R22 Replacement for Chillers

Andrew Keogh
Engineering Manager
Carrier Air Conditioning

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Current Situation

- No new large chillers sold with R22 since 2000
- Many thousands of units still in service
- Restricted supply of R22
- No new R22 within 15 months
- Problem or opportunity ?

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Strategy

- Survey
  - Identify plant that uses R22
  - Determine the quantity of refrigerant
  - Review service records – reliability / leakage
  - Operational data – load / temperatures / running hours
  - Is the plant business-critical ?

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Options

- Do nothing
  - Retire old plant
  - Average age of R22 units currently ~ 15 years
  - Run until obsolete
  - Recover R22 for use elsewhere
- Convert
  - R134a
  - R407C
  - R422D (ISCEON 29) R417A (ISCEON 59)
- Replace

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Convert

- R134a
  - Reduction in capacity of ~ 30%
  - Slight improvement in efficiency
  - Convenience of a single component refrigerant
  - Lower system pressures

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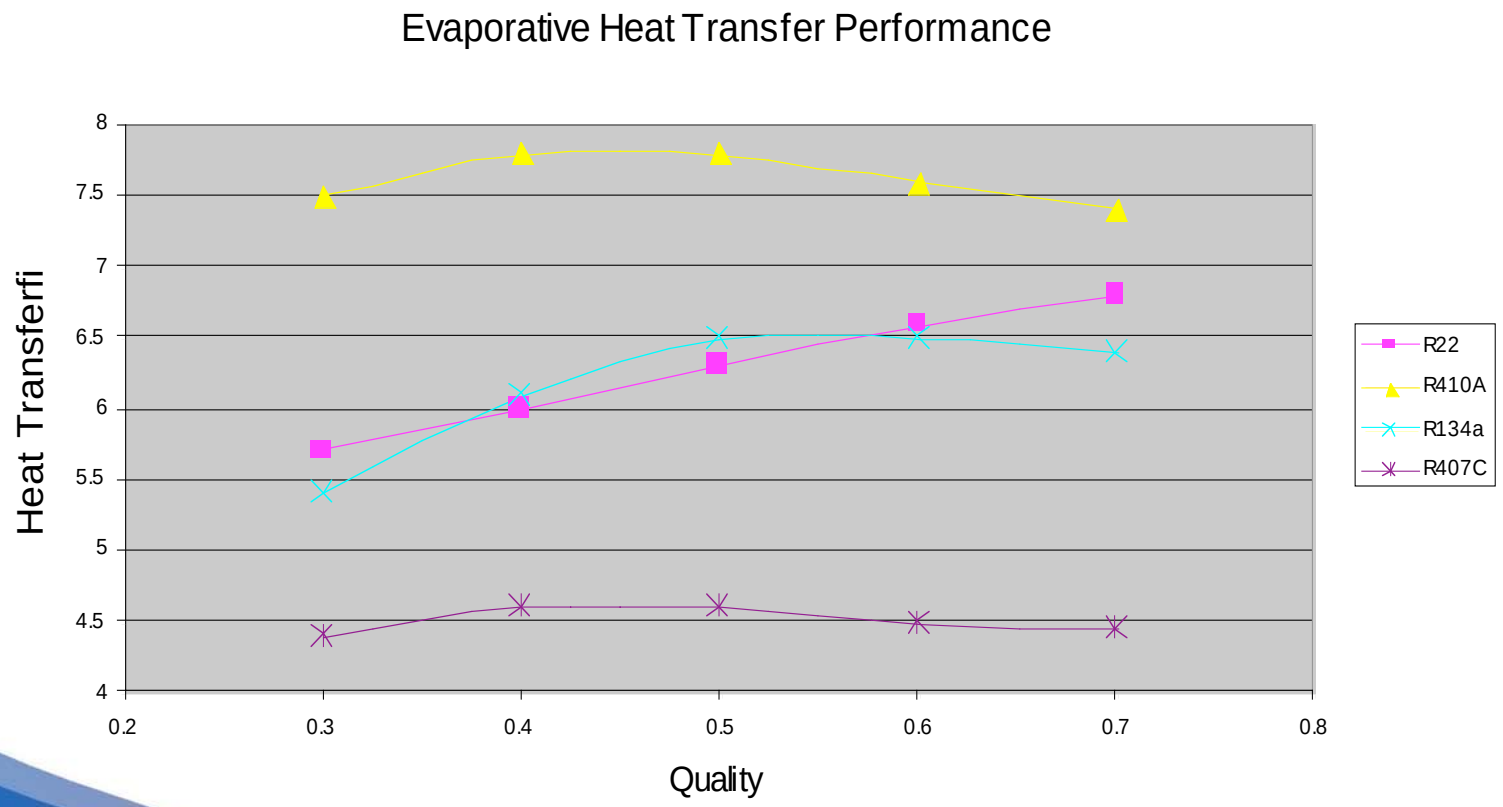
Convert

- R407C
  - Reduction in capacity and efficiency of ~ 5-10%



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Convert

- R407C procedure
  - Reclaim R22 and drain mineral oil
  - Charge with POE oil, evacuate and recharge with R22
  - Run plant, take oil sample; if >5% mineral oil, repeat
  - Reclaim R22 and evacuate
  - Change filter-driers / elastomeric seals
  - Charge with R407C
  - Run system, monitor and adjust charge if necessary
  - Label system
- Specific proposals produced on a case by case basis

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Convert

- R422D Procedure
  - Monitor baseline performance
  - Reclaim R22 and weigh
  - Replace filter-driers / elastomeric seals
  - Evacuate and leak check
  - Charge with R422D (~ 10% < R22 charge)
  - Start-up, adjust TXV and / or charge
  - Monitor oil levels, add if necessary
  - Gradual addition of POE if oil return ineffective
  - Label system

- Specific proposals produced on a case by case basis

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Replace

- Choice of refrigerant
  - HFC's
  - Ammonia
  - Hydrocarbon
- HFC's still the best overall compromise
  - Performance
  - Safety
  - Practicality
- Leakage is the only issue
- Energy efficiency is the driver

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Total Equivalent Warming Impact

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Evaluating Efficiency

Full load EER

ESEER / Part L SEER			
OAT °C	Load %	Time %	EER
35	100	3%	3.15
30	75	33%	3,92
25	50	41%	4,04
20	25	23%	5.08
ESEER kW/kW			4.21

IPLV			
OAT °C	Load %	Time %	EER
35	100	1%	3.15
26.7	75	42%	3,98
18.3	50	45%	5,15
12.8	25	12%	5.65
IPLV kW/kW			4.70

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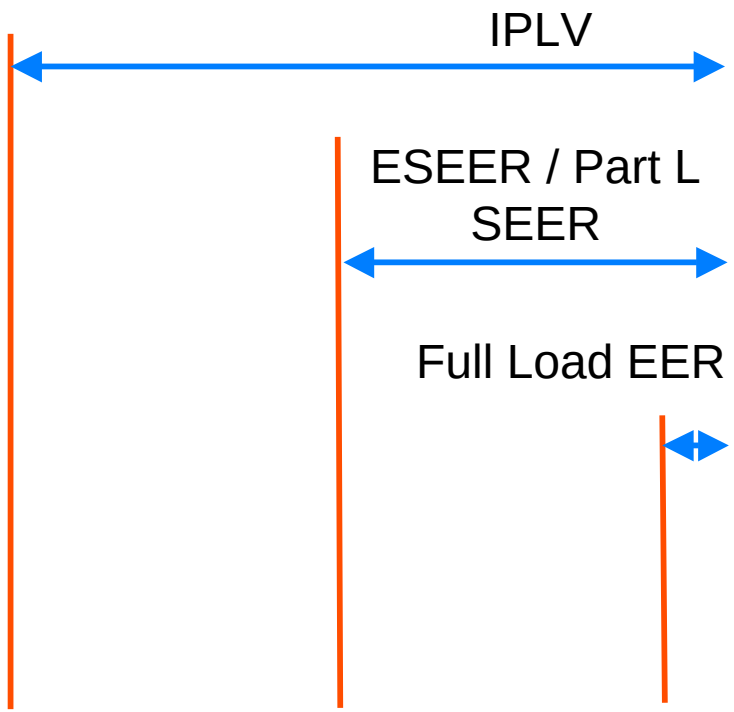
Evaluating Efficiency



(3150 operating hours)

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Evaluating Efficiency

Compliance Guide

'*For a system with multiple chillers for use in office buildings, combined EER values may be calculated based on the sum of the energy consumptions of all the operating chillers. In this case care must be taken to include all of the factors that can influence the combined performance of the multiple chiller installation. This will include:*

Degree of oversizing of the total installed capacity

Sizing of individual chillers

EER's of individual chillers

Control mode; e.g. parallel or sequential

Load profile of the proposed cooling load

Where these are known it may be possible to calculate a SEER which matches more closely the proposed installation than the simplifications described earlier.'

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System Comparison

Weather

City	London - United Kingdom
Schedule	0700-1800: Weekday
	0700-1300: Saturday
	Off All Day: Sunday

Loads

Peak Building Load	990 kW at 28.1 C
Building Load #2	200 kW at 0.0 C
Outdoor Economizer Used	No

Analysis Parameters

Type of Analysis	Energy Costs Only
Include Pump Energy Use	No
Include Tower Energy Use	No

Chiller Systems

(A) R134a Screw Compressor chillers
(B) R22 Reciprocating Compressor chillers

Economics

Lifecycle Period	25 years
Minimum Attractive Rate of Return	10 %
Electric Energy	0.100 £/kWH
Electric Demand	0.000 £/kW
Natural Gas	0.600 £/THM
Steam	10.000 £/MMBTU

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System Comparison

	R134a Screw	R22 Recips	Savings	Percent Savings
Annual Energy Cost Details				
Chiller Electric Cost (£)	31,388	44,589	(13,201)	-42%
Cooling Tower (£)	0	0	0	0%
Chilled Water Pump (£)	0	0	0	0%
Condenser Water Pump (£)	0	0	0	0%
Total Energy Cost (£)	31,388	44,589	(13,201)	-42%
Annual Energy Use Details				
Chillers (kWh/yr)	313,877	445,887	(132,009)	-42%
Cooling Towers (kWh/yr)	0	0	0	0%
Chiller Water Pumps (kWh/yr)	0	0	0	0%
Condenser Water Pumps (kWh/yr)	0	0	0	0%
Total Electric (kWh/yr)	313,877	445,887	(132,009)	-42%

55,700 kg CO_2

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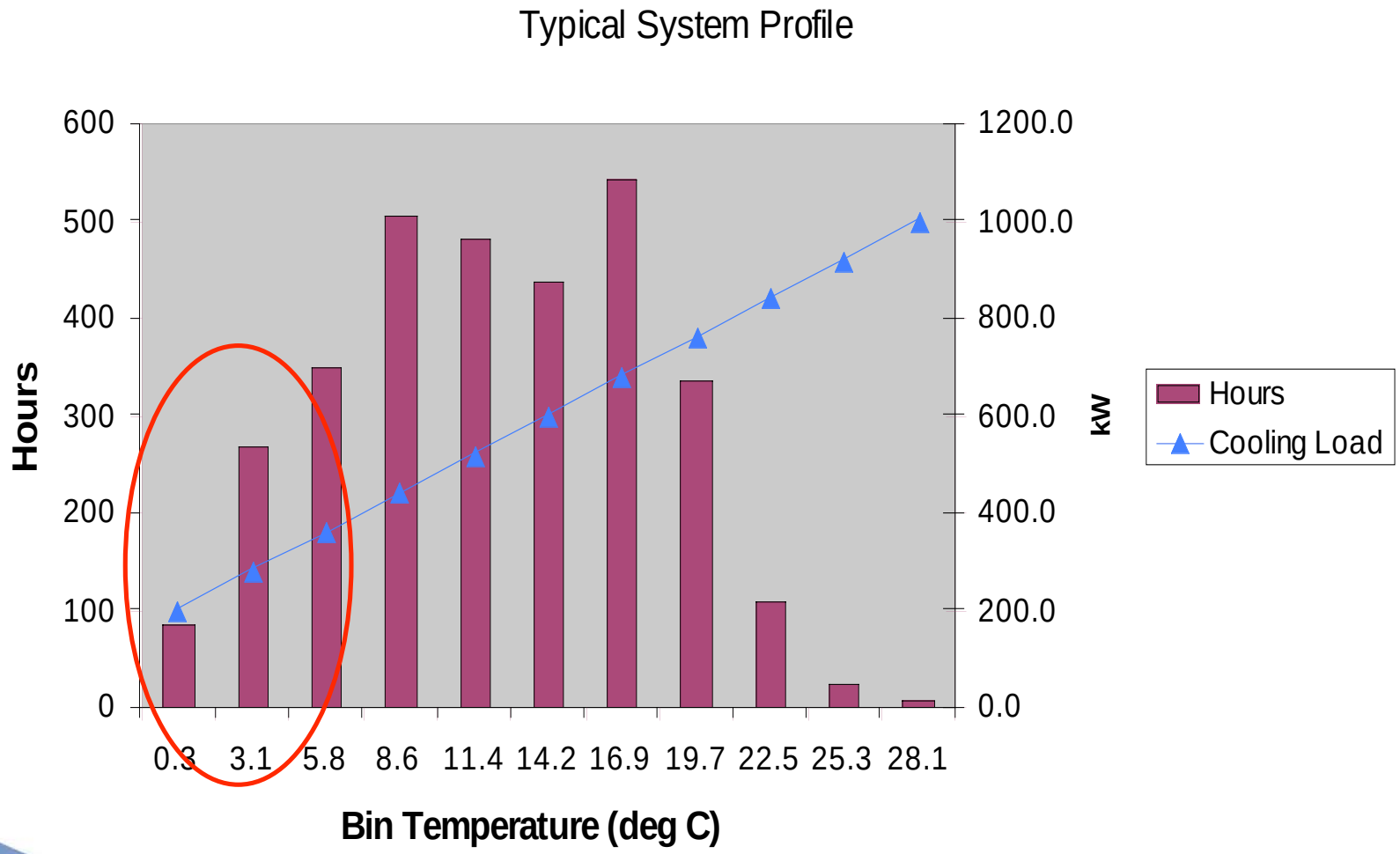
Free Cooling



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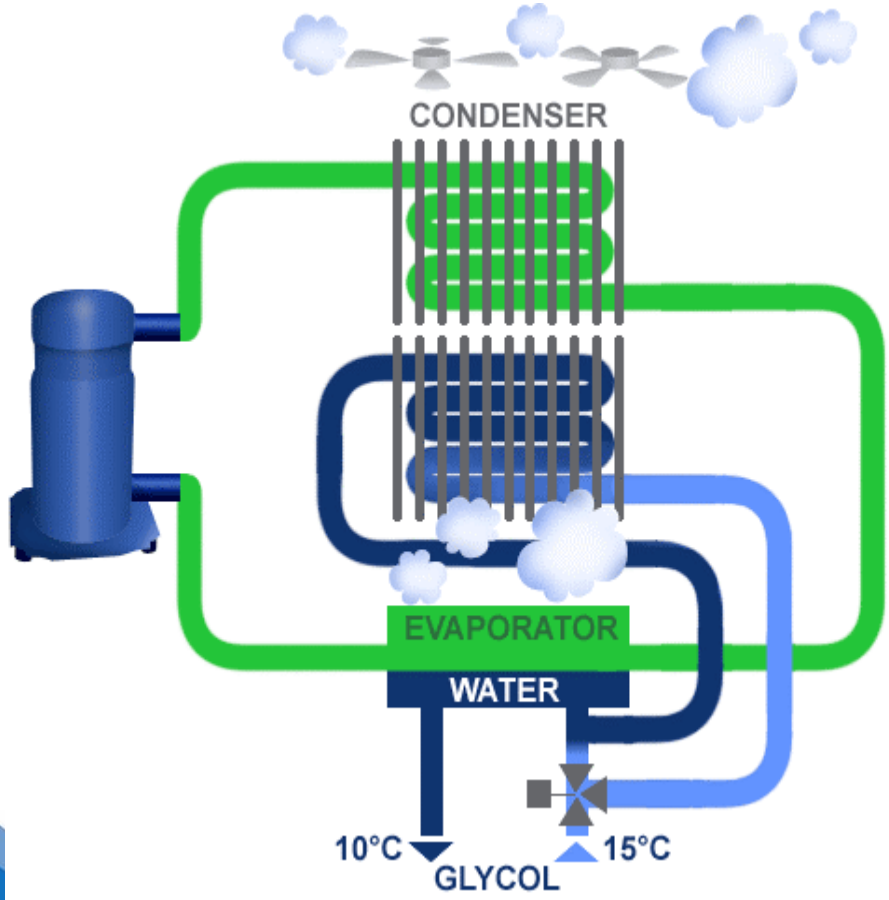
Free Cooling



- Excellent performance
- Glycol
  - Expensive
  - Reduced heat transfer
  - System performance ?
- Additional pressure drops
  - Pump replacement ?
- Reduced EER
- Control conflicts
- Increased weight

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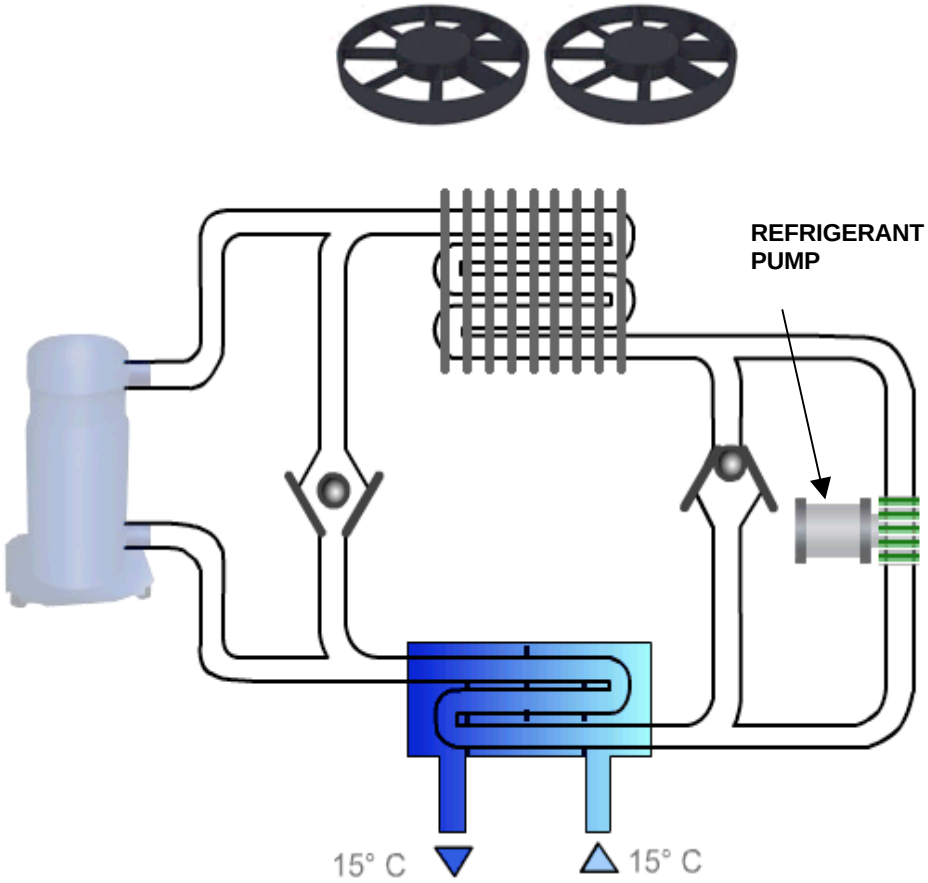
Free Cooling



- Reduced performance
- No glycol required
  - No effect on system
- No additional pressure drop
- Minimal effect on EER
- No control conflicts
- No increased weight

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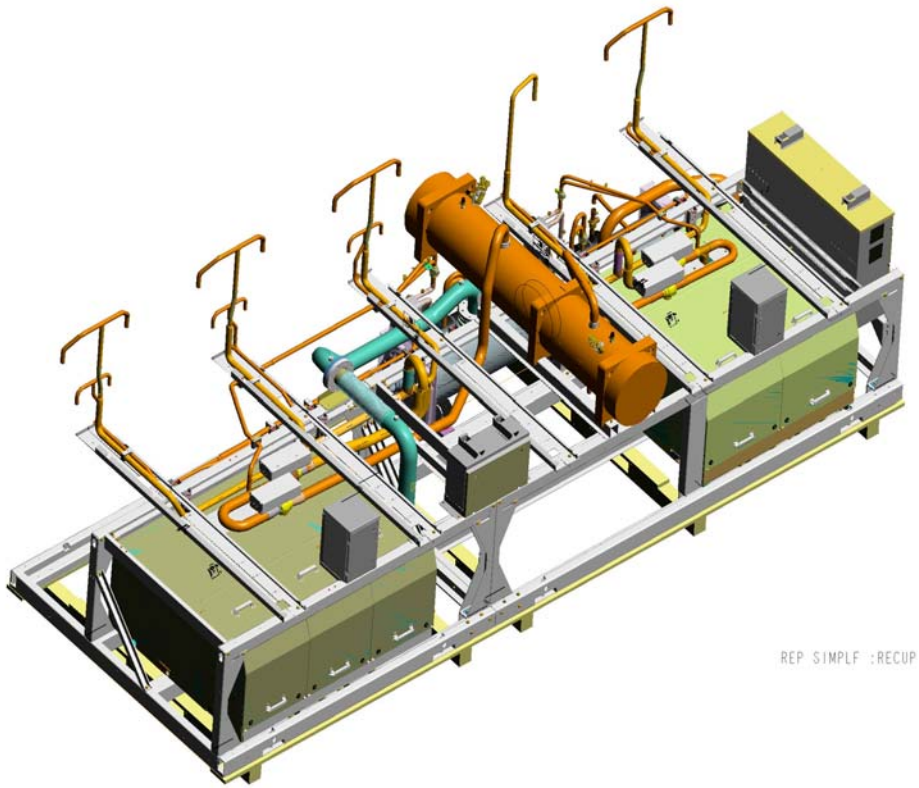
Heat Recovery



- ‘Free’ generation of hot water
- Total heat recovery
  - Hot water to ~ 50 deg C
- Partial heat recovery
  - De-superheater
  - Hot water to ~ 65 deg C

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Summary

- Survey and plan
- Retire, retrofit or replace
- Incorporate new, energy efficient technologies
- Make a virtue out of necessity

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