Minimum Energy Efficiency Standards (MEES) for Water-cooled Chilled Water Systems in Industrial Facilities
Presentation Outline

1) Background
2) Proposed Requirements
3) Examples of Chilled Water System Configurations
4) Enhanced Industry Energy Efficiency (IEE) Package
5) Summary & Feedback
1 Background
Among the electricity consuming systems, cooling systems account for \( \approx 16\% \) of total electricity consumption in the industrial sector.

\[
\text{Total Electricity Consumed} = 42 \text{ PJ}^{(1)}
\]

\(^{(1)}\) Based on 2016 energy use reported by companies regulated under the Energy Conservation Act.
Current Efficiency Levels of Water-cooled Systems in Industrial Facilities (1)

More efficient

System Efficiency (kW/RT) (2)

Estimated (Water-cooled) Measured (Water-cooled)

Cooling Load (RT)

>70% of reported (3) water-cooled chilled water systems were operating at sub-optimal levels

BCA Green Mark “Certified” Standard

(1) Based on 2016 energy use reported by companies regulated under the Energy Conservation Act
(2) Electrical input to the chilled water system in kW ÷ Chilled water system output in terms of cooling load in refrigeration tons (RT)
(3) 78% of the reported chilled water system efficiencies were estimated
# Improving Energy Efficiency of Cooling Systems in Industrial Facilities

<table>
<thead>
<tr>
<th>Type of system</th>
<th>Large cooling loads</th>
<th>Small cooling loads</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water-cooled chilled water systems</td>
<td>Air-cooled chilled water systems</td>
</tr>
<tr>
<td>Approach</td>
<td>System-level Minimum Energy Efficiency Standards (MEES)</td>
<td></td>
</tr>
<tr>
<td>Affected Party</td>
<td>Enforced at end-users i.e. industrial companies</td>
<td></td>
</tr>
</tbody>
</table>
Benefits of Introducing MEES

- Transform the market towards more efficient chilled water systems
- Reduce total life-cycle cost for end-users
- Reduce energy use and carbon emissions
Proposed MEES Requirements for Water-cooled Chilled Water System
Scope & Coverage

Type of chilled water system

Any industrial facility that has an electrically driven water-cooled chilled water system:

a) With an installed system capacity of 300 RT or more; and
b) Produces chilled water at a temperature of 3°C or higher

And

Industry sectors

The business activity carried out at the facility is attributable to one of the following industry sectors:

a) Manufacturing and manufacturing-related services;
b) Supply of electricity, gas, steam, compressed air and chilled water for air-conditioning;
c) Water supply and sewage and waste management.
Minimum Energy Efficiency Standards (MEES)

- The Operating System Efficiency (OSE) in kW/RT shall meet the relevant MEES level as indicated below:

<table>
<thead>
<tr>
<th>Chilled water temperature (°C)</th>
<th>MEES Levels (kW/RT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>0.59</td>
<td>0.60</td>
</tr>
</tbody>
</table>

- Starting with 0.67 kW/RT at chilled water temperature of 7°C, the MEES level will be adjusted by **0.01 kW/RT for each 1 °C deviation from 7°C**

1 Rounded to the nearest whole number (e.g. 2.5°C will be rounded to 3°C)
Compliance Timeline for New Industrial Facility

Example of a new industry facility:

- **2018**: Facility put up for Planning Permission after MEES effective date
- **2019**: Comply with MEES
- **2020**: Announce MEES in 4Q 2019
- **2021**: MEES Effective Date in 4Q 2020
- **2022**: Obtained Temporary Occupancy Permit (TOP)
- **2023**: Submit 1st Report To show compliance with MEES
- **2024**: Facility put up for Planning Permission on or after MEES effective date
- **2025**: Comply with MEES

1 year
Compliance Deadline for Existing ECA Industrial Facility

ECA Companies:

- **Announce MEES**: 4Q 2019
- **Periodic reporting**: to show efficiency is maintained
- **EEOA for existing ECA facilities**: Encouraged to include chilled water system
- **Compliance Deadline**: 4Q 2025
  - Submit 1st report to show compliance with MEES

Timeline:

- 2018
- 2019
- 2020
- 2021
- 2022
- 2023
- 2024
- 2025
- ...
Compliance Deadline for Existing Non-ECA Industrial Facility

Non-ECA Companies:

- **Announce MEES**
  - 2018

- **Compliance Deadline**
  - Submit 1st report to show compliance with MEES
  - 2029

- **Periodic reporting**
  - to show efficiency is maintained

- 2022, 2023, 2024, 2025, 2026, 2027, 2028

7 years
# Key Requirements – M&V System

1. Install permanent measurement & verification (M&V) system

- Similar to requirements under SS 591 and BCA Green Mark

<table>
<thead>
<tr>
<th>Measurement system*</th>
<th>Maximum allowable uncertainty</th>
<th>Data points to be measured (minimally)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong>^</td>
<td>0.05 °C.</td>
<td>Temperatures measured at:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• chilled water supply and return headers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• condenser water supply and return headers</td>
</tr>
<tr>
<td><strong>Flow</strong></td>
<td>1%</td>
<td>Flow rate measured at chilled water header and condenser water header</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>Class 0.5 for power meter, Class 0.5 for current transformer (CT)</td>
<td>Electrical power inputs (kW) to the following groups of equipment of the chilled water system:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• chiller(s),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• chilled water pump(s),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• condenser water pump(s), and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• cooling tower(s).</td>
</tr>
</tbody>
</table>

*Uncertainty should include the entire chain of the measurement system i.e. sensor, transmitter (if applicable), wiring and data acquisition system

^ Additional thermowells before and after each temperature sensor shall be installed along the chilled water and condenser water pipe lines for verification purposes
Objective:
To show that

i. OSE meet the MEES

ii. Heat balance is within 5% for 80% of the operating points

Submission Requirements:

i. Signed off by the person who prepared the report
   • Person can be EEO Assessor, QuESS or PE

ii. Endorsed by the Chief Executive of the company
3. For **Existing Facilities**, report key performance data periodically after First Report

- Obtain NEA’s approval for the first report and M&V system installed
- Key performance data shall be aggregated on a **monthly basis**, and “push” to NEA database
- Ensure the OSE\(^*\) meet the MEES level on a **yearly basis**

If the OSE does not meet the MEES level or M&V system does not meet the uncertainty requirements, corrective actions will have to be taken

\(^*\text{OSE = Annual power consumption of the chilled water system (kWh) ÷ annual cooling load produced by the system (RTh)}\)
Examples of Chilled Water System Configurations
Typical Chilled Water System Configuration

Legend:
- PCHWPs – Primary chilled water pumps
- SCHWPs – Secondary chilled water pumps
- CDWPs – Condenser water pumps

Boundary of chilled water system

- Cooling towers
- PCHWPs
- CDWPs
- Chillers
- Booster pump
- Excluded

Process | Clean room | Office
Chilled Water System with Thermal Storage

Legend:
PCHWPs – Primary chilled water pumps
SCHWPs – Secondary chilled water pumps
CDWPs - Condenser water pumps

Boundary of chilled water system

Process | Clean room | Office

Excluded
Booster pump

Chilled water supply | Chilled water return

Thermal Storage Tank
Chilled Water System with LT and MT Chillers

Boundary of chilled water system*

* If LT & MT systems share equipment such as cooling towers and/or secondary chilled water pumps

The MEES level will be the weighted-average of the MEES for different CHWST category:

$$\frac{\text{Load}_{LT}}{\text{Load}_{Total}} \times 0.69 \text{ kW/RT} + \frac{\text{Load}_{MT}}{\text{Load}_{Total}} \times 0.59 \text{ kW/RT}$$
Chilled Water System with “Shared” Condenser Water System

Power consumption of condenser water system needs to be apportion for the heat load for process 2.
Example of breakdown of chilled water system efficiency

At chilled water supply temperature of 7°C:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>kW/RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiller</td>
<td>0.45 - 0.55</td>
</tr>
<tr>
<td>Chilled water pump (Primary &amp; Secondary)</td>
<td>0.04 - 0.08</td>
</tr>
<tr>
<td>Condenser water pump</td>
<td>0.04 - 0.08</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>0.02 - 0.06</td>
</tr>
<tr>
<td>System</td>
<td>0.67</td>
</tr>
</tbody>
</table>
Water Efficiency Best Practices for Cooling Towers

- Cold water out
- Hot water in
- Dry air in
- Install high efficiency drift eliminators
- Install conductivity-based automated blowdown control system
- Improve cycles of concentration (COC) to minimum of 7 (Potable Water) and 10 (NEWater)
- Use alternative sources as makeup water, such as air handling units (AHU) condensate.
- To reclaim/recycle cooling tower blowdown to be used as makeup water
4 Enhanced Industry Energy Efficiency (IEE) Package
Enhanced Industry Energy Efficiency Package

Funding support of up to 50% of qualifying cost—an increase from previous 30%

For more information, pls contact the following officers:

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Summary
# Summary of Proposed Detailed Requirements for MEES

| Eligibility | Any industrial facility that has an **electrically driven water-cooled** chilled water system:
|             | a) With an installed system capacity of 300 RT or more; and
|             | b) Produces chilled water at a temperature of 3°C or higher |
| MEES Levels | From 0.59 to 0.71 kW/RT, depending on the chilled water temperature
|             | • Starting with **0.67 kW/RT** at chilled water temperature of 7°C, the MEES level will be **adjusted by 0.01 kW/RT for each 1 °C deviation from 7°C** |
| Compliance deadline | **Existing facilities:**
| | • Comply with MEES by **2025** for **ECA companies**
| | • Comply with MEES by **2029** for **non-ECA companies**
| | **New facilities:**
| | • Will be covered if the facility is put up for development control clearance on or after the date when MEES comes into force (4Q2020)
| | • Comply with MEES 1 year after the temporary occupancy permit is obtained |
| Key Requirements | • Permanent instruments for monitoring energy efficiency
|             | • First Report by the compliance deadline, and automated monthly reporting subsequently |

For any enquiries or feedback, please send them to [NEA_EEPC@nea.gov.sg](mailto:NEA_EEPC@nea.gov.sg)
Our Environment
Safeguard • Nurture • Cherish