SWEHEAT & COOLING

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“District Cooling Concepts applied in China.”

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District Cooling 2016 a Climate Solution
Dubai, November 2016

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District Cooling in China

District Cooling

- Very limited development of District Cooling systems, first systems developed early 2000;
- Standard approach for cooling is split units for apartments and building or block level chilled water plants;
- Indoor design temperature is +26 C (77 F)
- For District Cooling systems a combination of compression chillers, absorption chillers and Ice Thermal Energy Storage are common;
- Almost all District Cooling plants with Ice Thermal Energy Storage have dual duty, single evaporator chillers and large heat exchangers between the glycol circuit and chilled water circuit for day time operation as well as heat exchangers between the Ice Thermal Energy Storage and the chilled water circuit;
- In almost all cases where both District Heating and District Cooling are developed the pipe network is two pipe system that are used for heat supply in winter and cooling supply in the summer;

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CONSIDERABLE CLIMATE DIFFERENCES

Climate Zones	Mean Monthly Temperature	
	Coldest	Hottest
Severe Cold	≤ -10 °C	≤ 25 °C
Cold	-10–0 °C	18–28 °C
Temperate	0–13 °C	18–25 °C
Hot Summer and Cold Winter	0–10 °C	25–30 °C
Hot Summer and Warm Winter	> 10 °C	25–29 °C

Source: Berkely Labs

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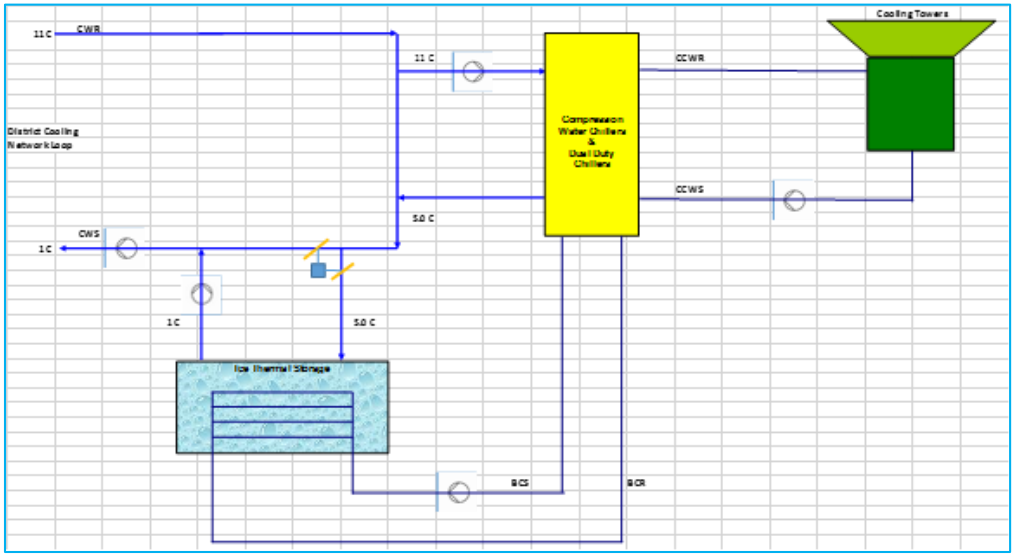
Compression Chillers with Ice Thermal Energy Storage Concepts

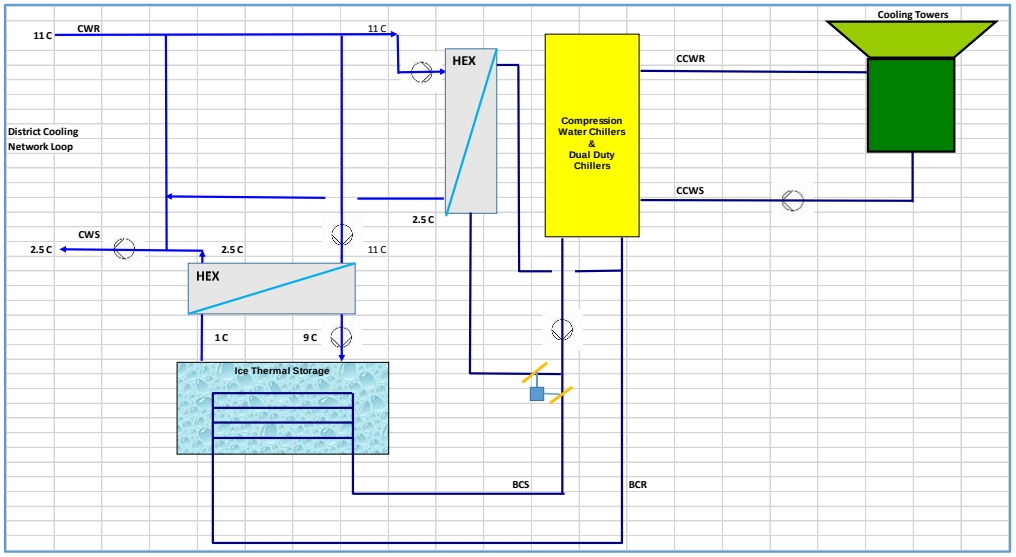
Best Practice

- Dual duty chillers with two evaporators where the chilled water evaporator is connected in series with the directly connected Thermal Energy storage;
- Provide the highest daytime COP at the same time as utilising low night time electricity;



Common solution in China

- Dual duty chillers with single evaporator, large heat exchangers between the glycol circuit and chilled water circuit for day time operation as well as heat exchangers between the Ice Thermal Storage and the chilled water circuit;
- Result in a lower COP;



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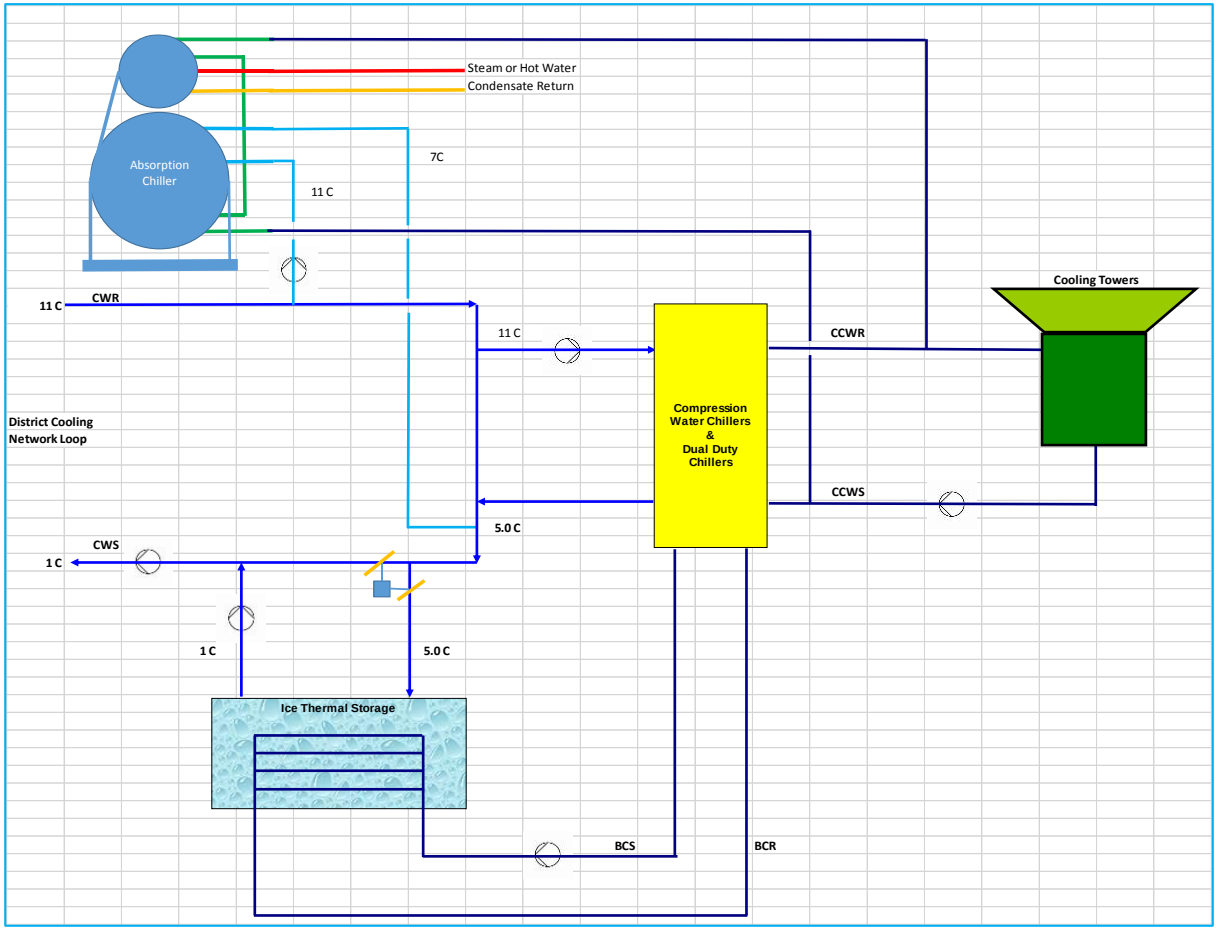
Absorption & Compression Chillers with Ice Thermal Energy Storage Concepts

Absorption Chillers added to the production mix

- In some cases there are discussions about using steam or hot water from existing power plants as base load production of chilled water;
- Then using dual duty chillers with ice thermal storage for peak production;



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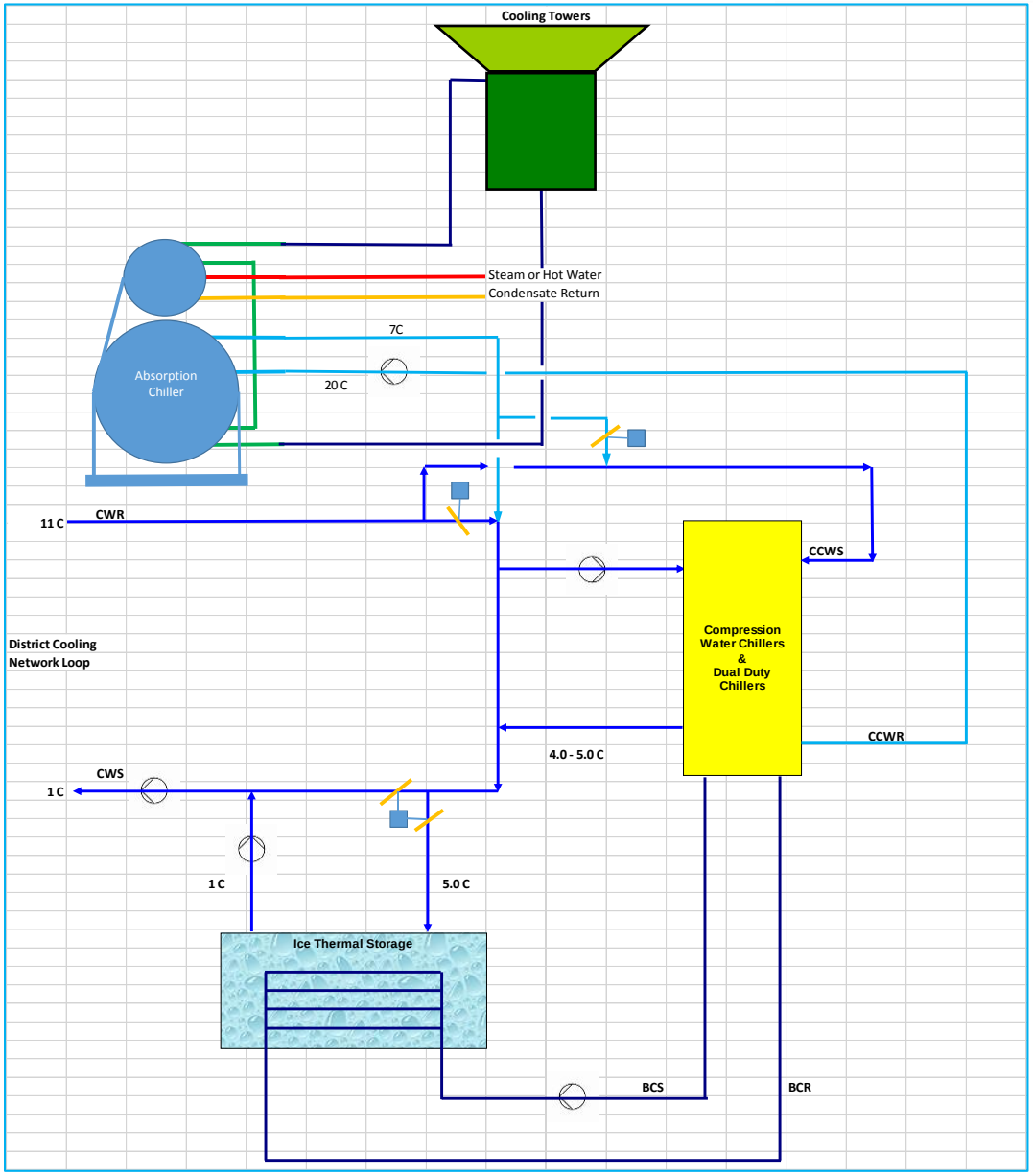
Absorption & Compression Chillers with Ice Thermal Energy Storage Concepts

Absorption Chillers also cooling the condensers on compression chillers

- In one case there is even a discussion to use an existing district heating pipeline as transmission line for chilled water in the summer and put the absorption chillers at the power plant 35 km away;
- In that case the concept is to move the cooling towers out of the down town area and use the return water from the consumers to cool the condensers of the chillers and the absorption chillers will cool the common return from consumers and chiller condensers;
- The aim is to use the compression machines as heat pumps in the winter season;



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COMPARISON OF PLANT SOLUTIONS

Comparison of three alternative Plant solutions

- Dual duty, twin compressor, double evaporator with ice TES;
- Dual duty, single compressor, double evaporator with ice TES;
- Dual duty, single compressor, single evaporator with HEX and ice TES;

Optimisation of ice TES size for the three Plant solutions

- Five different sizes of ice TES capacity has been analysed;
- Depending on ice TES capacity the plant configurations has been modified to fit each one of the cases;
- 16 different plant scenarios has been developed and analysed;

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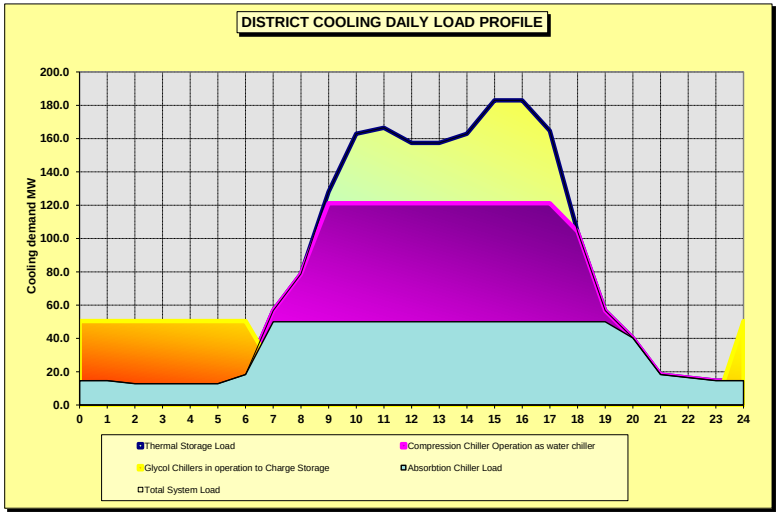
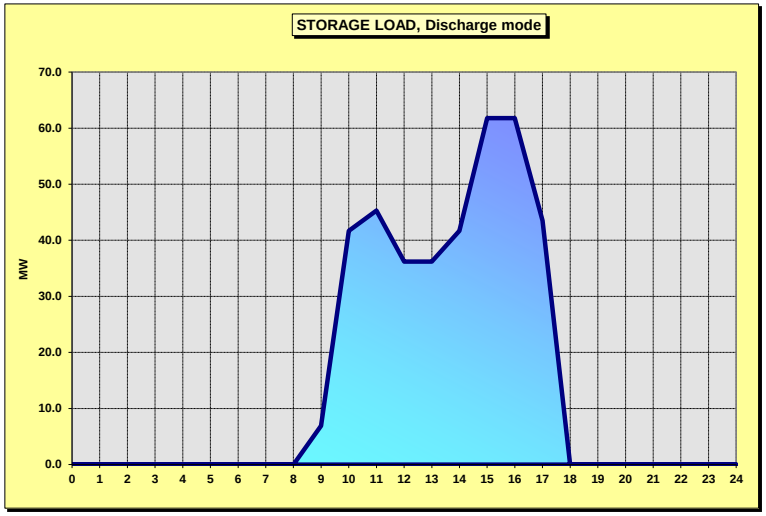
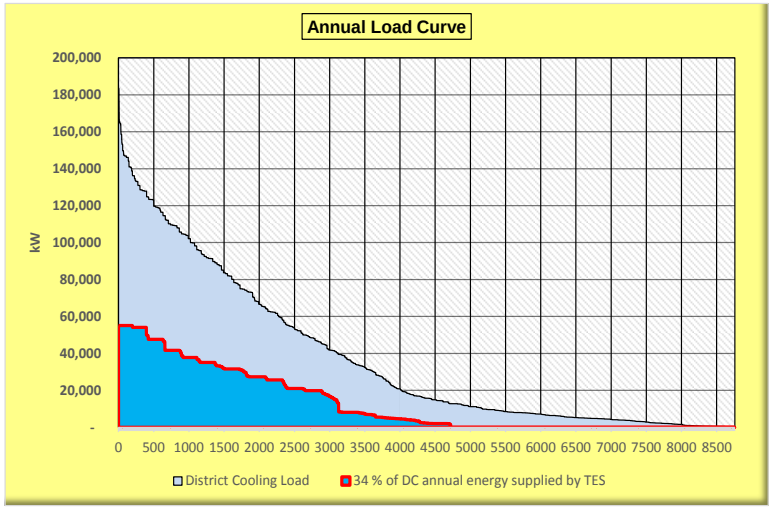
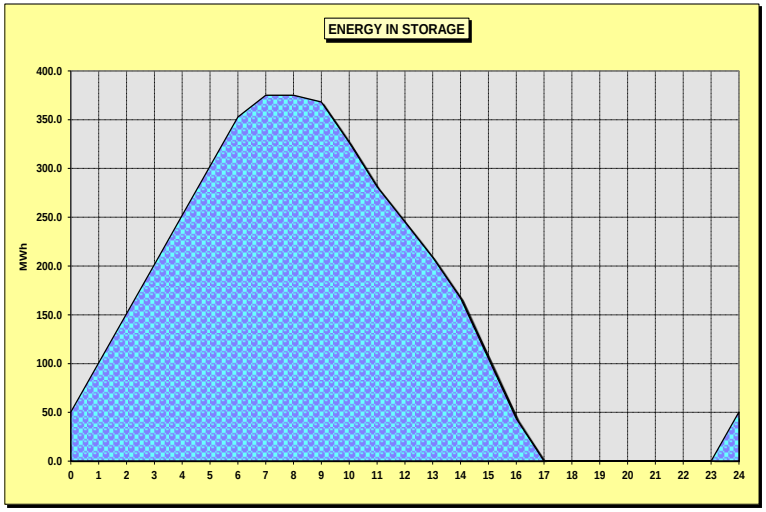
LOAD CURVES

- Sizing of Chilled Water Plants with Thermal Energy Storage is a complex task;









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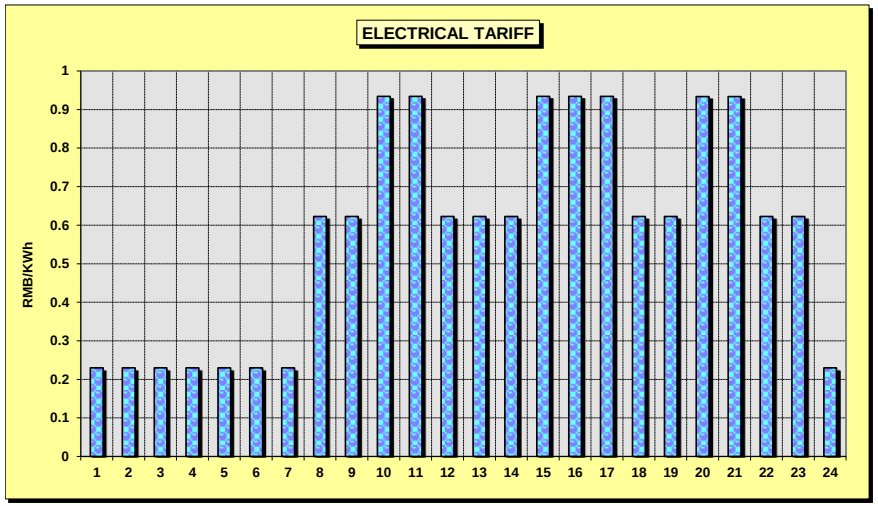
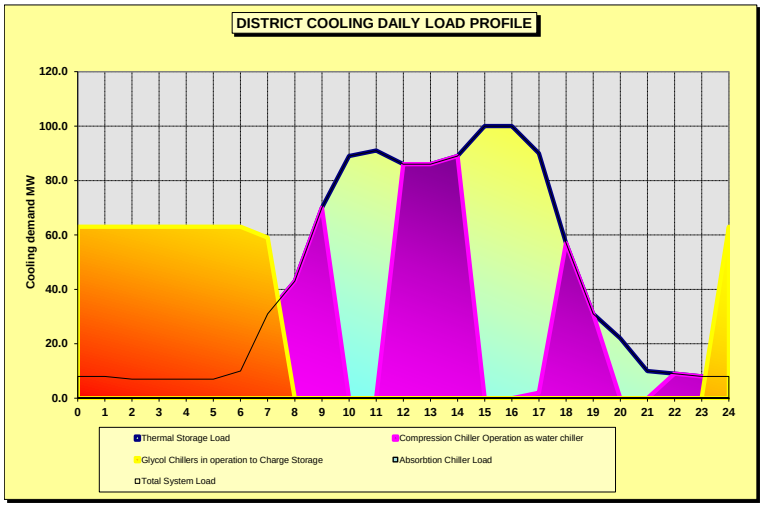
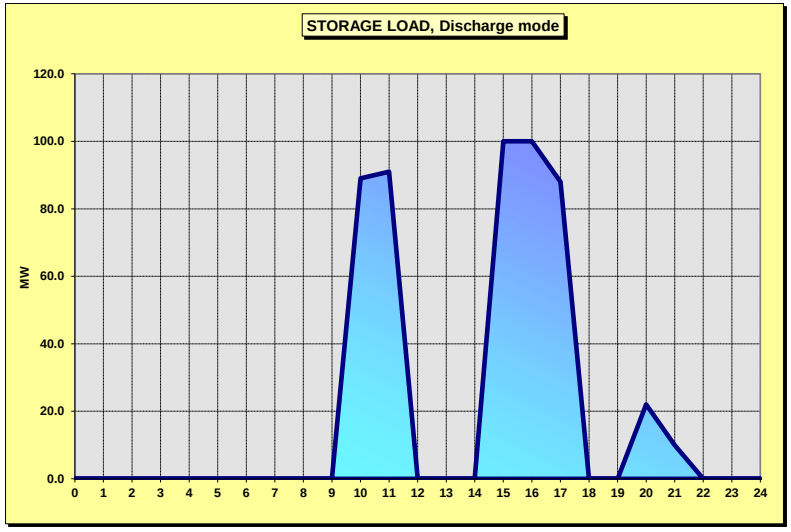
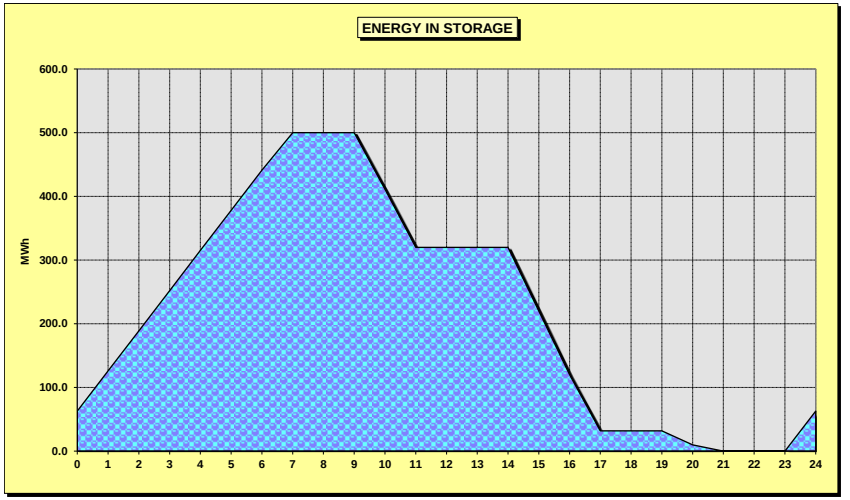
Operation Strategy based on Time of Day Tariff

- Most economic operation on a 55% of peak day, but practical?









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COMPARISON OF PLANT CONFIGURATIONS

Mode of opeartion	Load	Dual Duty, twin compressor, double evaporator	Dual Duty, Single compressor, double evaporator	Dual Duty, single compressor, single evaporator with HEX	Single duty Chillers
CW mode COP	100%	5.48	4.96	4.723	5.321
Ice mode COP	100%	3.61	4.09	3.98	-

	Percentage of Annual Energy Supply	TES Capacity	Single duty Water Chillers	Dual duty Chillers; chilled water/ice		Dedicated ice making chiller	
			# of units	Total Capacity	# of units	Total Capacity CW mode/Ice mode	# of units	Total Capacity
	%	MWh		MW		MW		MW
No TES	0%	0	21	184.8				
Ice TES	34%	407	6	52.8	9	79.2/56.7		
Ice TES	39%	467	4	35.2	10	88/63		
			1	1.76				
Ice TES	41.6%	500	4	35.2	10	88/63		
Ice TES	45.2%	552	4	35.2	9	79.2/56.7	2	12.6
			2	3.52				
Ice TES	52.7%	675	3	26.4	9	79.2/56.7	5	31.5
			2	3.52				

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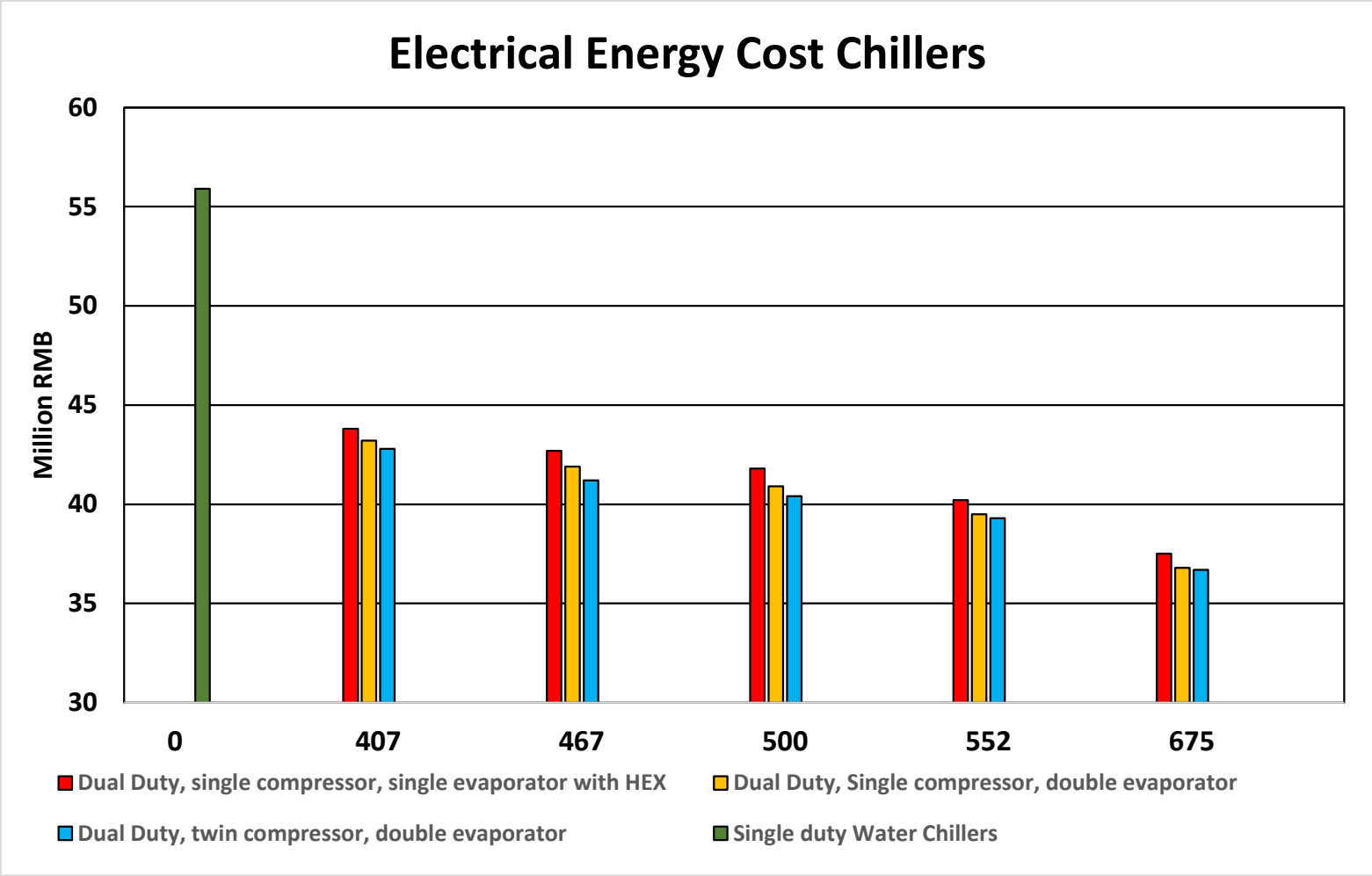
Energy Cost for Chillers

- The day tariff is about 4 times the night tariff;



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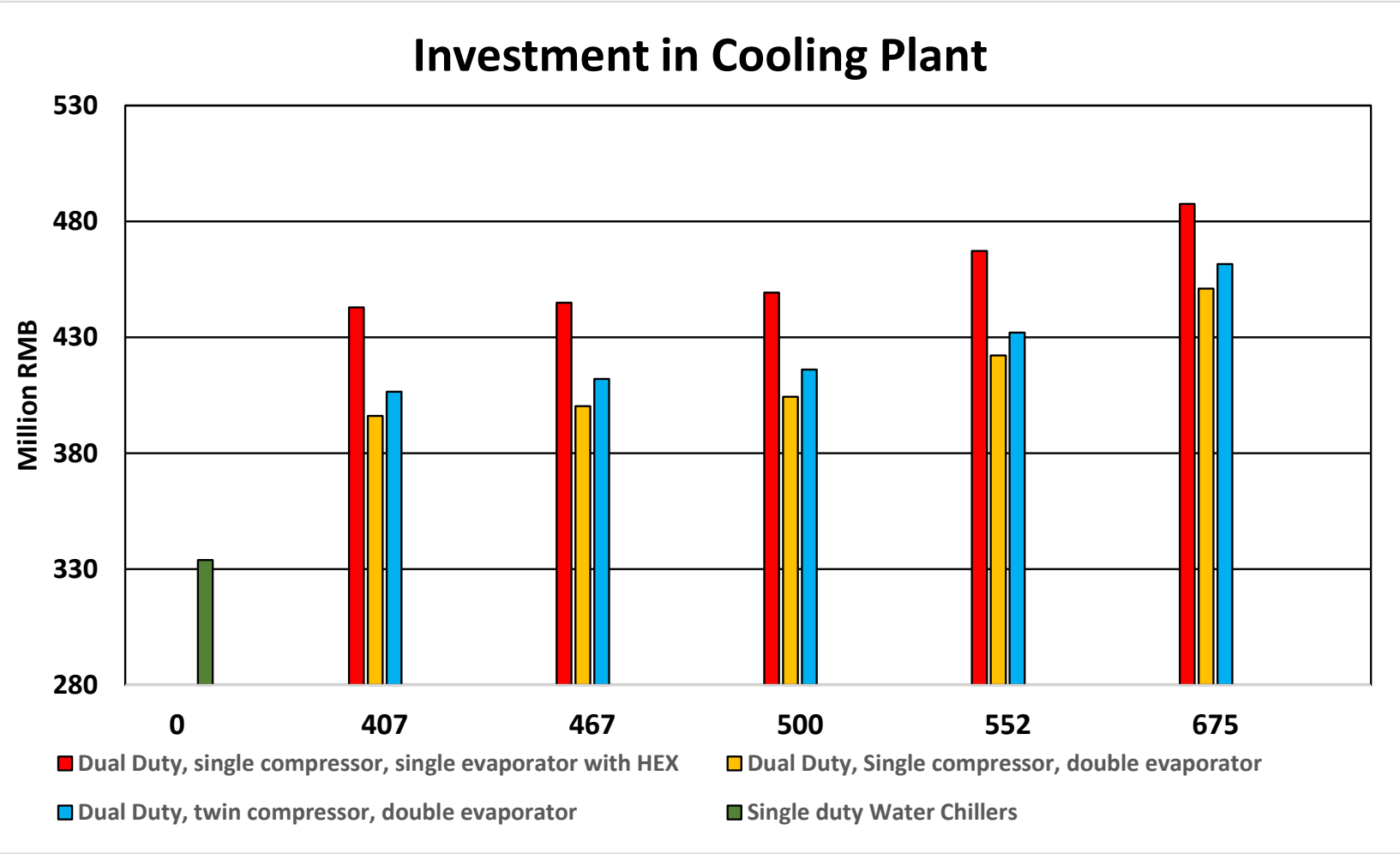
INVESTMENTS

- The difference in investment is up to 12% higher for the single evaporator with HEX ;



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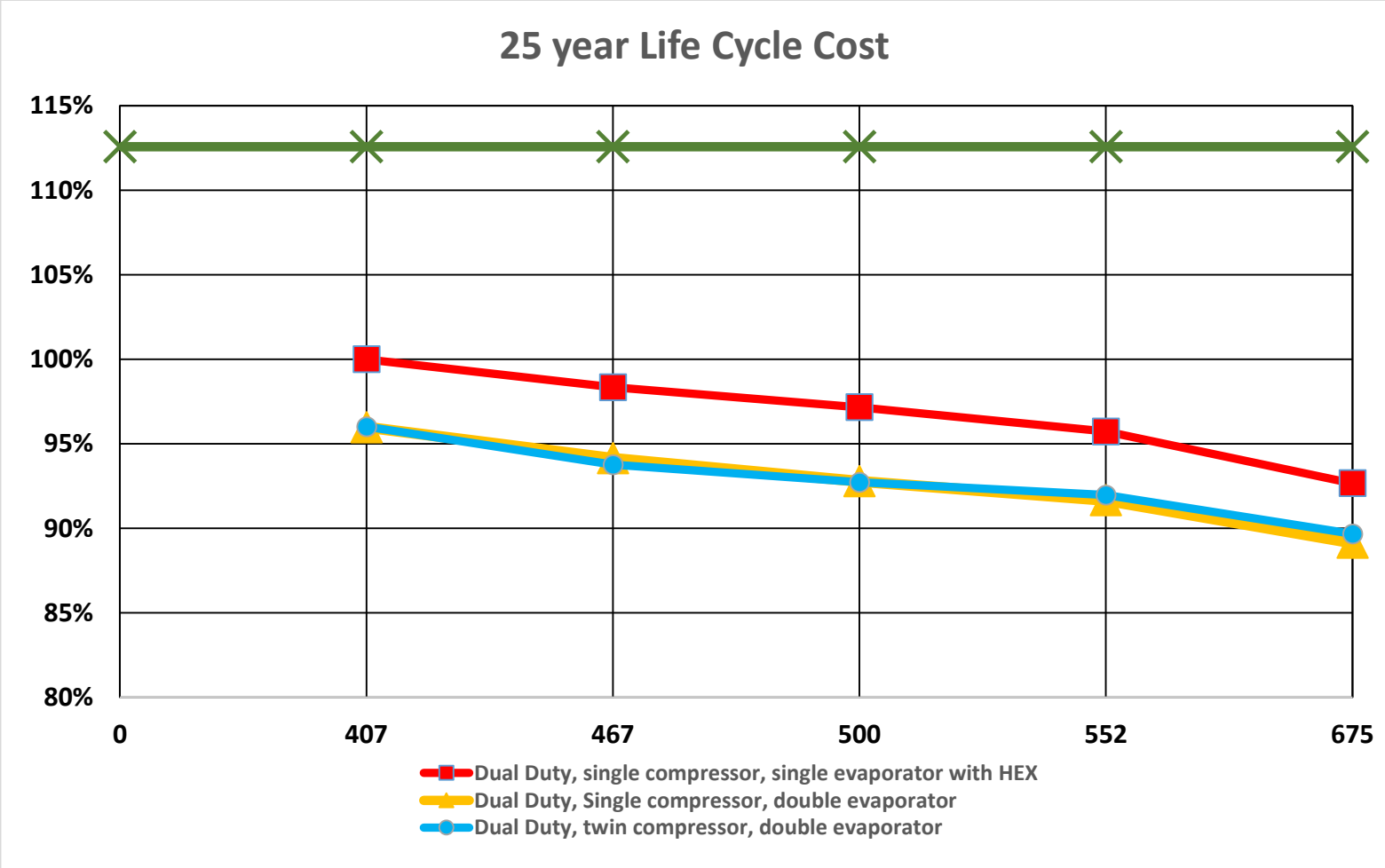
25 Year Life Cycle Cost

- As the size of ice TES increases the 25 year LCC is reduced;



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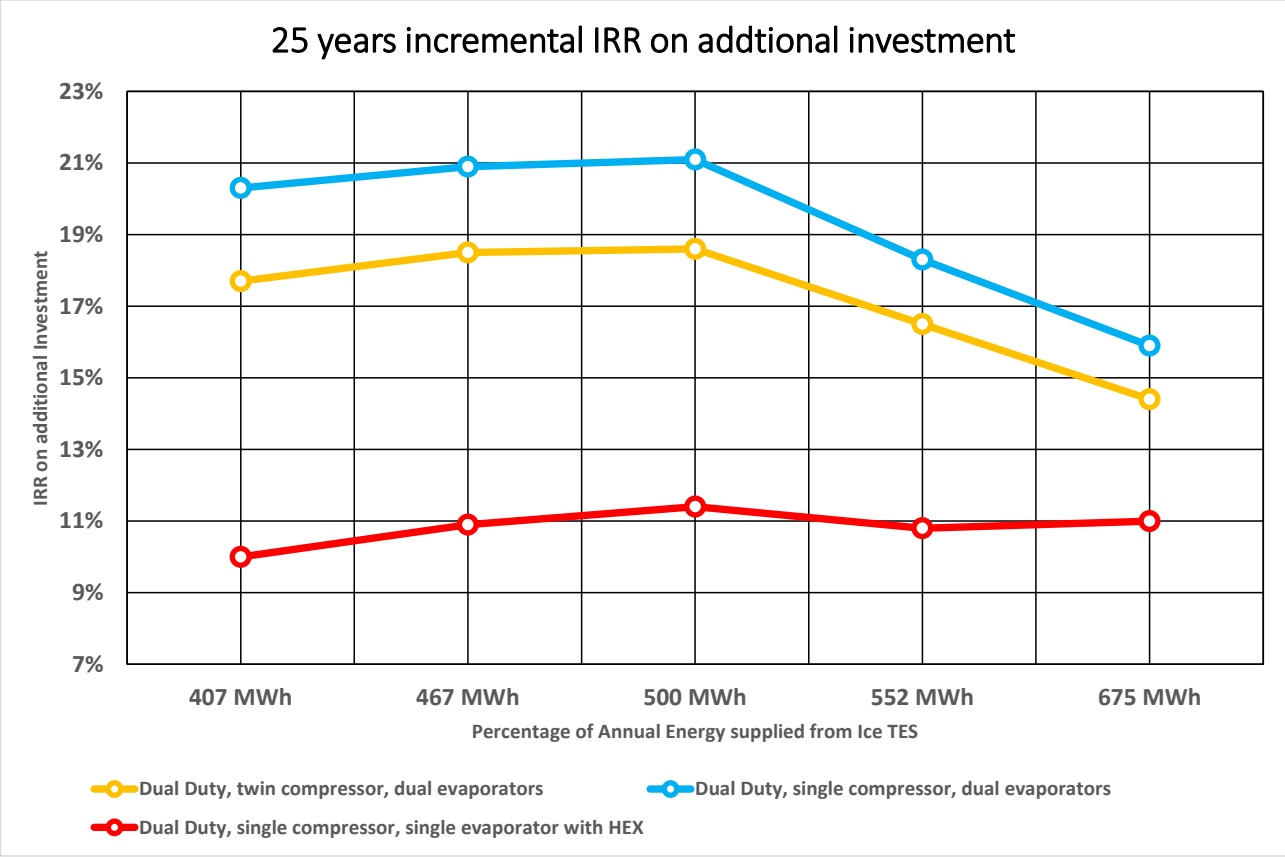
Optimisation of Ice TES

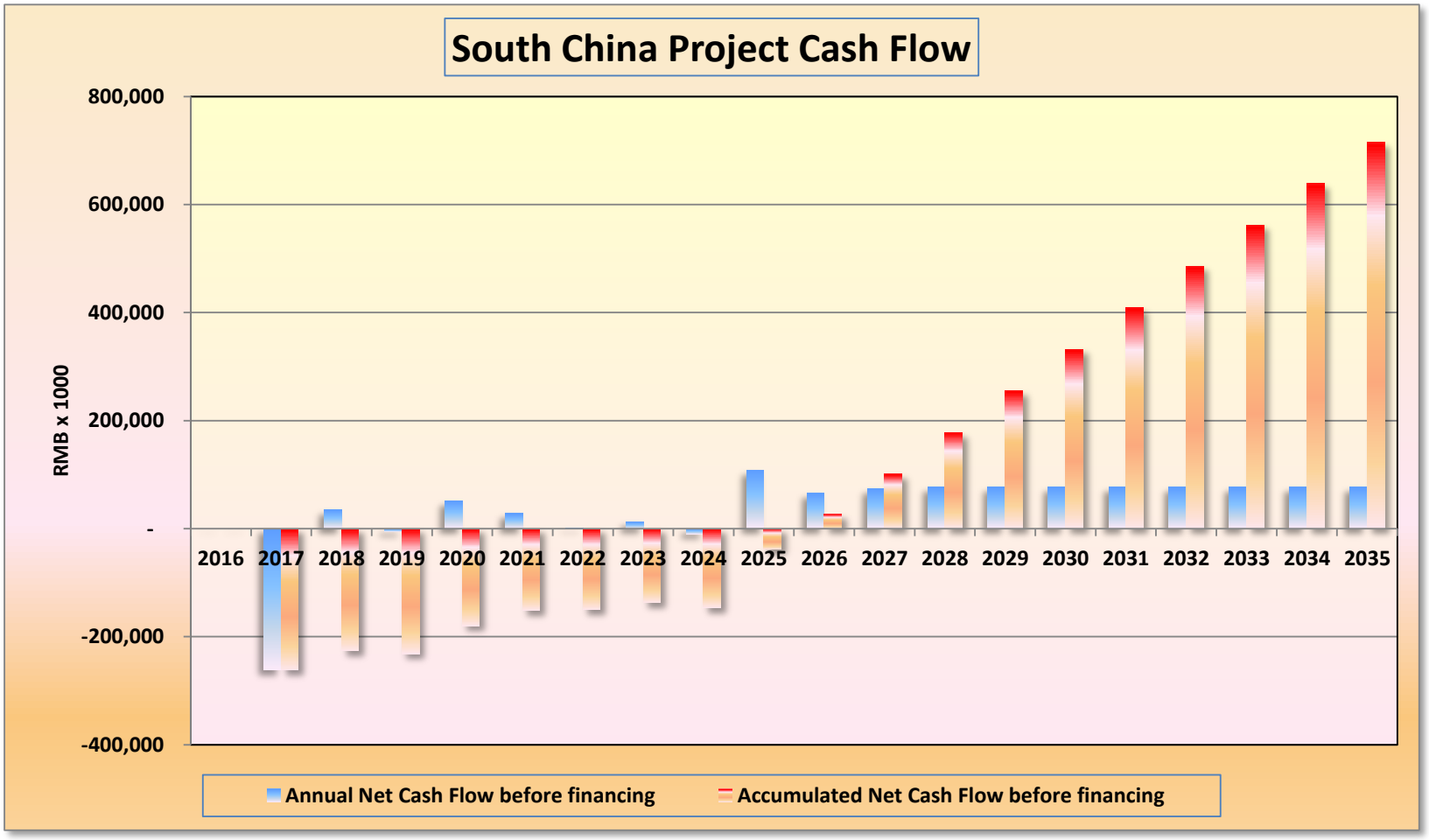
- We concluded that the 25 year LCC goes down with increased ice TES sizes but does it make sense to have such large TES?



- To answer this question we looked at the incremental investment between a chiller only plant and each one of the ice TES cases with the different chiller configurations and compared to the 25 year benefit generated and the resulting IRR;

FINANCIAL ANALYSIS

- Financial analysis for the best case with expected tariff levels and technical performance;



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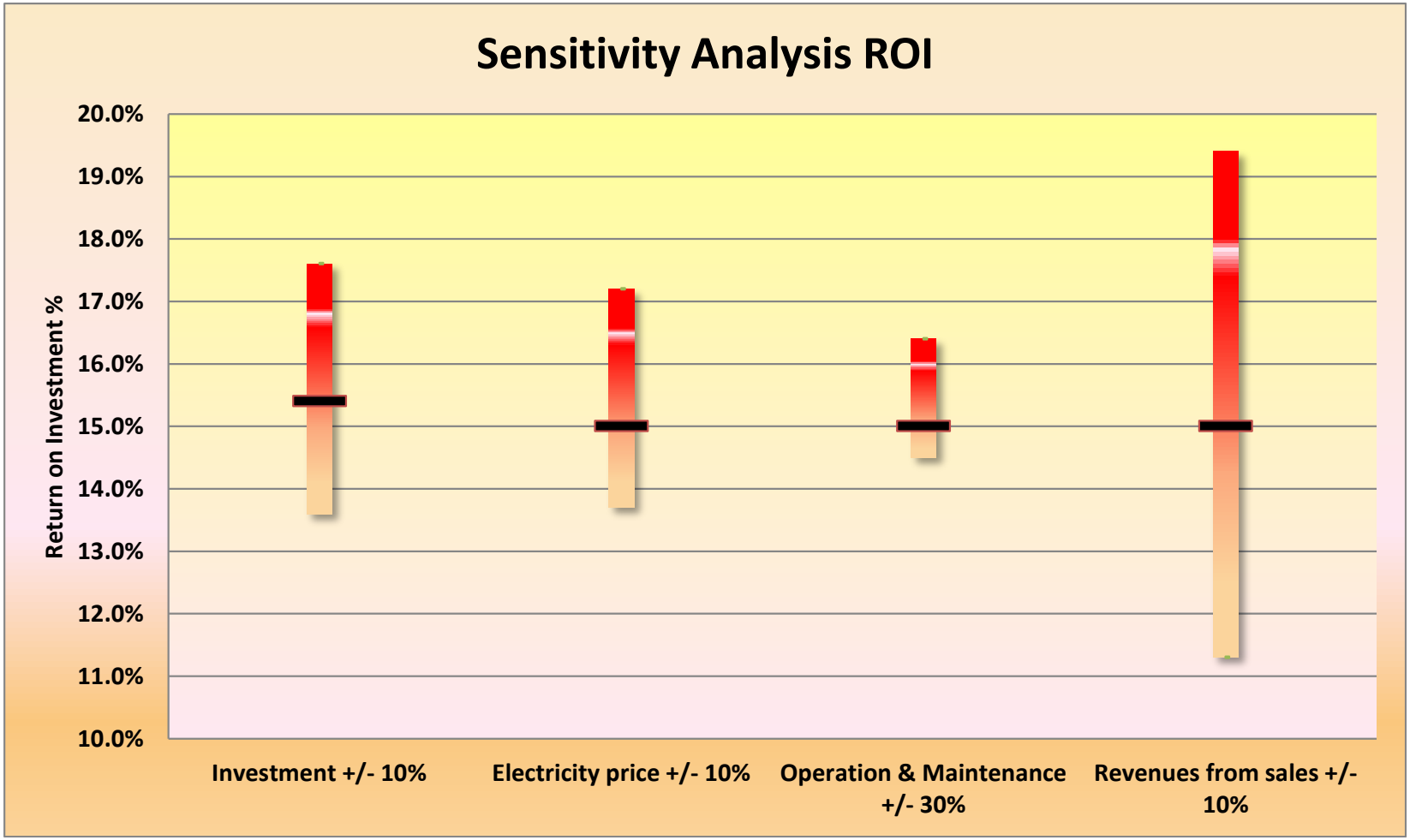
Sensitivity Analysis

- The most sensitive parameter is that predicted revenues for the project is achieved, a combination of price level and amount of energy sold;



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FINAL COMMENTS

- The combined solution with absorption chillers, compression Heat Pump/Chillers and ice TES and no cooling towers in the down town area is a very interesting concept;
- The conclusion from the comparison of alternative plant solutions is that dual duty solutions provide better economics;
- The optimal size of TES is specific for each and every project and are depending on electrical tariff structures and local circumstances;
- The key to all District Cooling developments are to match the ramp-up of connection of buildings to the staging of installation of plant capacity;

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Thank you!

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