Webinar # 1

Myth Busters
Absorption Cooling Technology

Rajesh Dixit

Johnson Controls

October 4th, 2018

Welcome to the IDEA Webinar Series

- The webinar will start promptly at 1:00pm EDT (Boston time) and is scheduled to last sixty (60) minutes; including time for questions.
- Please mute your phone during the webinar. All lines are muted.
- If you are having problems with video or audio, please send a note via the Chat Box function on the right side. Click the Chat box and choose – “Chat privately to Cheryl Jacques (host)”. Or call to IDEA at +1-508-366-9339. .
- Questions to Presenters: Please enter your Questions in the Q&A box at the lower right of the screen. These questions will be moderated and addressed as time allows. We plan to handle Q&A at the conclusion of the presentation.
- Survey: Please complete the brief on-line survey following the webinar.
- Webinar Download or Streaming: Webinar will be recorded and available via download or streaming. Slides will be made available in pdf format. Please visit www.districtenergy.org.

Upcoming IDEA Conferences

Microgrid 2.0
Advancing Industry Growth
OCTOBER 29-31, 2018 | BALTIMORE, MD

DistrictCooling2018
Efficient Energy for Smarter Cities
DECEMBER 9-11, 2018 – ATLANTIS, THE PALM – DUBAI, UAE

CampusEnergy2019
February 26 - March 1, 2019 | New Orleans, LA | Hilton New Orleans Riverside

IDEA2019
The Energy for More Resilient Cities
110TH ANNUAL CONFERENCE & TRADE SHOW | June 24-27
David L. Lawrence Convention Center and The Westin Convention Center | Pittsburgh, PA

Speaker and Moderator

Speaker:

Rajesh Dixit

Director – Global Product Management

Johnson Controls

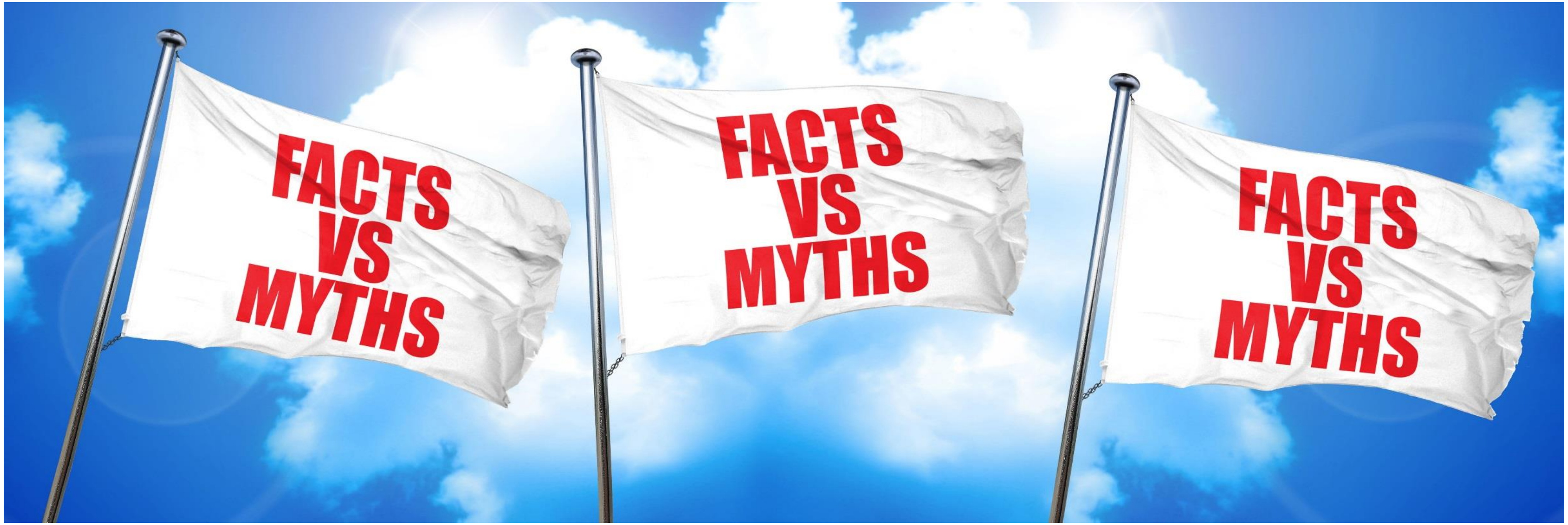
Moderator:

Rob Thornton

IDEA President & CEO

Learning Objectives

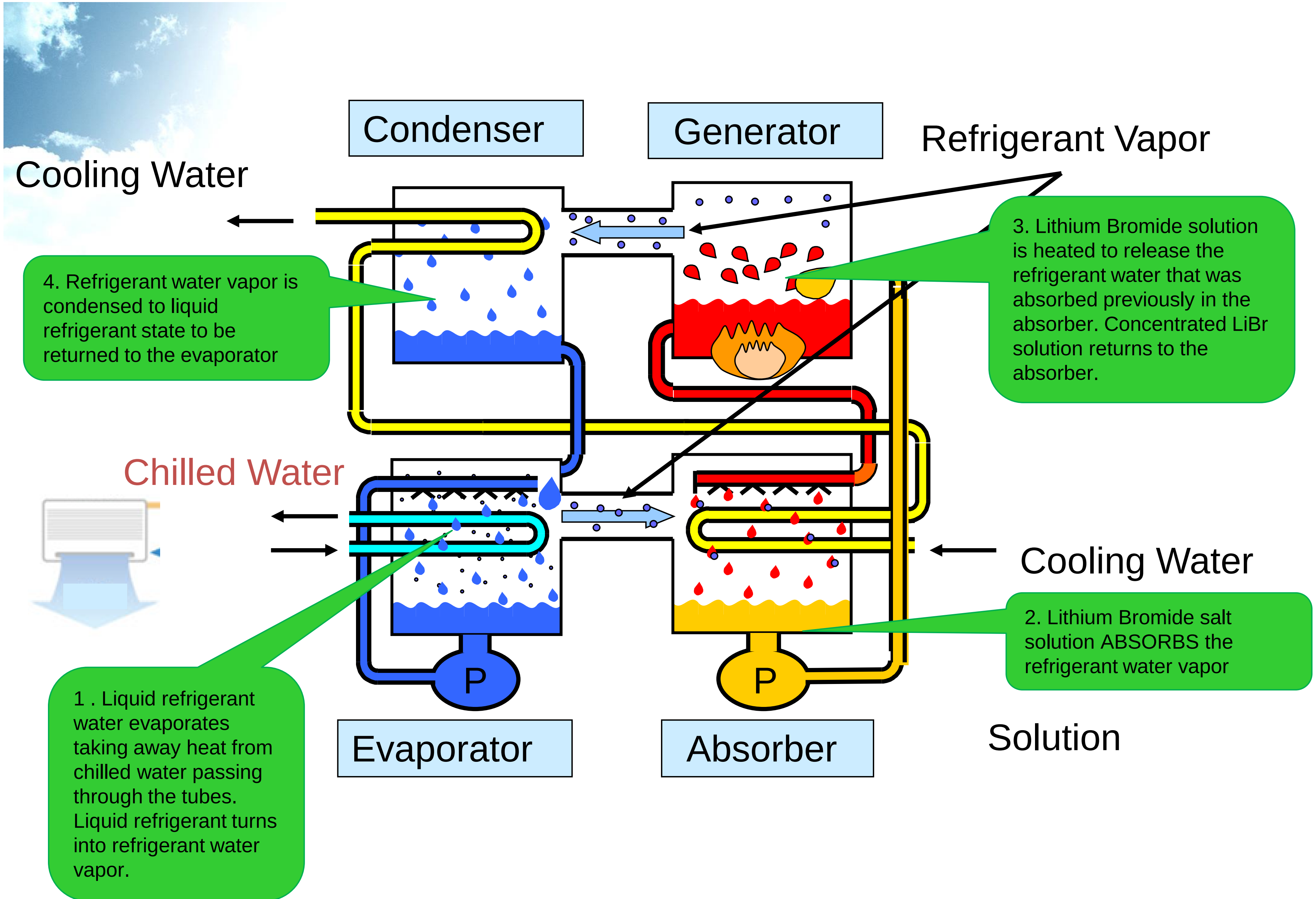
- Busting Myths About Absorption Cooling Technology
    - Understand the Facts About Technology
    - Break the Stereotype About Technology
    - Shatter Old Misconceptions



Outline

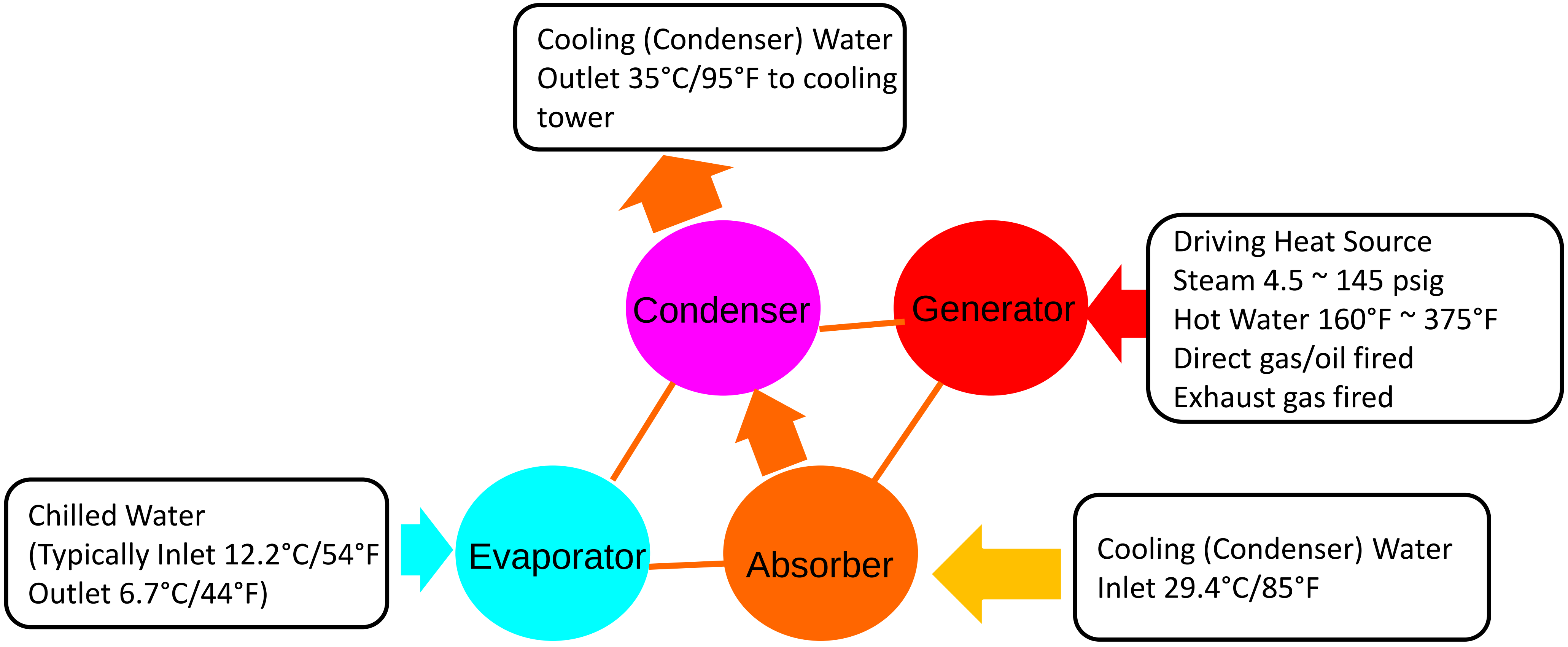
1. Overview of the Technology
2. Myth – Less Efficient
3. Myth – High Cost
4. Myth – Rigid Operational Range
5. Myth – Crystallization A Common Problem
6. Conclusions

How it works



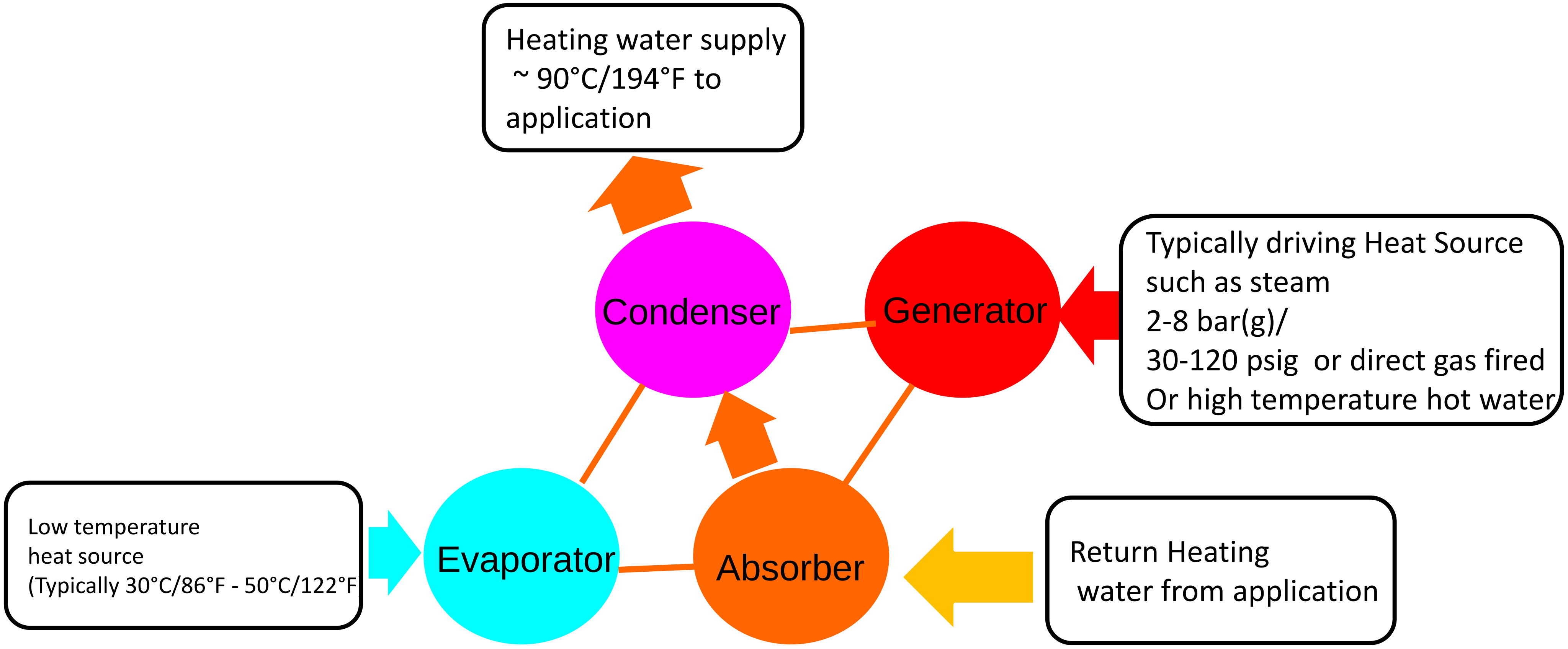
Johnson Controls

Four Basic Components
Chiller Mode



Johnson Controls

Four Basic Components
Heat Pump Mode



Overview of the Absorption Technology

1. Water as the refrigerant (zero ODP/GWP)
2. Driven by waste Heat or low cost natural gas
3. Operates under vacuum, Quiet, Very few moving parts
4. Negligible electric consumption
5. Well established, around for last 75 years
6. Helps reduce electrical and water costs, reduced emissions
7. Not reliant on the congested electric grid
8. Truly green sustainable solution
9. Thousands of commercial, industrial, marine Applications

Myth # 1
Absorption Chillers Are Less Efficient

1. Electric Water-Cooled Centrifugal Chiller COP is ~ 6.5
2. Absorption Chiller COP ONLY 0.7 (single effect) and 1.2 ~ 1.4 (double effect)

Myth # 1
Absorption Chillers Are Less Efficient

Facts

1. Formula for COP and Driving Input Energy Is Different
   1. Grid purchased electricity for an electric chiller
   2. Waste heat or low cost natural gas for an absorption chiller
2. COP of an electric chiller does not account for generation, transmission and distribution losses for the electricity (can be as high as 60% ~ 70%)

Myth # 1 BUSTED
Absorption Chillers Are Less Efficient

1. Typical Chiller COPs Assumed

Electric Centrifugal Chiller	Direct Natural Gas Fired Absorption Chiller	Double Effect Steam Absorption Chiller	Single Effect Steam Absorption Chiller
6.5	1.2	1.4	0.7

2. Natural Gas $ 5/MMBTU, Electricity $ 0.15/kWh, Steam $4 per 1,000 lb (450 Kg)

3. Operational Costs (US Cents/ton-hour)

Electric Centrifugal Chiller	Direct Natural Gas Fired Absorption Chiller	Double Effect Steam Absorption Chiller	Single Effect Steam Absorption Chiller
8.12	5.00	3.43	6.86

Higher COP does not necessarily result in low operational cost

1 MMBTU = 1,000,000 BTU

Myth # 1 BUSTED
Absorption Chillers Are Less Efficient

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Example

1. Average US City, Process Cooling Application, 500 Cooling Tons
2. Electricity $ 0.15/kWh, Natural Gas $ 5/MMBTU, Steam $ 4 per 1,000 lb (450 Kg)

	Electric Centrifugal Chiller	Direct Natural Gas Fired Absorption Chiller	Double Effect Steam Absorption Chiller	Single Effect Steam Absorption Chiller
Chiller COP	6.5	1.2	1.4	0.7
Chiller cost of operation (Input Energy)	$ 253,714	$ 169,451	$ 135,181	$ 235,513
Plant cost of operation (Chiller + Pumps + Tower)	$ 330,330	$ 256,071	$ 222,152	$ 316,044

MMBTU = 1,000,000 Btu

Johnson Controls

Myth # 1 BUSTED
Absorption Chillers Are Less Efficient

- **FACTS**
  - Higher COP (numerical value) of an electric chiller does not necessarily mean it has a lower operating cost compared to an absorption chiller
  - Absorption Chiller can be cost-efficient to operate provided low cost driving heat source is available
  - Efficiency (COP) in combination with input energy cost is the right way to decide the chiller of choice for a facility

Myth # 2
Absorption Chillers Are Very Expensive

1. 500 Cooling Tons

2. Assumed Chiller Prices

Electric Centrifugal	Direct Fired Absorption	Double Effect Steam	Single Effect Steam
$ 150k	$ 300k	$ 275k	$ 250k

1. First Impression - Absorption Does Not Make Sense

Myth # 2
Absorption Chillers Are Very Expensive

Recollect our example from slide # 14

1. Average US City, Process Cooling Application, 500 Cooling Tons
2. Electricity $ 0.15/kWh, Natural Gas $ 5/MMBTU, Steam $ 4 per 1,000 lb

	Electric Centrifugal Chiller	Direct Natural Gas Fired Absorption Chiller	Double Effect Steam Absorption Chiller	Single Effect Steam Absorption Chiller
Chiller COP	6.5	1.2	1.4	0.7
Chiller cost of operation (Input Energy)	$ 253,714	$ 169,451	$ 135,181	$ 235,513
Plant cost of operation (Chiller + Pumps + Tower)	$ 330,330	$ 256,071	$ 222,152	$ 316,044

Myth # 2 BUSTED
Absorption Chillers Are Very Expensive

1. Even though initial capital cost of an electric chiller is much lower than an absorption chiller, the fact is annual cost of operation of an electric chiller is not necessarily lower than an absorption chiller

2. Simple Payback Compared to Electric Chiller (not considering utility rebates) for this particular example

Direct Fired	Double Effect Steam	Single Effect Steam
2 years	1 year	7 years

3. In many/certain situations, absorption chiller does make economic sense

Myth # 3
Absorption Chillers Not Flexible In Operation

1. Chilled Water Leaving Temperature Below 5°C (41°F) Not Possible
2. Chilled Water and Condenser Water Flow Rates Should Not Be Varied
3. Chiller Must Be Operated At Full and Steady Loads, Avoid Part Loads
4. Operate Closer to the Design Condenser Water Inlet Temperature
5. Don’t Reduce The Chilled Water or Condenser Water Flow Rates

Myth # 3 BUSTED
Absorption Chillers Not Flexible In Operation

FACTS

1. Chilled water leaving temperature can be as low as 4°C (39°F) or even minus 5°C (23°F)

2. Chilled/Condenser water flow rates can be changed
    1. Typically 5% per minute up to 50% per 10 minutes
    2. Evaporator 1.3 ~ 2.9 gpm/ton (0.29 ~ 0.65 m3/hr/ton)
    3. Absorber-Condenser
        1. Single Effect 3.0 ~ 8.0 gpm/ton (0.68 ~ 1.81 m3/hr/ton)
        2. Double Effect 2.2 ~ 6.0 gpm/ton (0.49 ~ 1.36 m3/hr/ton)

3. Turndown 100% to 10% of the design cooling load

4. Design entering cooling water range 20°C (68°F) ~ 37°C (98.6°F)

Myth # 3 BUSTED
Absorption Chillers Not Flexible In Operation

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Myth – Not a good idea to design an absorption chiller with low condenser flow

Fact – Reduced condenser water flow 3 gpm/ton or 2 gpm/ton, compared to typical 4 gpm/ton, is possible

Condenser Flow	4 gpm/ton (0.9 m3/hr/ton)	3 gpm/ton (0.68 m3/hr/ton)	2 gpm/ton (0.45 m3/hr/ton)
Capacity (tons)	1000	1000	1000
Chilled Water Inlet/Outlet	12.2/6.7 °C 54/44°F	12.2/6.7 °C 54/44°F	12.2/6.7 °C 54/44°F
Condenser Water Inlet	29.4°C 85°F	29.4°C 85°F	29.4°C 85°F
Condenser Water Outlet	35.1°C 95.1°F	37.1°C 98.8°F	41.1°C 106°F
Pressure drop	58 kPa 19.4 ft wc	42 kPa 14 ft wc	20 kPa 6.7 ft wc
COP*	1.42	1.40	1.36

*Steam 8 bar(g) 115 psig

Note that the capacity and COP are maintained at varying condenser water flow rates

Johnson Controls

Myth # 4
Crystallization – A Common Problem

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

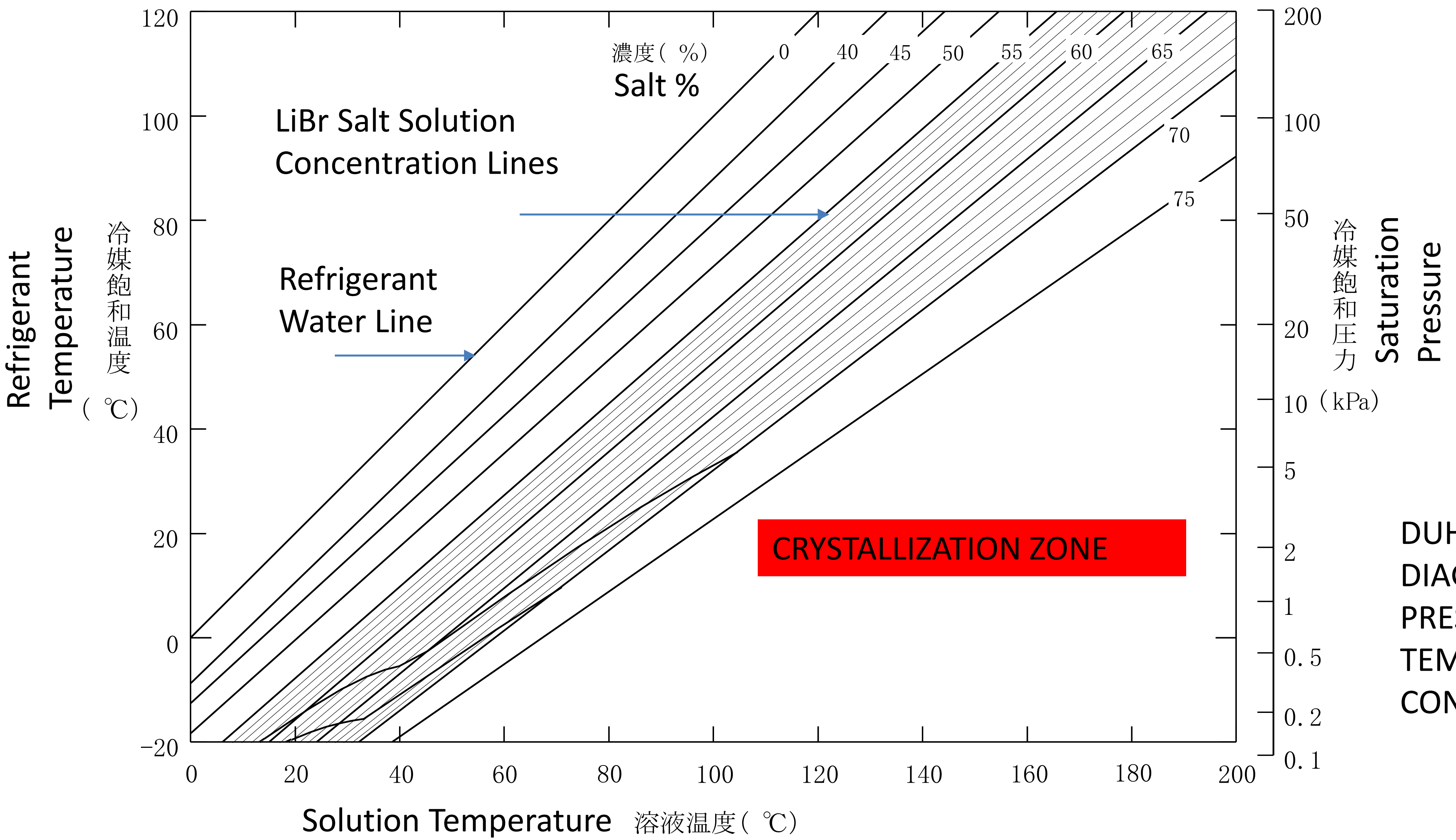
1. **REVIEW THE BASICS**
   1. Lithium Bromide (LiBr) as a salt solution absorbs refrigerant water vapor
   2. Solution concentration represents amount of LiBr salt in the solution
      1. 0% solution means 0% by weight salt, 100% by weight water (this is pure refrigerant water)
      2. 54% solution means 54% by weight salt, 46% by weight water

Salt % in Solution	54%	57%	58%	60%	61.5%	63.5%
Crystallization Temperature	-16.1°C (3.02°F)	-3°C (26.6°F)	0.9°C (33.6°F)	10.5°C (50.9°F)	18°C (64.4°F)	26°C (78.8°F)

2. Solution with a higher salt % has a higher probability to crystallize
   1. 63.5% solution will crystallize more easily than 61.5% solution
   2. 61.5% solution will crystallize more easily than 58% solution

Johnson Controls

Myth # 4
Crystallization – A Common Problem



DUHRING DIAGRAM – PRESSURE TEMPERATURE CONCENTRATION

Myth # 4
Crystallization – A Common Problem

1. Most Common Causes of Crystallization
   - Low condenser water temperature at high cooling loads
   - Air leakage (improper vacuum)
   - Loss of electric power

2. Protect from Crystallization
   - Sophisticated Controls limiting the driving heat input
   - Automatic Purging (vacuum pump operation)
   - Small UPS (uninterrupted power supply) for dilution

3. PREVENT Crystallization (BEST WAY)
   - Design the unit with LOW salt solution concentrations, which are easier to boil
   - Low salt solution concentrations are difficult to crystallize, thus they operate farthest from the crystallization zone

Myth # 4 BUSTED
Crystallization – A Common Problem

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Single Effect

58% @ 42°C/107.6°F
Crystallization Temperature 0.9°C/33.62°F

Absorber2

Absorber1

54%
Crystallization Temperature -16.1°C/3.02°F

60%
Crystallization Temperature 10.5°C/50.9°F

Absorber

57%
Crystallization Temperature -3°C/26.6°F

VERY DIFFICULT TO GET CRYSTALLIZED

MAY EASILY GET CRYSTALLIZED

ALWAYS DESIGN A CHILLER WITH LOWEST SALT SOLUTION CONCENTRATIONS

Johnson Controls

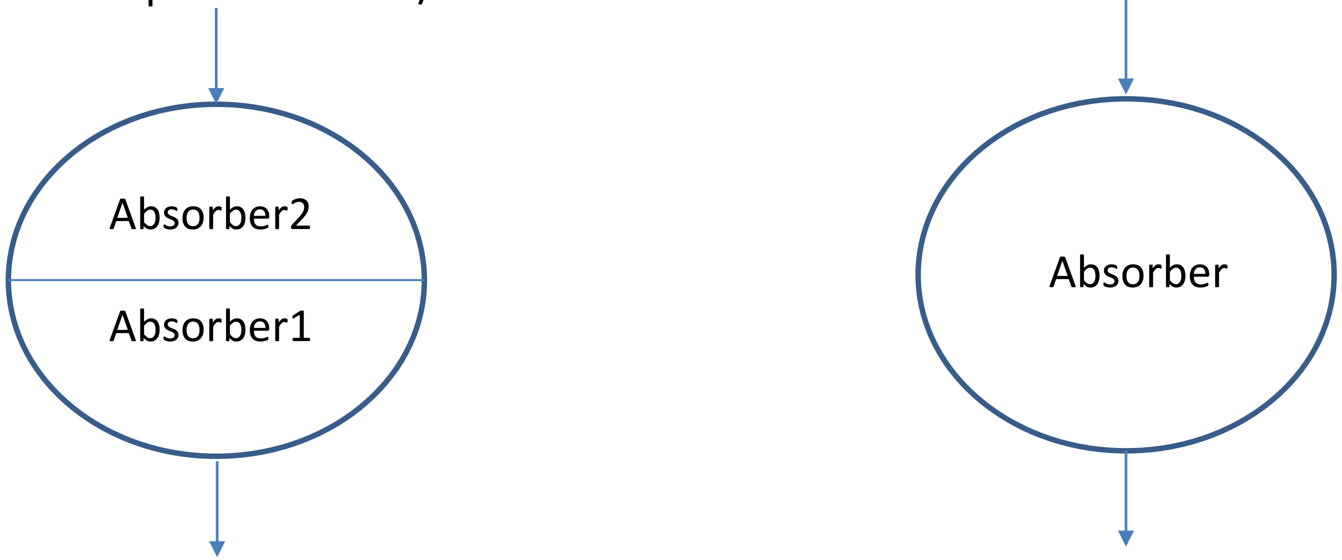
Myth # 4 BUSTED
Crystallization – A Common Problem

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Double Effect

61.5% @ 47°C/116.6°F
Crystallization Temperature 18°C/64.4°F

63.5% @ 49°C/120.2°F
Crystallization Temperature 26°C/78.8°F



54.5%
Crystallization Temperature -16.1°C/3.02°F

57%
Crystallization Temperature -3°C/26.6°F

VERY DIFFICULT TO GET CRYSTALLIZED

MAY EASILY GET CRYSTALLIZED

ALWAYS DESIGN A CHILLER WITH LOWEST SALT SOLUTION CONCENTRATIONS

Johnson Controls

Conclusions

1. Decision to use the right chiller technology must be based on first cost, operating cost, maintenance cost and life cycle cost
2. Absorption Chillers have been deployed on large scale basis world-wide since 1950s
3. Variety of applications as chiller, chiller-heater, heat pump
4. Absorption Chiller deserve serious consideration for first choice, if waste heat or low cost heat is available
5. Absorption Chillers help save energy, water and cuts down emissions – truly green and sustainable

Questions?

Thank you for attending

be-chillersolutionsmarketing@jci.com

http://york.com/absorption-chillers

Registration – Future Webinars

https://www.districtenergy.org/events/webinars

November 1st

Incorporating Absorption Technology In District Cooling And Heating

November 15th

Absorption 101