# Kawasaki turbo chiller using water as a refrigerant

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Kawasaki
Powering your potential

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1. Introduction of Kawasaki turbo chiller using water as a refrigerant
2. Estimated $CO_2$ emission in Australia and New Zealand

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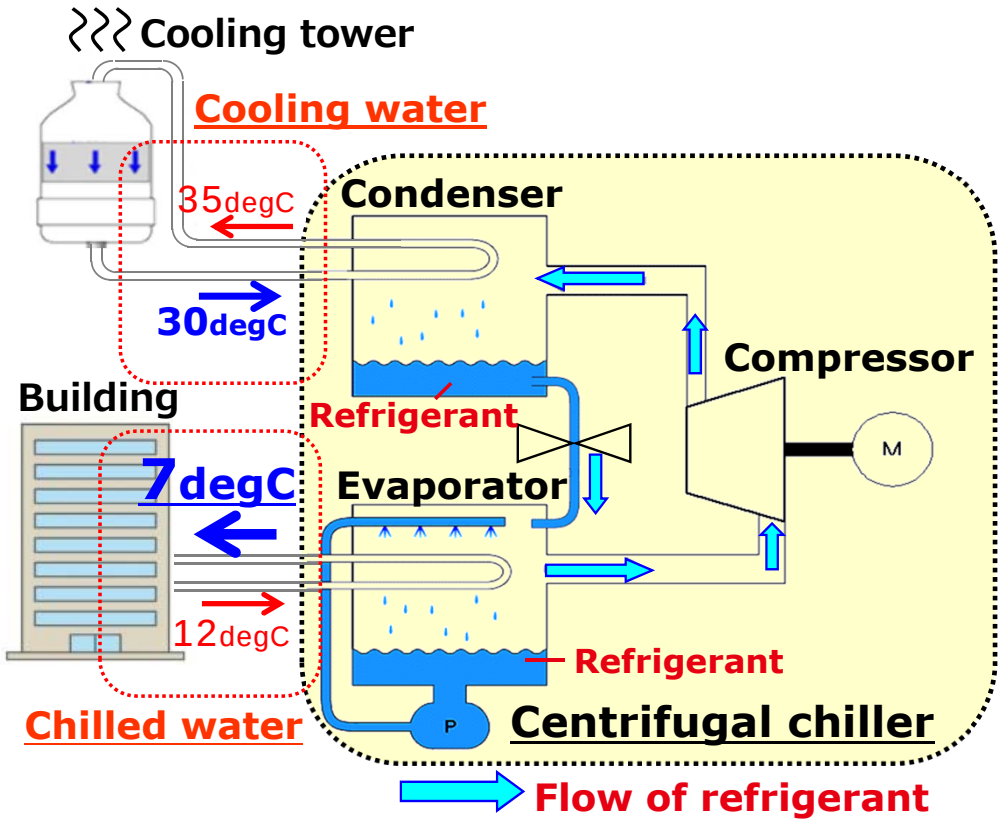
1. **Introduction of Kawasaki turbo chiller using water as a refrigerant**
2. **Estimated $CO_2$ emission in Australia and New Zealand**

# Principle of Centrifugal chiller




## Evaporator

① Refrigerant is heated by returned chilled water and evaporates.

② Returned chilled water is chilled by evaporative latent heat of the refrigerant.

Refrigerant : Liquid -> Vapor

## Condenser

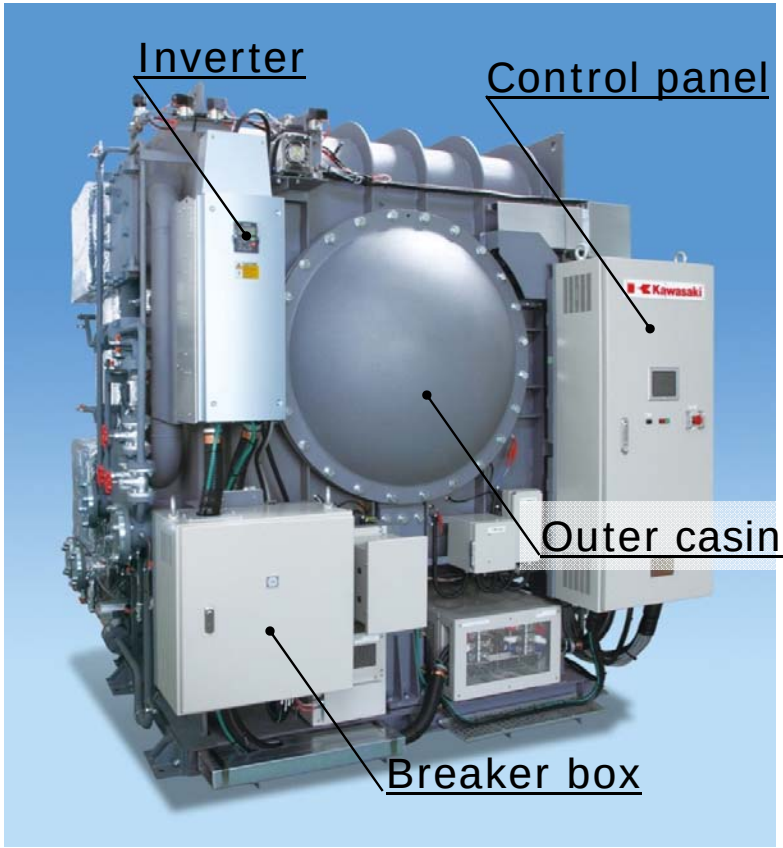
① Compressed vapor of the refrigerant is cooled by cooling water and condenses.

② Cooling water is heated by latent heat of the refrigerant.

Refrigerant : Vapor -> Liquid

| | Common chiller | Kawasaki turbo chiller |
|---|---|---|
| Refrigerant | HFC | Water |

# Kawasaki turbo chiller




| | | |
|---|---|---|
| **Cooling capacity** | | **100USRt (352kW)** |
| **Power consumption** | | **69kW** |
| **Refrigerant** | | **R718(water)** |
| **Chilled Water temp.** | **Inlet** | **12degC** |
| | **Outlet*** | **7degC** |
| **Cooling Water temp.** | **Inlet** | **30degC** |
| | **Outlet** | **35degC** |
| **Motor drive** | | **Inverter** |
| **Power supply** | | **3Φ, 400/440V (50/60Hz)** |
| **Size** | | **2.5m x 2.5m x 2.6m** |
| **Weight** | | **8.0 ton** |
| **Intended application*** | | **Air conditioning** |

* Kawasaki turbo chiller can supply the chilled water at higher temperature up to 20degC, and be applied to other applications such as process cooling.

**Compressor, Motor, Evaporator and Condenser are in the outer casing.**

# Features

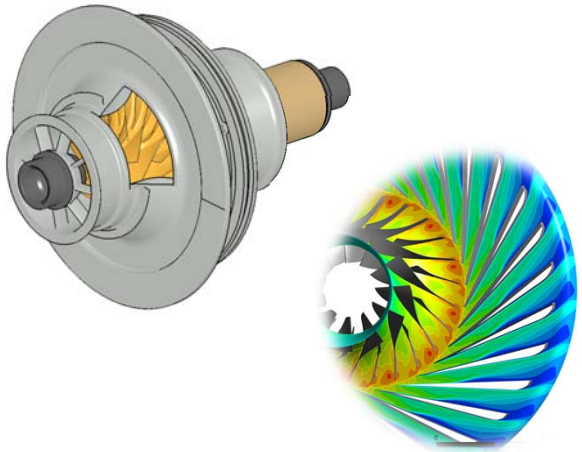
## Water refrigerant

➡ **Zero emission of HFC**

## High efficient performance

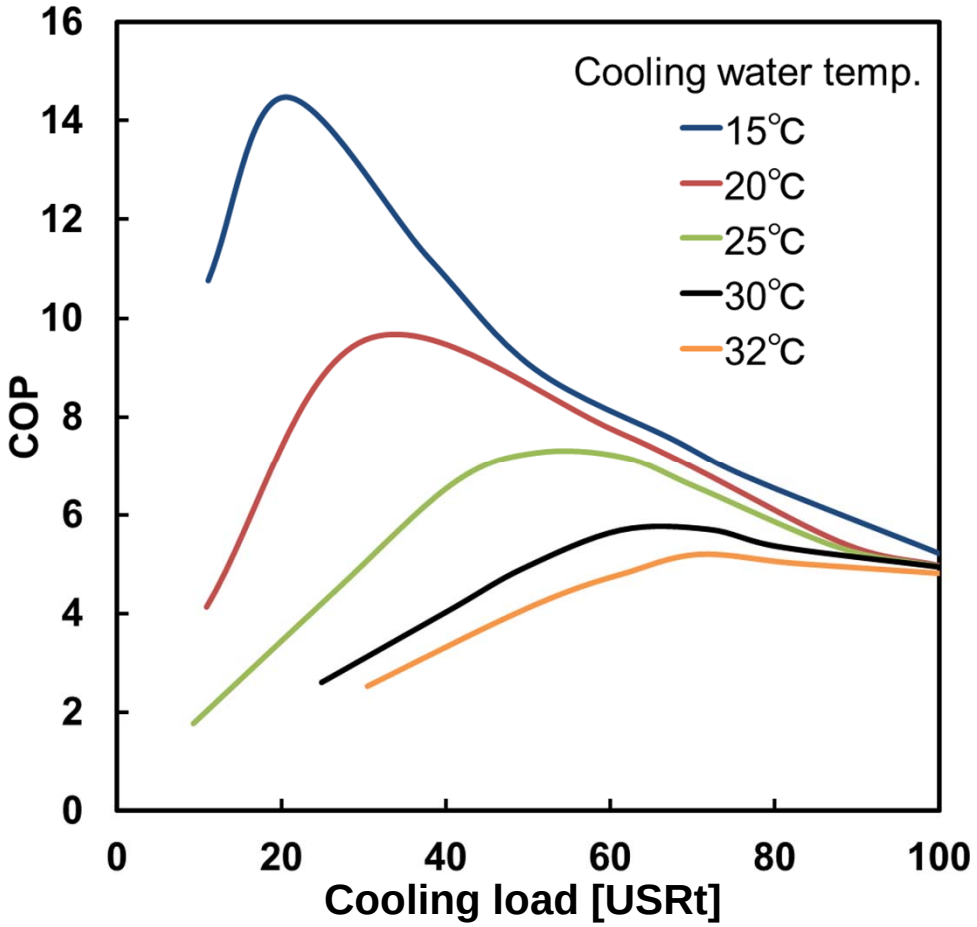
- Development of the high efficient compressor under low pressure and high pressure ratio

➡ **Low power consumption**



Centrifugal compressor

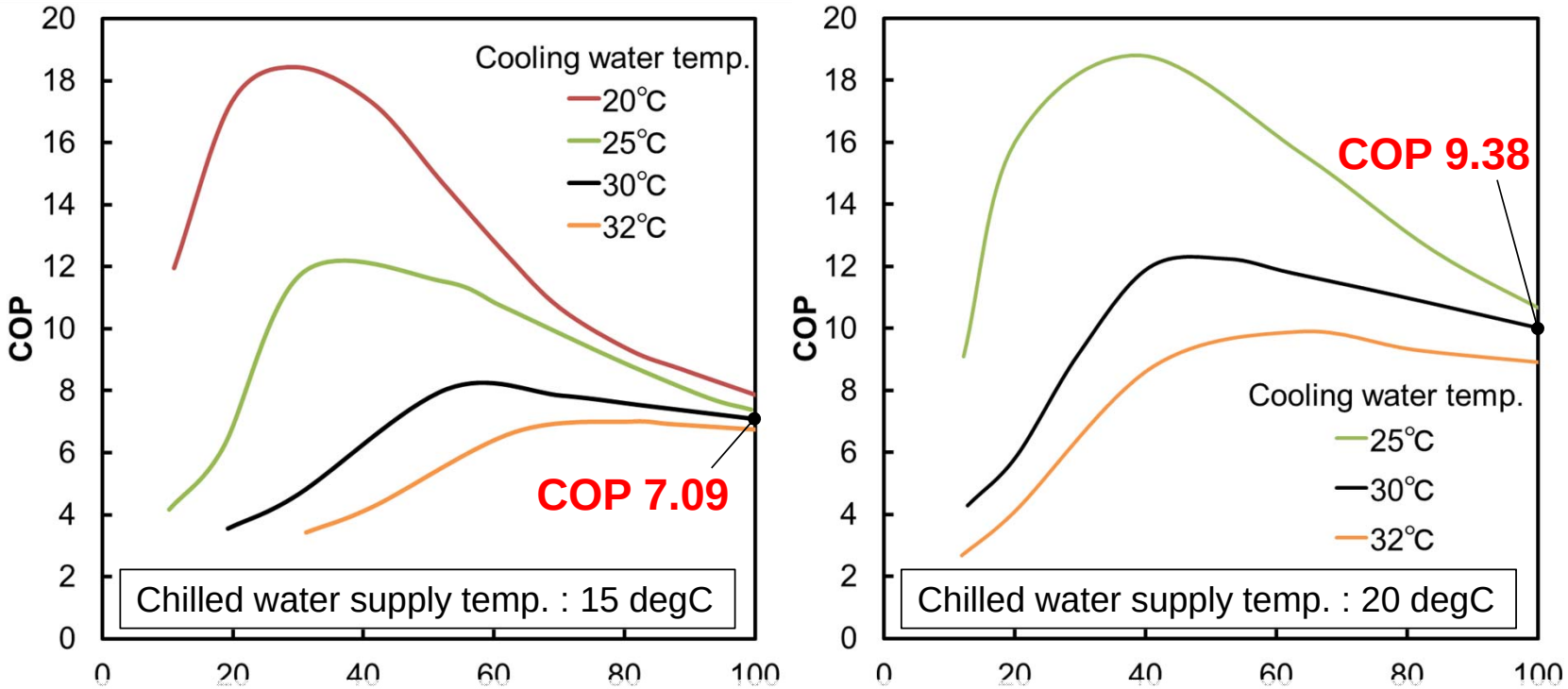
# Performance - 7degC supply -




- **COP(capacity[kW]/input power[kW])**
  - **5.10 at 100%**
  - **Higher at a partial load**
- **Operatinal range**
  - **10%~100% at less than 25degC of cooling water temperature**
- **IPLV(Integrated Part Load Value)**
  - **8.50 (AHRI 551/591)**

**Comparable performance to the other centrifugal chillers**

# Performance - 15degC & 20degC supply -




- **Kawasaki turbo chiller shows higher COP for 15-20 degC supply.**
  **Possible application : Air conditioning for data center**
  **Air conditioning system combined with desiccant**
  **Process cooling**
  **etc.**

# Features

## Water refrigerant

➡ **Zero emission of HFC**

## High efficient performance

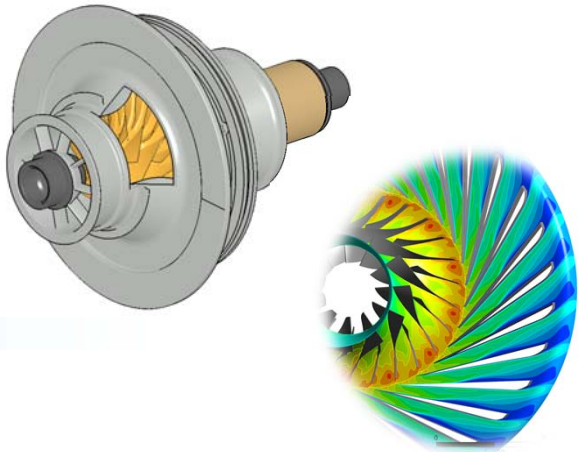
- Development of the high efficient compressor under low pressure and high pressure ratio

➡ **Low power consumption**

## Compact

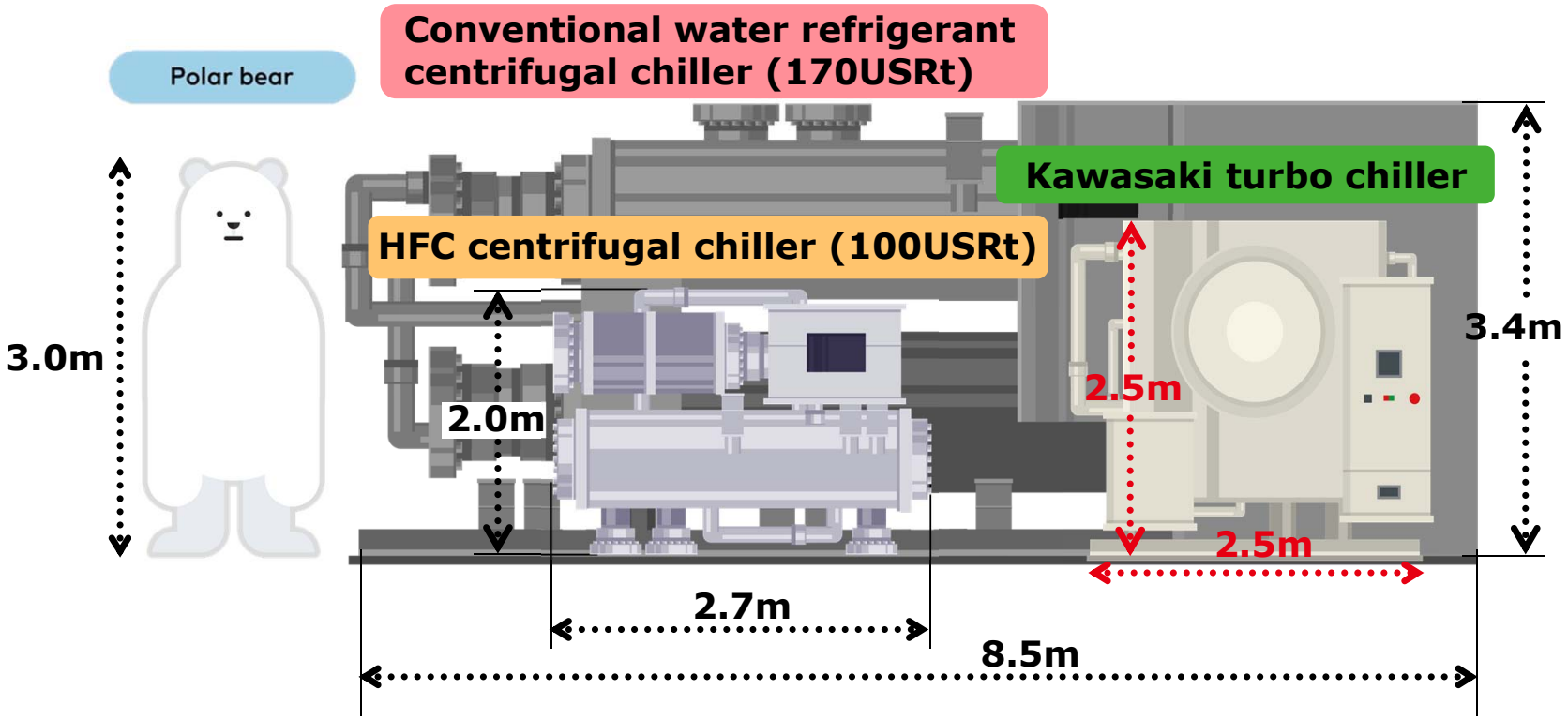
- Development of the core components
- Optimization of their layout

➡ **Alternative to existing chillers**



Centrifugal compressor

# Compact




- Conventional water refrigerant centrifugal chiller is extremely large because of high specific volume.
- Kawasaki turbo chiller is as compact as the existing chillers by optimum arrangement of components.

# Features

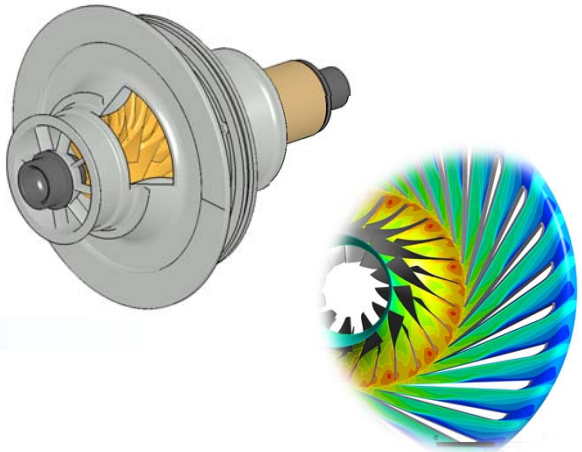
## Water refrigerant

➡ **Zero emission of HFC**

## High efficient performance

- Development of the high efficient compressor under low pressure and high pressure ratio

➡ **Low power consumption**



Centrifugal compressor

## Compact

- Development of the core components
- Optimization of their layout

➡ **Alternative to existing chillers**

## Oil-free

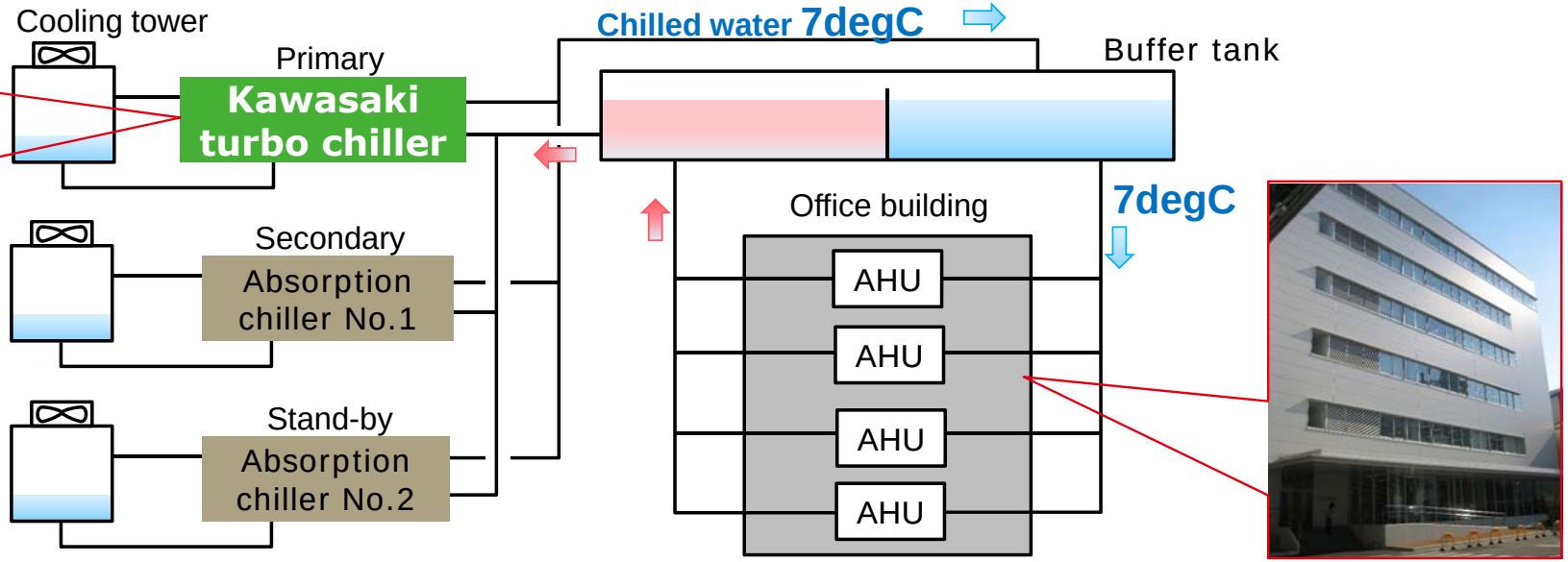
- The compressor is driven by the high speed motor

➡ **Auxiliary system for oil is not necessary**

# Actual operation in Japan

Kawasaki turbo chiller has been used for an air conditioning in Kawasaki's Kobe works in Japan since 2013

- Floor Area : 5,000m$^2$
- Primary chiller : Kawasaki turbo chiller 100USRt 1unit
  Secondary chiller : Absorption chiller 120USRt 1unit



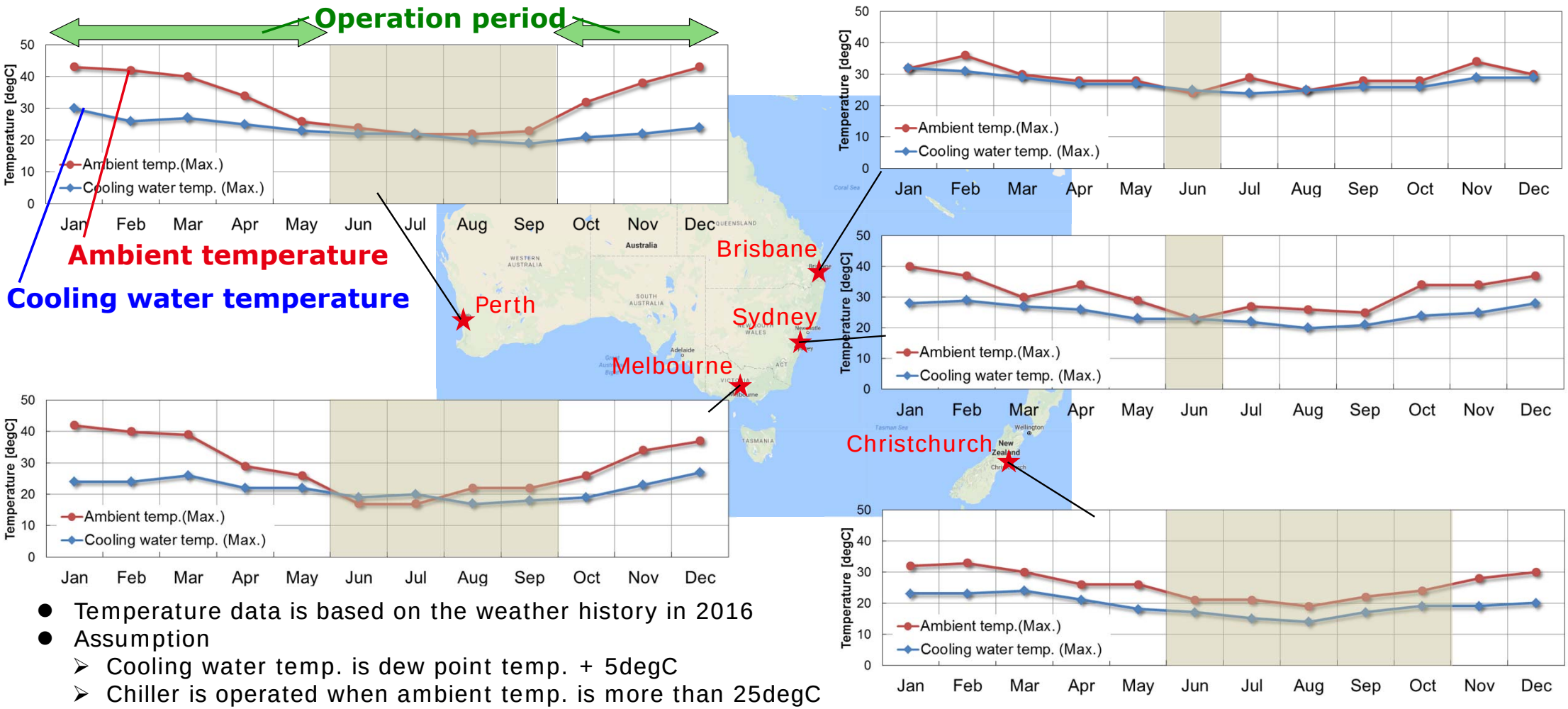

**Total operation time is 4,260 hours.**

# Contents

1. Introduction of Kawasaki turbo chiller using water as a refrigerant

2. **Estimated $CO_2$ emission in Australia and New Zealand**

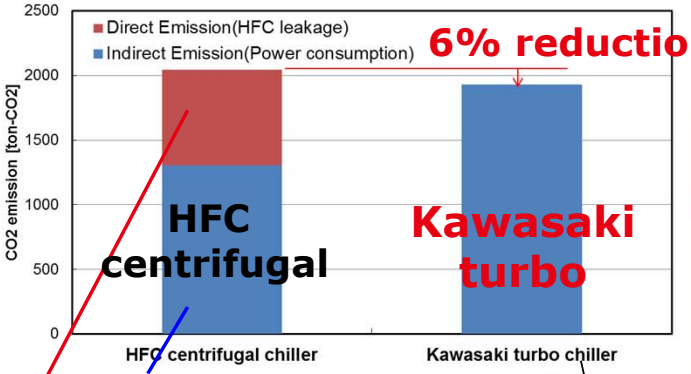
# Calculation conditions - Temperature -

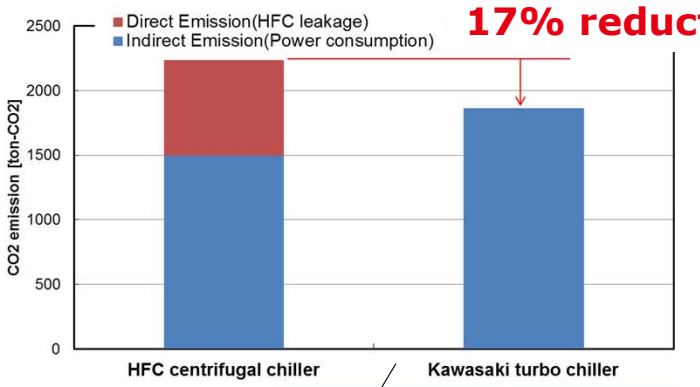


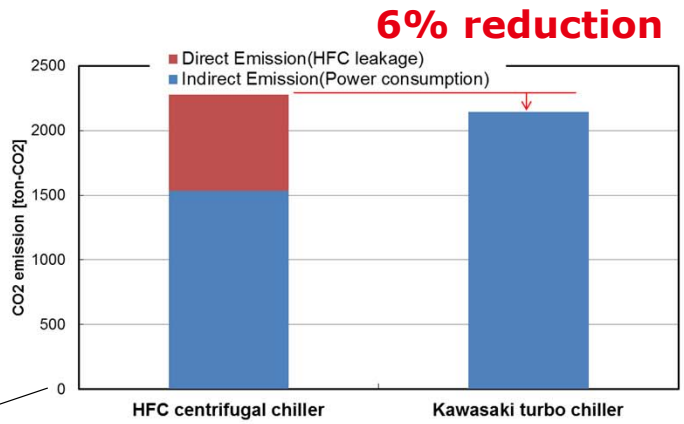

- Temperature data is based on the weather history in 2016
- Assumption
  - Cooling water temp. is dew point temp. + 5degC
  - Chiller is operated when ambient temp. is more than 25degC

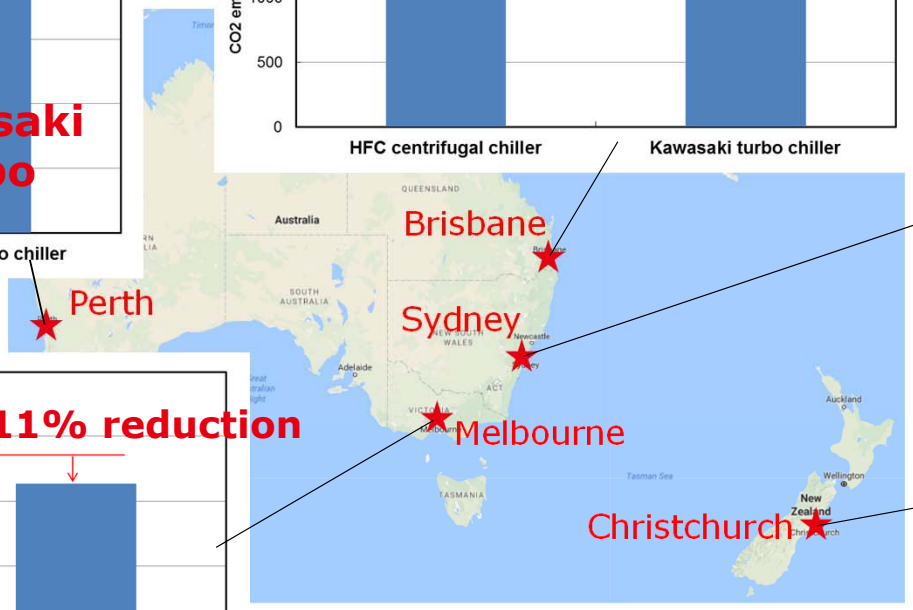
# Result - Comparison of $CO_2$ emission -

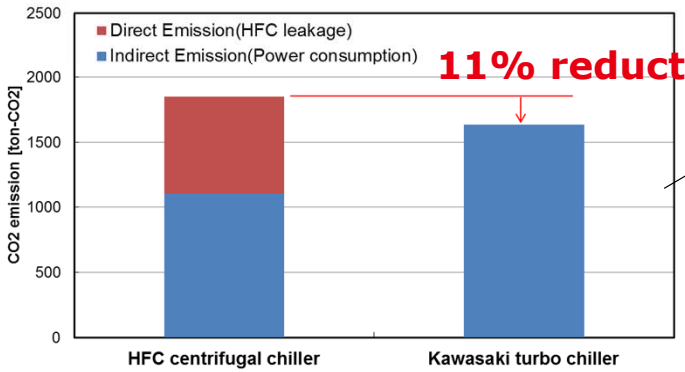
- Average HFC leakage rate : 15%/year (“ Refrigerant emissions in Australia – Sources, causes and remedies, 2010 ”)
- Operation days : 20 days / month
- Lifetime : 15 years
- $CO_2$ emission factor : 0.852 kg-$CO_2$/kWh

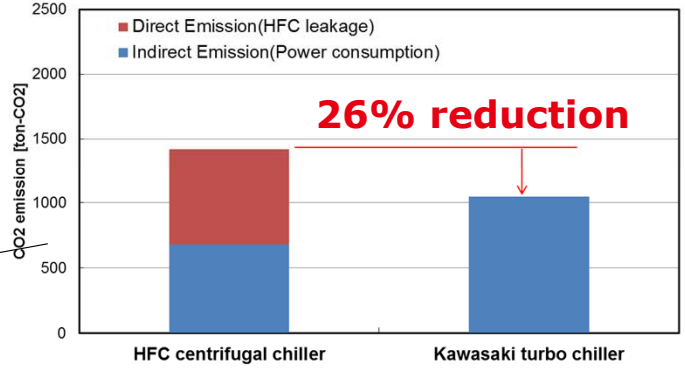



**$CO_2$ emission would be reduced by Kawasaki turbo chiller.**

# Summary

- Introduction of Kawasaki turbo chiller
  - Features : water(R718) refrigerant, High efficient, compact and oil-free
  - 4,260 hours operation in Japan

- $CO_2$ emission in Australia and New Zealand

  $CO_2$ emission would be reduced in Australia and New Zealand by Kawasaki turbo chiller

- Availability in Australia and New Zealand

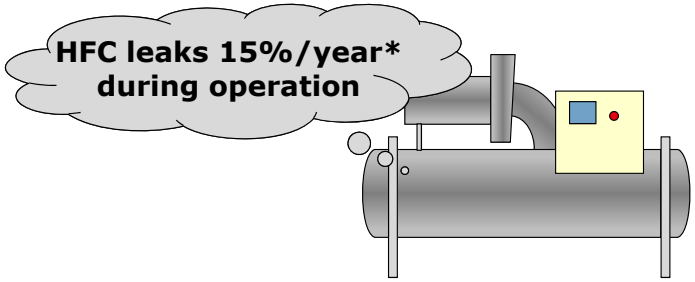
  The followings are the items to be solved.
  - Compliant with the standards, regulations etc. in Australia and New Zealand
  - Cooperation with customers and governments to create a path of introduction

AUSTRALIA

ATMO sphere

# Thank you very much!

# HFC emission reduction




HFC centrifugal chiller

$CO_2$ equivalent emission : ? ton

Kawasaki turbo chiller

$CO_2$ equivalent emission : 0 ton

| For 100 USRt | HFC centrifugal chiller | Kawasaki turbo chiller |
|---|---|---|
| Refrigerant | HFC134a | R718(Water) |
| Filled refrigerant | 230 kg | 120 kg |
| Global warming potential(GWP) | 1430 | --- |
| Refrigerant leakage (15 years) | **740 $CO_2$-ton** | **0** |

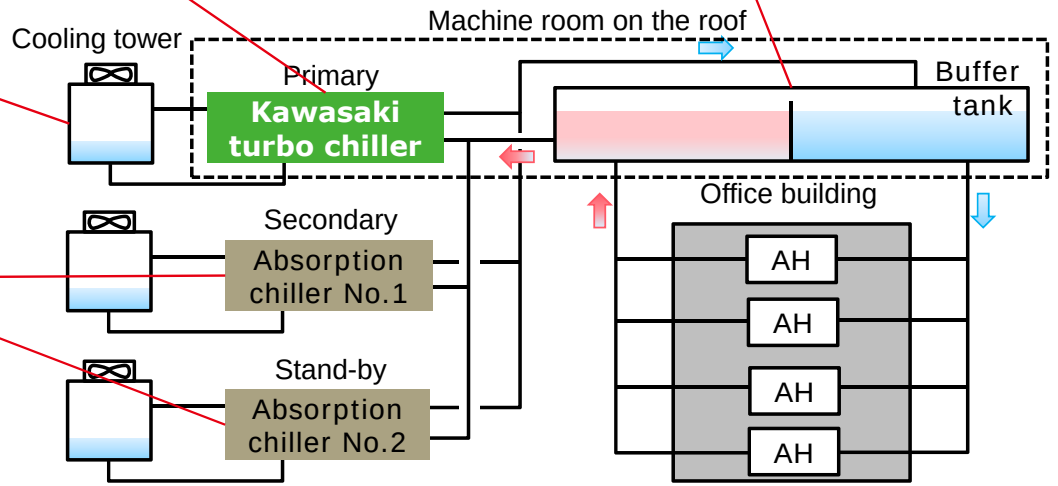
* Referred to " Refrigerant emissions in Australia – Sources, causes and remedies, 2010 "
Including gradual leaks during normal operation, losses during plant service and maintenance and losses at end of plant life.

**740 $CO_2$-ton of HFC emission is eliminated**

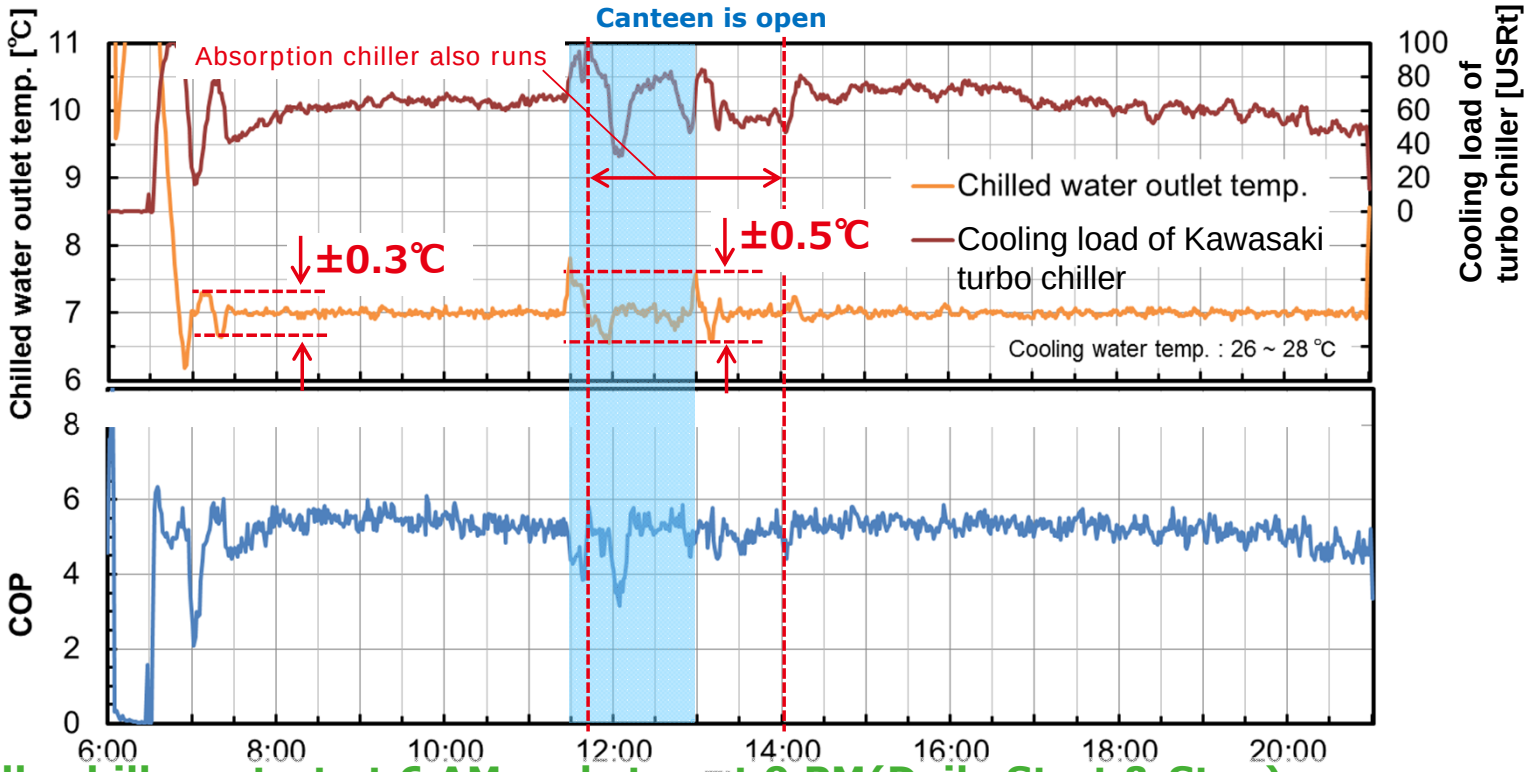
# Equipment configuration in Kobe, Japan





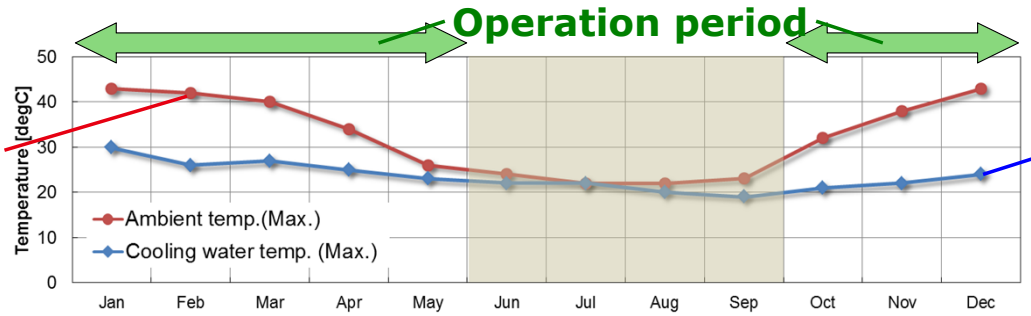


# Operation pattern in Kobe, Japan




- Normally chillers start at 6 AM and stop at 9 PM(Daily Start & Stop).
- Secondary chiller is operated when the load is more than 100USRt.
- Kawasaki turbo chiller can keep the temp. at 7.0±0.5 degC in case of sudden load changes
- Total operation time is 4,260 hours.

# Estimation method of load & COP

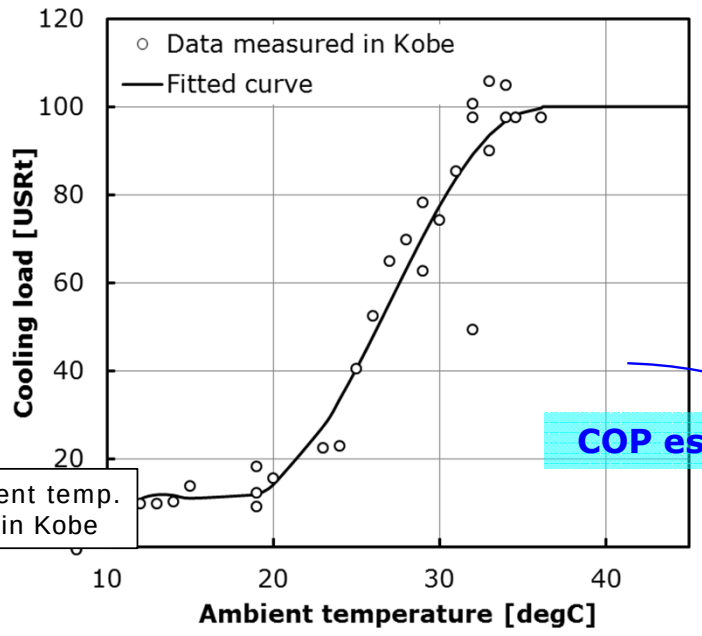



**Ambient temperature**

**Cooling water temperature**

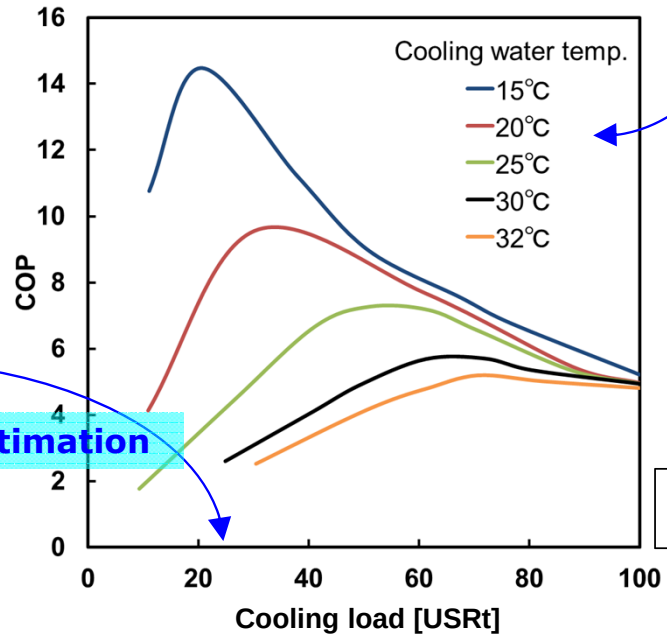
**Load estimation**

**COP estimation**



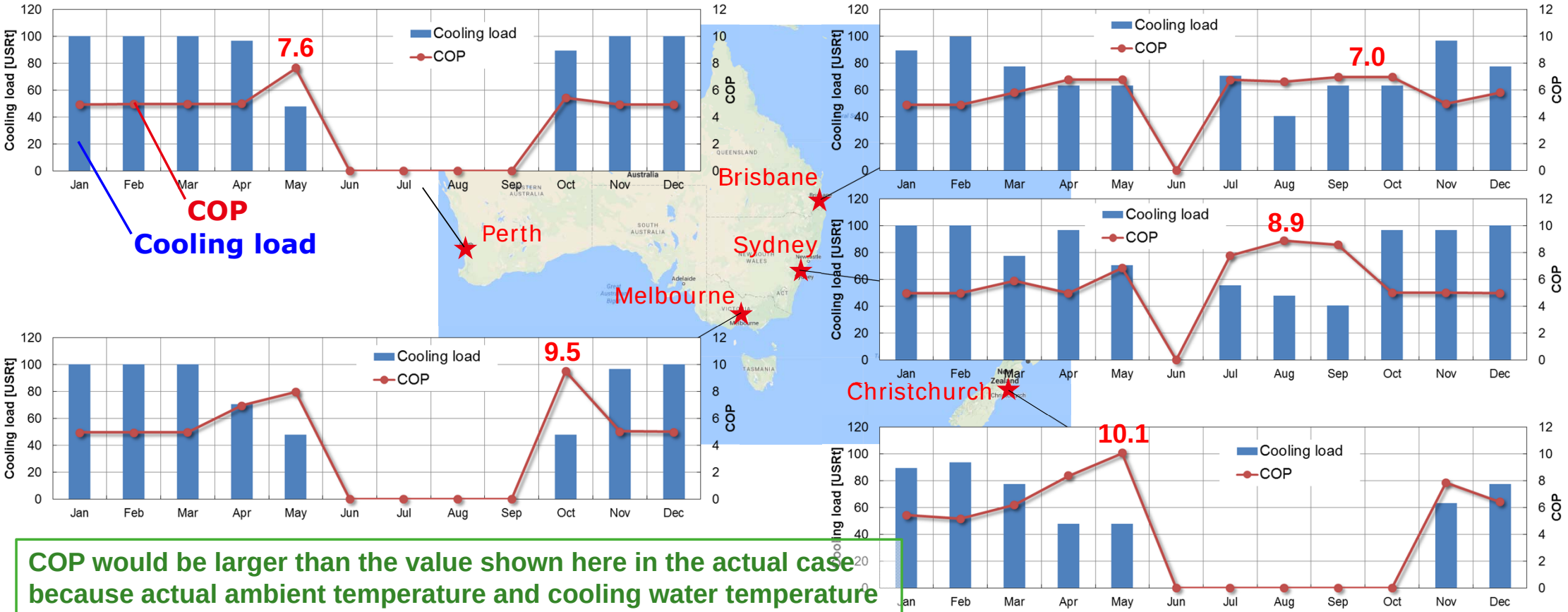

Relationship between Ambient temp. and cooling load measured in Kobe

**COP estimation**




Performance curve of Kawasaki turbo chiller

# Result - Cooling load & COP -




COP would be larger than the value shown here in the actual case because actual ambient temperature and cooling water temperature are lower than the calculation conditions.
Cal. Conditions : Max. ambi. temp. and Max. cooling water temp.