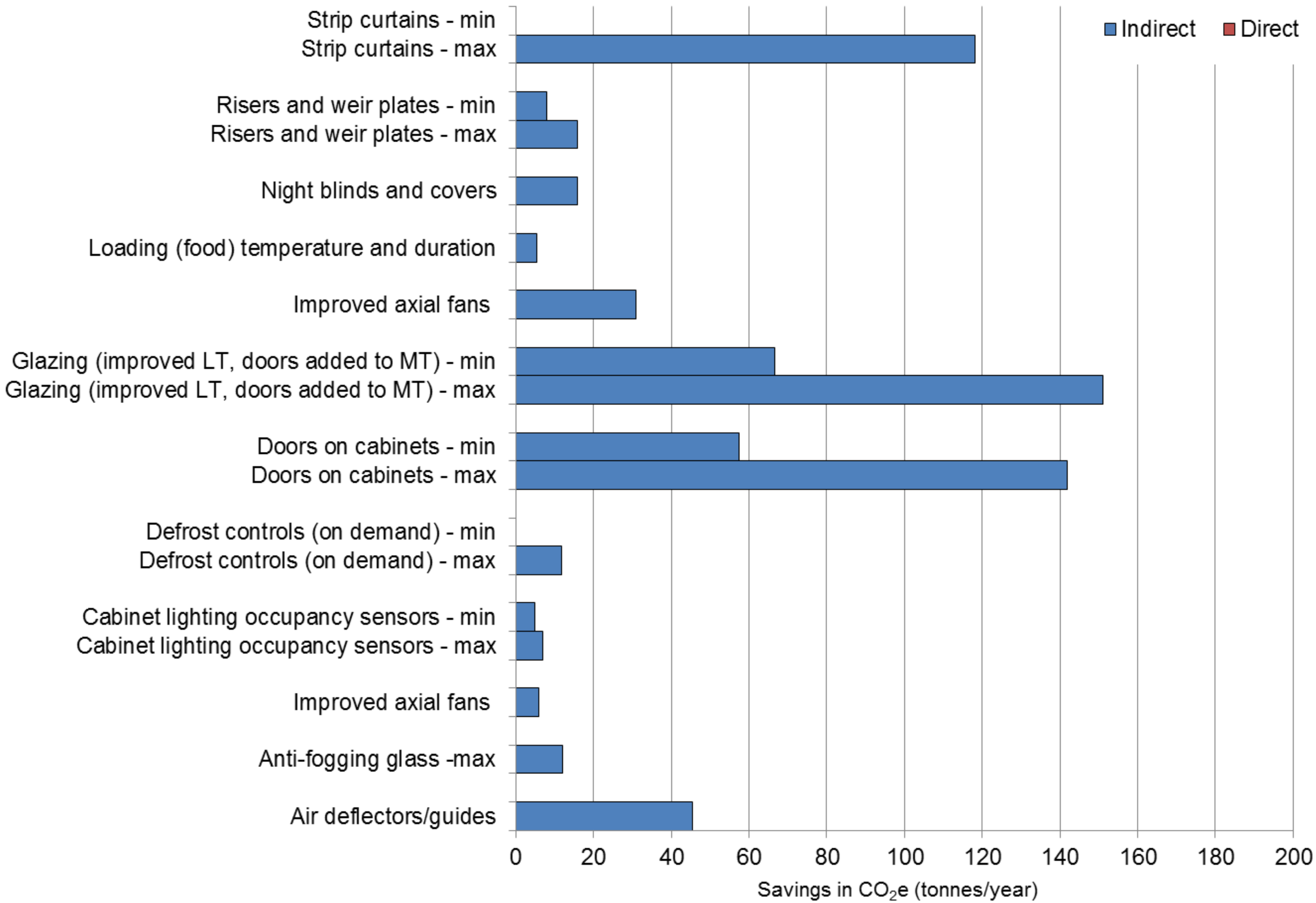
Technologies excluded

Already applied in baseline supermarket	Insufficient evidence
Anti-sweat heaters (RH controlled) ~70-80% of ASH energy, ~3.5% overall refrigeration energy consumption DC (EC) evaporator fans ~2.3% of energy for large cabinet, 29% for small Distributed system – lower leakage Lighting - cabinets (LED) 40-70% of lighting energy Pipe insulation – part of design Minimising pipe pressure drops – part of design	Absorption Adsorption Improved cabinet loading Improved cabinet location Improved cabinet temperature control Diagonal compact fans Dual port TEV Dynamic demand Electronic expansion valves Enhanced internal heat transfer (micro-fins) Heat exchanger rifling High-efficiency compressors Polygeneration Radiant reflectors Training and maintenance Ultrasonic defrosting of evaporators

London South Bank University

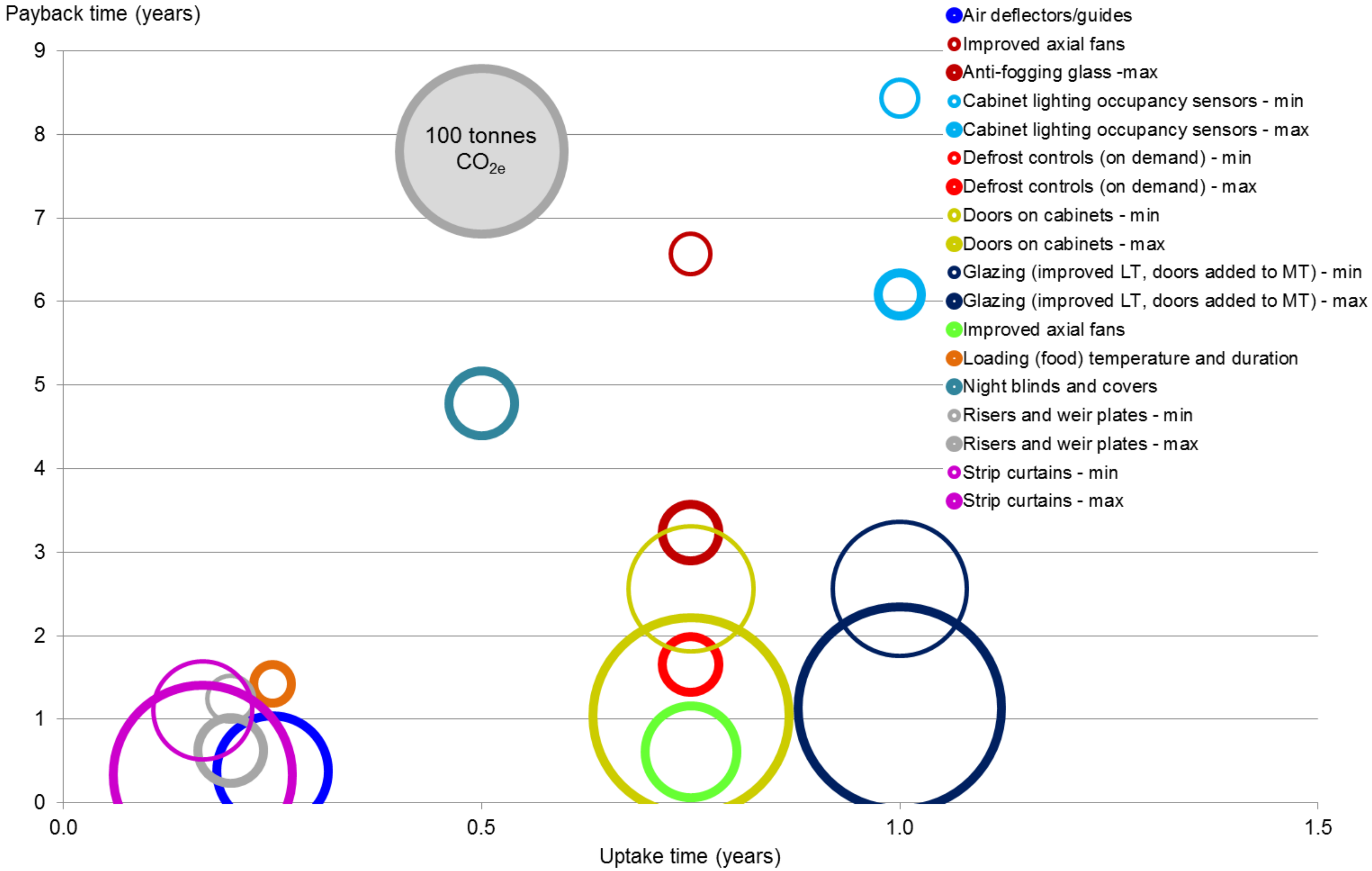
i-STUTE

Cabinets - current



London South Bank University

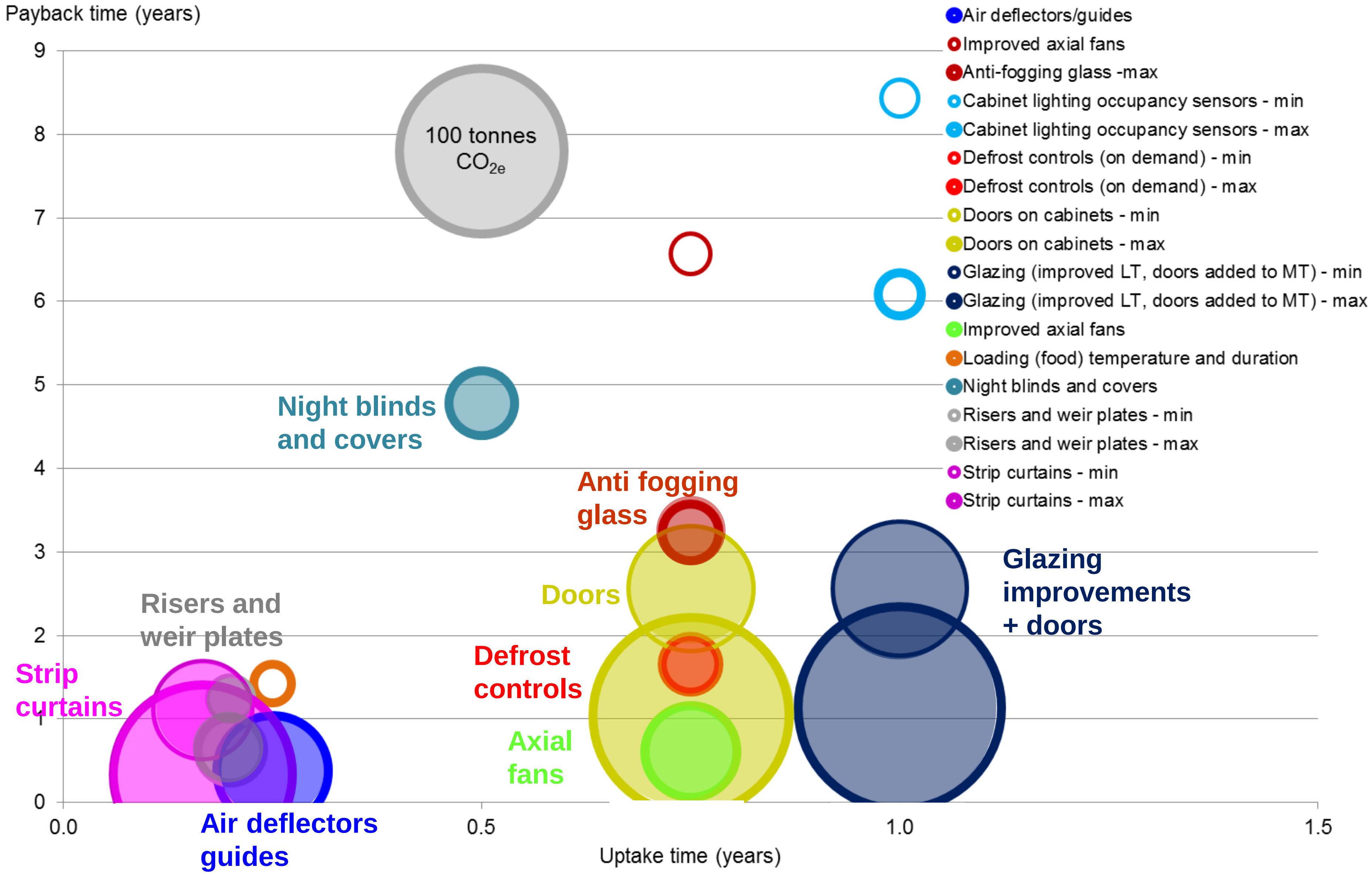
Cabinets - current



London South Bank University

i-STUTE

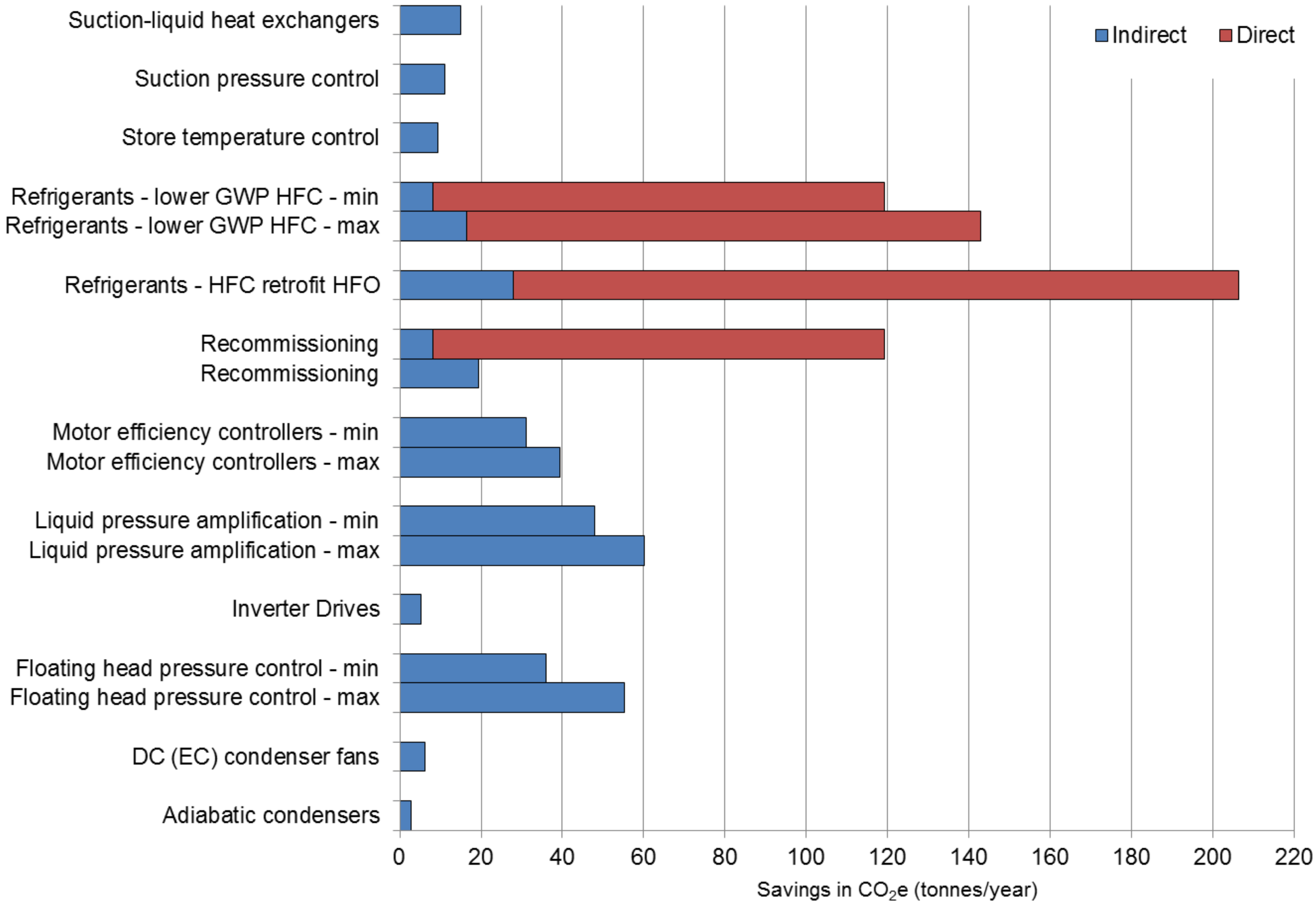
Cabinets - current



London South Bank University

i-STUTE

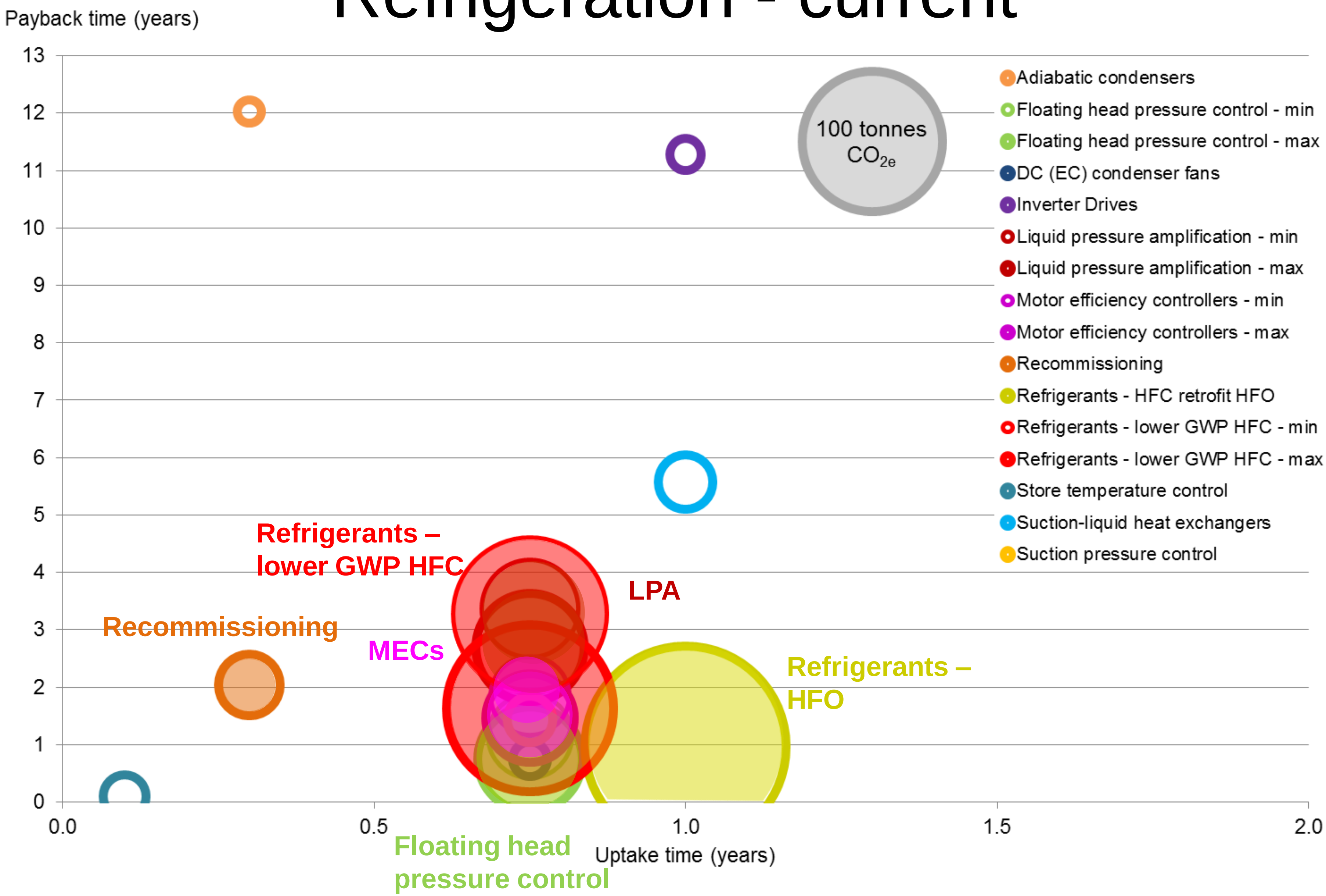
Refrigeration - current



London South Bank University

i-STUTE

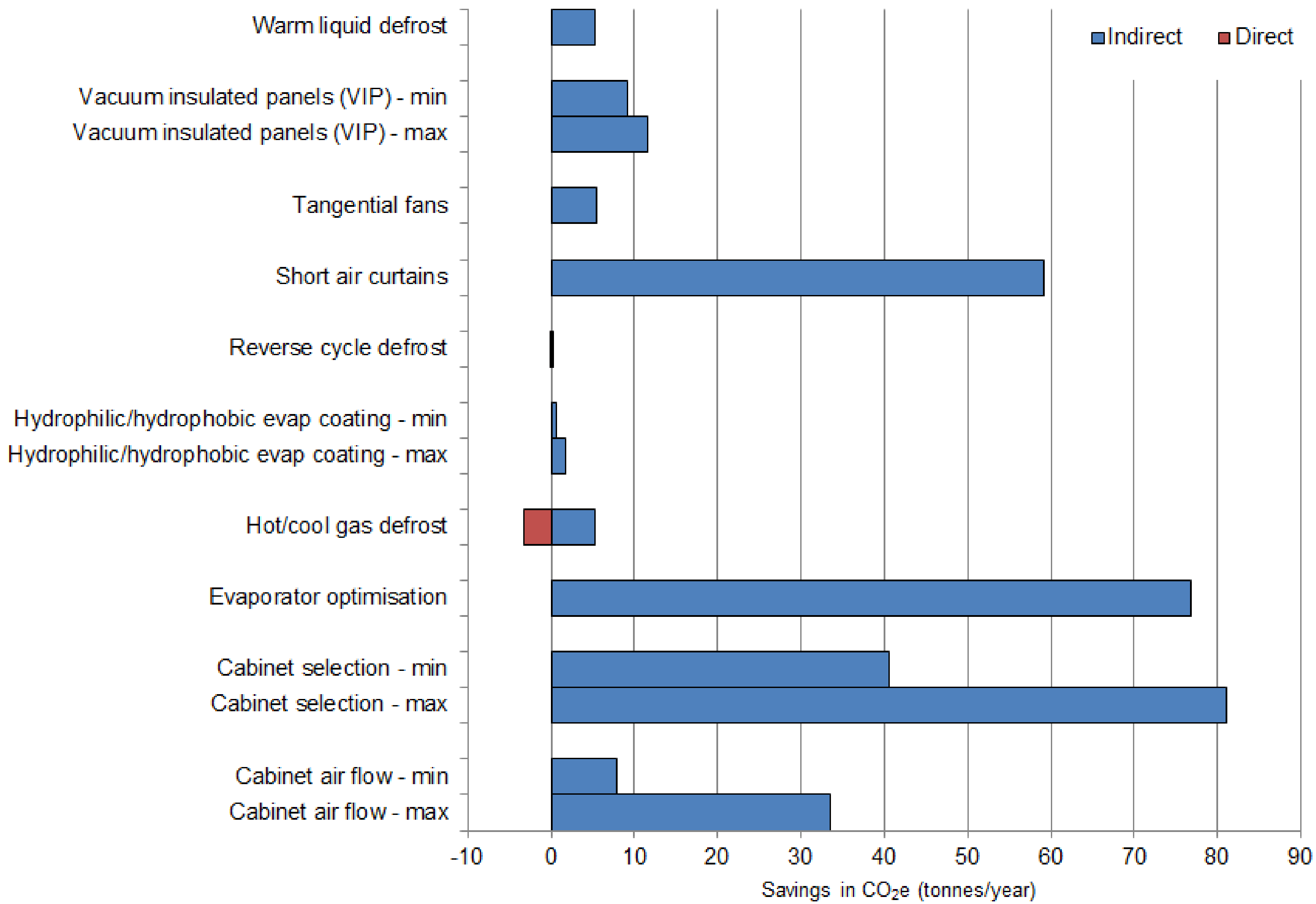
Refrigeration - current



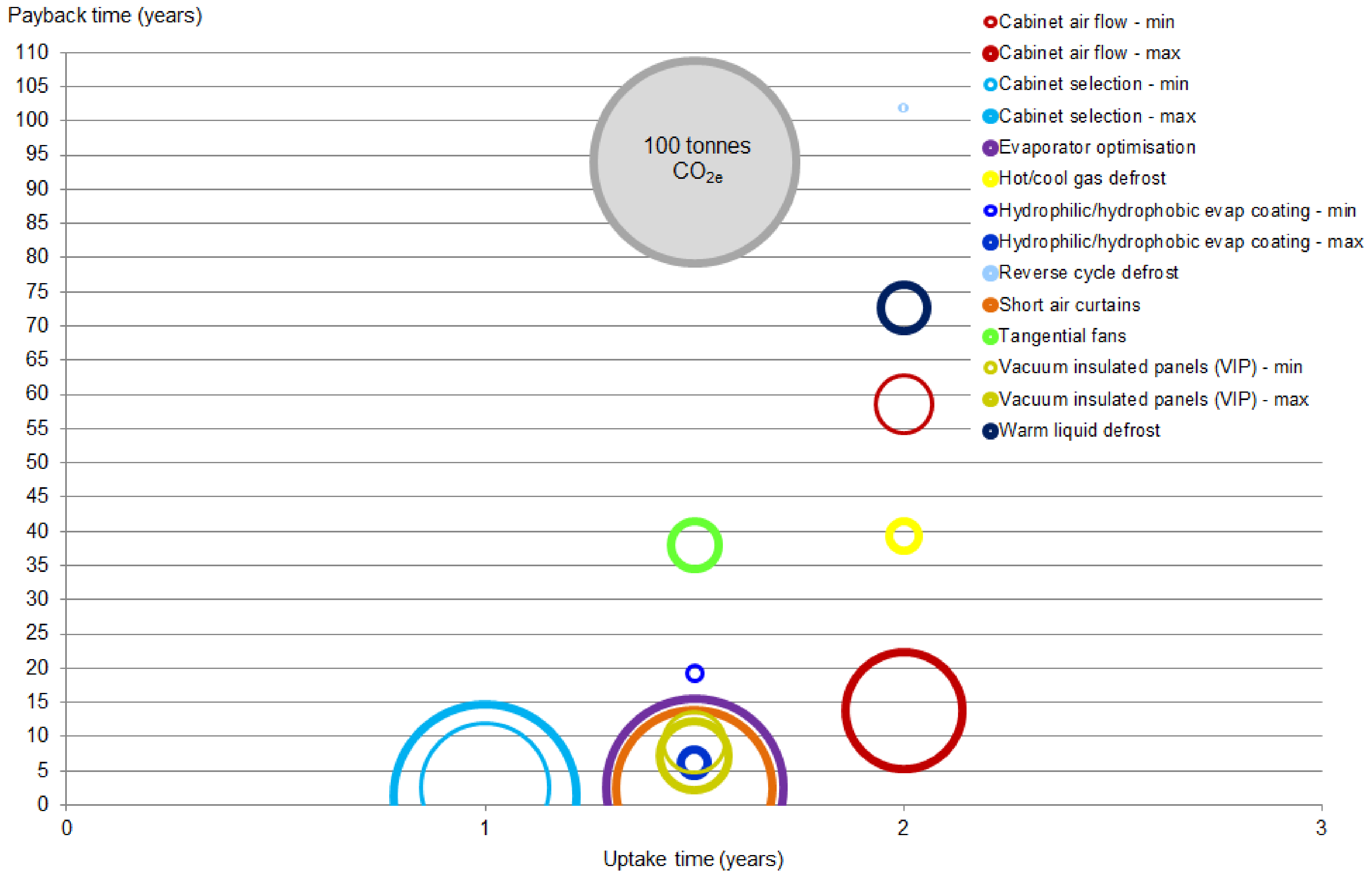
London South Bank University

i-STUTE

Cabinet technologies – medium term



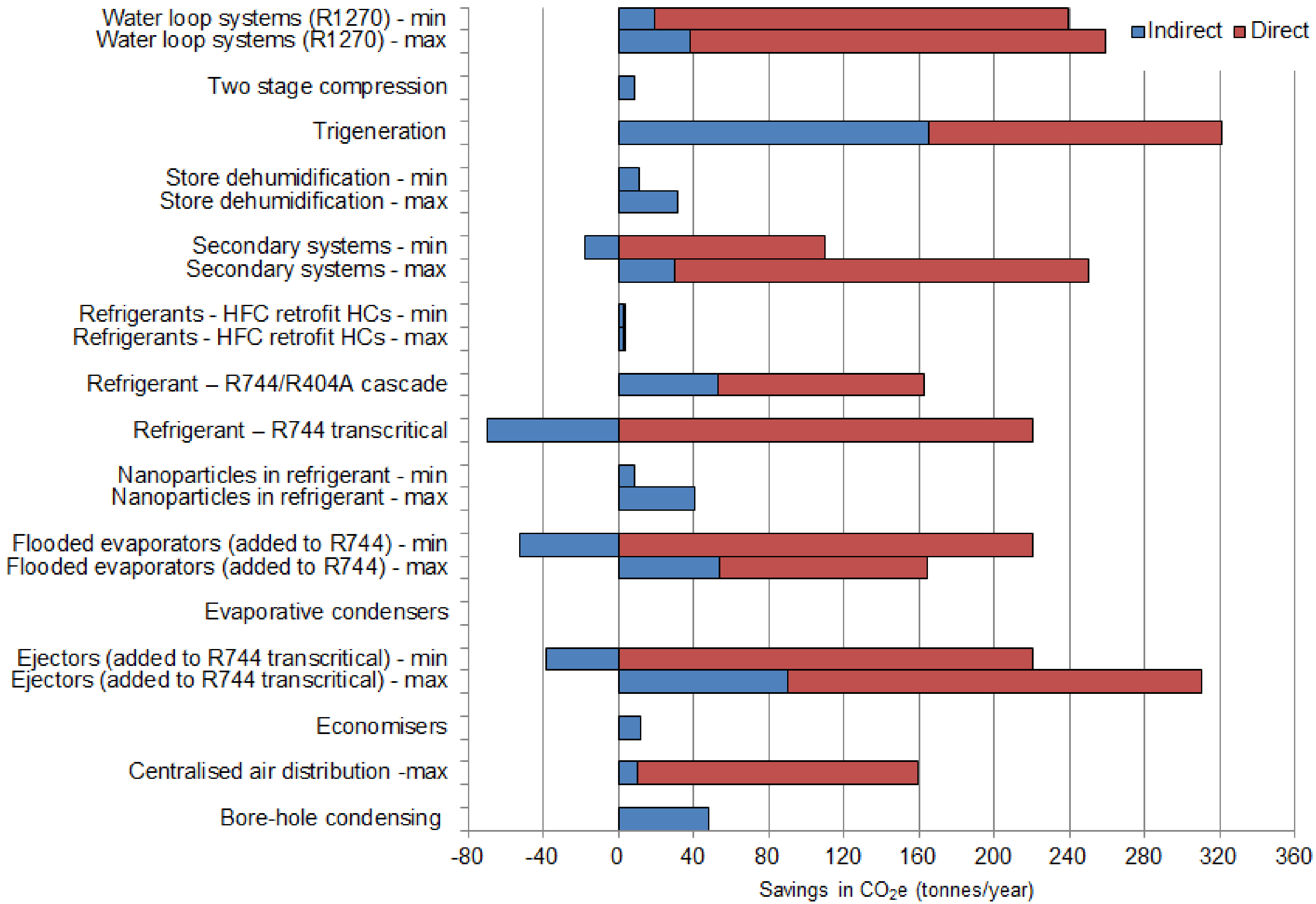
Cabinet technologies – medium term



London South Bank University

i-STUTE

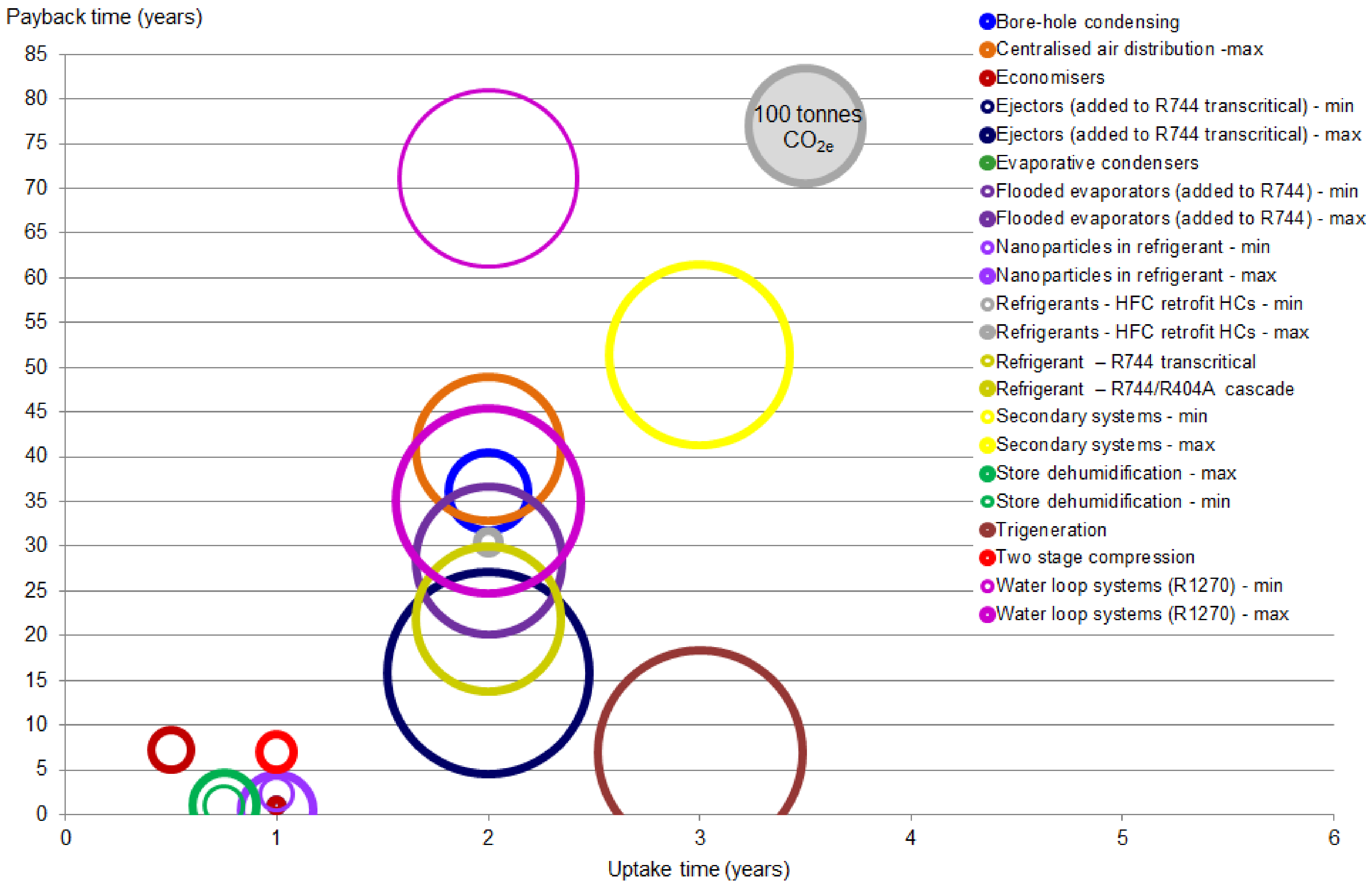
Refrigeration system technologies - medium



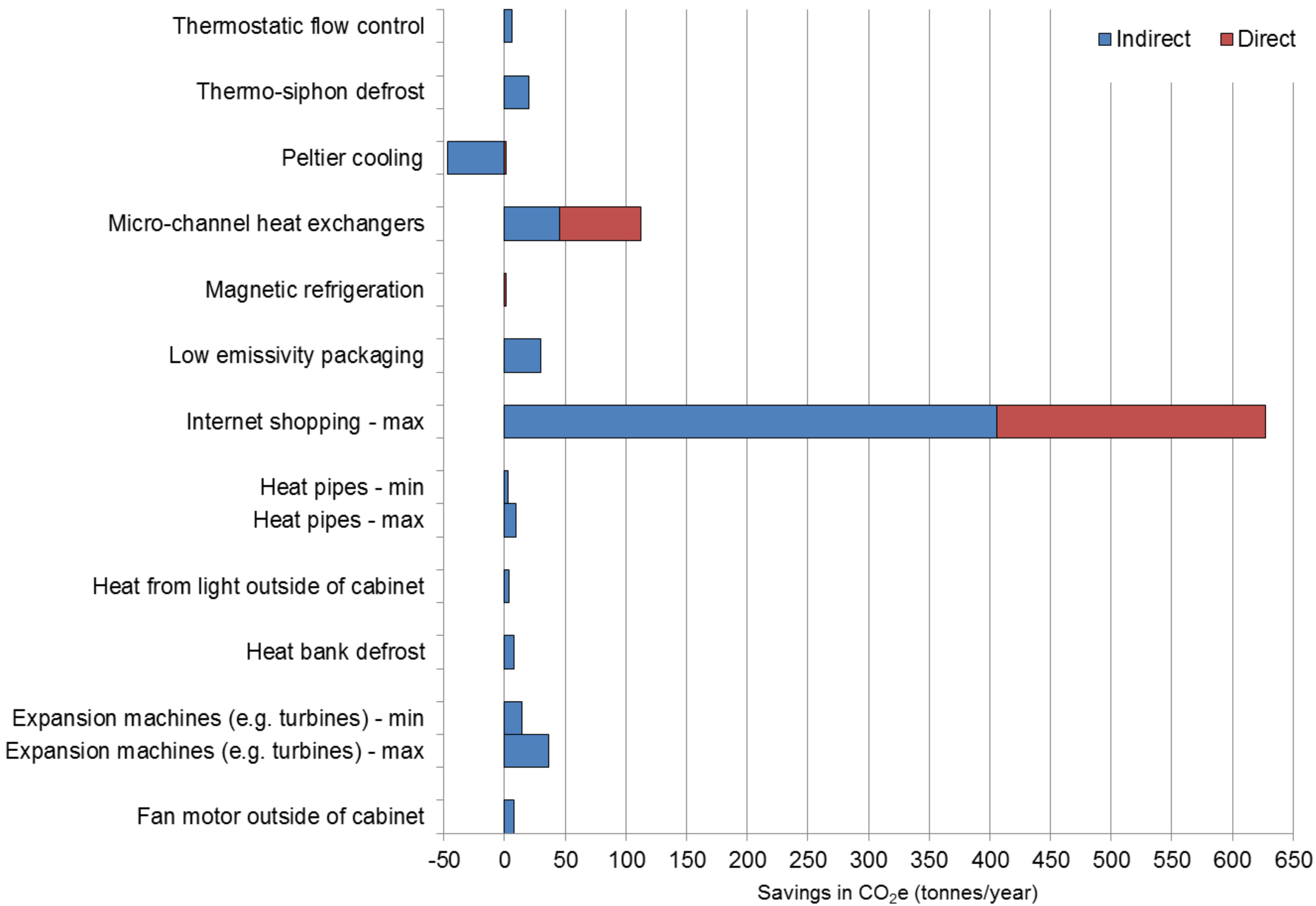
London South Bank University

i-STUTE

Refrigeration system technologies- medium



Future

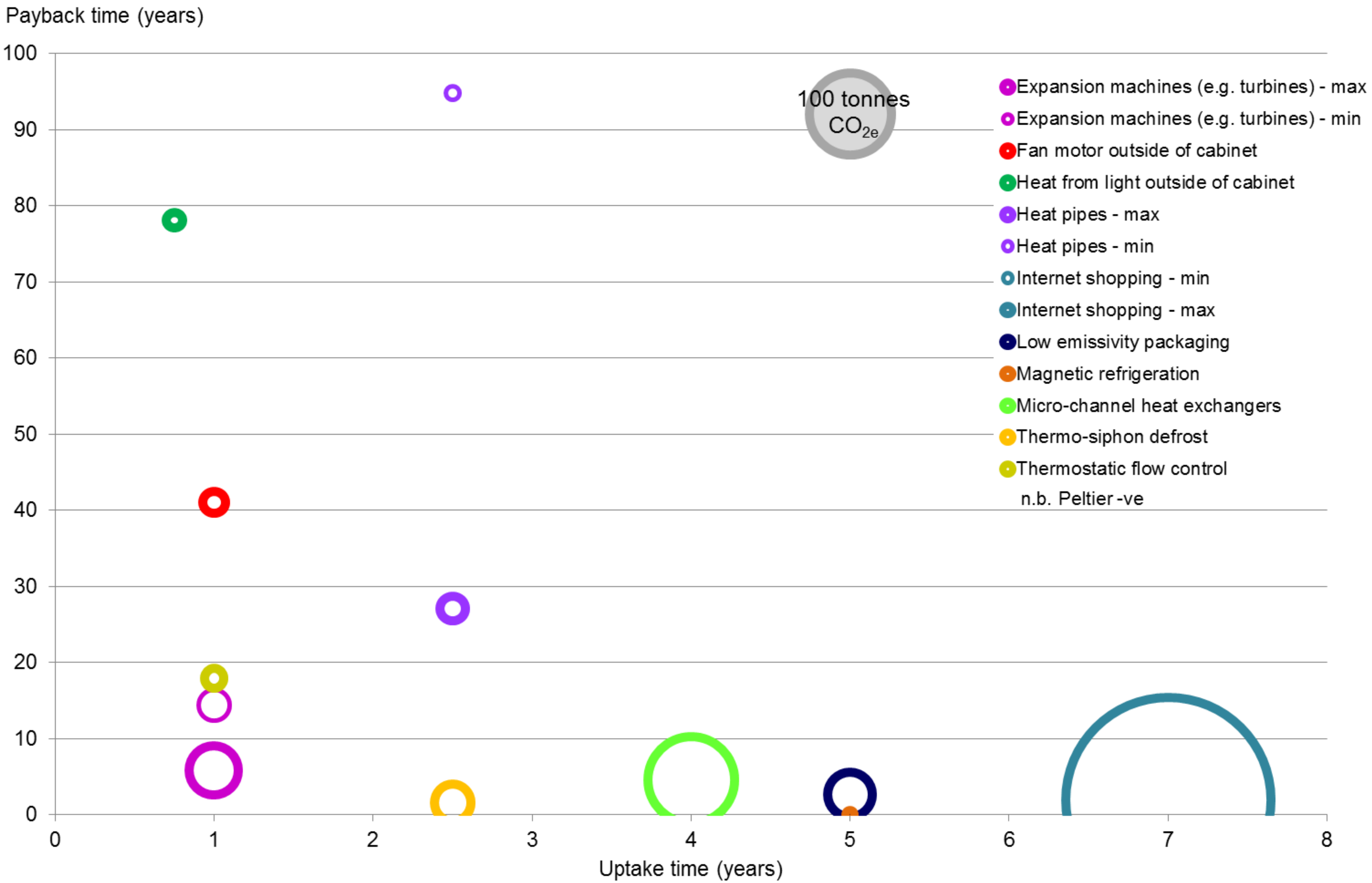


Thermostatic flow control
Thermo-siphon defrost
Peltier cooling
Micro-channel heat exchangers
Magnetic refrigeration
Low emissivity packaging
Internet shopping - max
Heat pipes - min
Heat pipes - max
Heat from light outside of cabinet
Heat bank defrost
Expansion machines (e.g. turbines) - min
Expansion machines (e.g. turbines) - max
Fan motor outside of cabinet
Indirect
Direct
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
Savings in CO_2e (tonnes/year)

London South Bank University

i-STUTE

Future



London South Bank University

IIR publication

Document available for review from IIR home page

For further information:

Judith Evans: j.a.evans@lsbu.ac.uk
Alan Foster (alan.foster@lsbu.ac.uk)

i-STUTE
London South Bank University