

ENGINEERING
TOMORROW

Danfoss

Navigating the **Singapore Green Mark 2021** Standard with Danfoss

Score up to

12.5

Points on
GM2021

www.danfoss.com

Green Mark 2021

Building and Construction Authority (BCA)

Energy Efficiency (EE)
– Only prerequisite in GM 2021.



Go to Sustainability section developed to address the UN SDG's Page 12

| | Energy Savings Prerequisite | | | | | Intelligence | Health & Well-being | Whole Life Carbon | Maintainability | Resilience |
|------------------------------|-----------------------------|------|------|------|----|--------------|---------------------|-------------------|-----------------|------------|
| | ≥40% | ≥50% | ≥55% | ≥60% | ZE | | | | | |
| GM 2021 Certification | | | | | | | | | | |
| SLE | | | | X | X | | | | | N/A |
| Platinum SLE | | | | X | X | | | | | 40 points |
| Gold Plus SLE | | | | X | X | | | | | 30 points |
| Platinum | | | X | | | | | | | 40 points |
| Gold Plus | | X | | | | | | | | 30 points |
| Gold* | X | | | | | | | | | |

* Gold Rating ONLY applicable to In-Operation buildings (already certified based on previous standard).
** ZE (Zero Energy) and PE (Positive Energy) are awarded only if SLE rating is reached and if energy production of the building is equal or higher than consumption.

Green Mark 2015



| | Energy Savings Prerequisite | | | Climatic Responsive Design | Building Performance | Advanced Green Efforts | Resource Stewardship | Smart & Healthy Building |
|------------------------------|-----------------------------|------|------|---|----------------------|------------------------|----------------------|--------------------------|
| | ≥25% | ≥30% | ≥60% | — 30 points for each section — 20 points for Advanced Green Efforts — Up to 15 points for Specialised buildings | | | | |
| GM 2021 Certification | | | | | | | | |
| SLE | | | X | N/A | | | | |
| Platinum | | X | | ≥70 points | | | | |
| Gold Plus | X | | | ≥60 points | | | | |
| Gold* | | | | ≥50 points | | | | |

* SLE requires a minimum Rating of Gold with additional energy savings prerequisite.

Over

3000

certified Green
Buildings in
Singapore



Green Mark 2021

EE Standards: Three Pathways

(BCA)

EE standard raised from GM: 2015 levels to set higher minimum regulatory standards in environmental sustainability for new and existing buildings. Parallel EE pathways developed to meet the new aggressive EE standards.

- EE** Energy Performance
- In** Intelligence
- Hw** Health & Well-being
- Cn** Whole life Carbon
- Mt** Maintainability
- Re** Resilience

Pathway 1

Energy Consumption based, using the Energy Use Intensity (EUI).

See Page 8

Pathway 2

Deemed-to-comply prescriptive performance, using Fixed Metrics.

See Page 9

Pathway 3

Performance-based energy modelling for Energy Savings calculation.

See Page 11



Energy Performance through one of the three pathways

Data Driven and Flexible

Aligned to real project performance with validated data. Flexible routes for projects to demonstrate their performance.

Outcome based

Full recognition of passive design strategies and renewable energy systems contribution to energy savings.

Supportive of innovation

Encourage the use of new technologies, approaches and solutions to energy performance.

| Minimum Requirements | New | Existing |
|----------------------------------|---------|----------|
| AC Total Systems Efficiency | 0.8 | 0.9 |
| Airside efficiency for buildings | 0.18 | 0.2 |
| EUI occupancy rate | 100% | >60% |
| Renewable Energy Included | On-Site | |

Only prerequisite in GM: 2021

| Energy Efficiency Pathways | EUI | Mixed Metrics | Energy |
|--|-------------------|---------------|-----------|
| Building type | Pathway 1 | Pathway 2 | Pathway 3 |
| Commercial | | | |
| Office Buildings | • | • | • |
| Hotels | • | • | • |
| Retail Buildings | • | • | • |
| Educational | | | |
| IHL (University, Politechnics and ITE) | • | • | • |
| Private Schools and Colleges | • | • | • |
| Junior Colleges (MOE) | • | • | • |
| Secondary Schools (MOE) | • | • | • |
| Primary Schools (MOE) | • | • | • |
| Healthcare | | | |
| Hospitals | • | • | • |
| Community Hospitals | • | • | • |
| Polyclinic | • | • | • |
| Nursing Home / Youth Homes | • | • | • |
| Other Non-Residential | | | |
| Mixed Developments | by GFA mix | | |
| Community Centres | • | • | • |
| Civic Buildings | • | • | • |
| Cultural Institutions | • | • | • |
| Sports and Recreation Centres | • | • | • |
| Religious / Place of Worship | | • | • |
| Industrial | | | |
| High Tech Industrial | | • | • |
| Light Industrial | | • | • |
| Warehouses, Workshops and Others | | • | • |
| Residential | | | |
| Multi Residential (HDB, EC, Condo) | | • | |
| Cluster Housing | | • | |
| Landed Housing | | • | |



14%
improvement in
EUI in commercial
buildings

Pathway 1. Energy Use Intensity (EUI)

Pathway 1.

Building assessed on total annual energy consumption over gross building floor area (kWh/m² /yr).

Buildings' EUI have to match values provided by Pathway 1 and EUI values are based on Energy modelling (Design).

Energy Calculation and measured data (Retrofit).

Measurement (In operation).

| Building type | Gold Plus EE >50% | | Platinum EE >55% | | SLE EE >60% | |
|---|----------------------|-----|---------------------|-----|----------------|-----|
| | DCS | | DCS | | DCS | |
| Commercial | | | | | | |
| Office Buildings / Large - GFA >15,000sqm | 155 | 100 | 140 | 90 | 115 | 80 |
| Office Buildings / Small - GFA >15,000sqm | 135 | 90 | 120 | 80 | 100 | 75 |
| Hotel / Large - GFA >15,000sqm | 230 | 150 | 220 | 135 | 190 | 120 |
| Hotel / Small - GFA >15,000sqm | 180 | 120 | 160 | 110 | 140 | 95 |
| Retail Malls | 240 | 156 | 210 | 140 | 160 | 125 |
| Educational | | | | | | |
| IHL (University, Politechnics and ITE) | 130 | | 120 | | 90 | |
| Private Schools and Colleges | 110 | | 100 | | 80 | |
| Junior Colleges (MOE) | 60 | N/A | 50 | N/A | 40 | N/A |
| Secondary Schools (MOE) | 40 | | 35 | | 30 | |
| Primary Schools (MOE) | 40 | | 35 | | 30 | |
| Healthcare | | | | | | |
| Hospitals | 375 | 245 | 340 | 230 | 300 | 210 |
| Community Hospitals | 230 | 150 | 210 | 140 | 185 | 130 |
| Polyclinic | 150 | 100 | 135 | 90 | 120 | 85 |
| Nursing Home / Youth Homes | 90 | 60 | 80 | 55 | 70 | 50 |
| Other Non-Residential | | | | | | |
| Mixed Developments | by GFA mix | | | | | |
| Community Centres | 150 | 100 | 125 | 90 | 110 | 80 |
| Civic Buildings | 80 | 50 | 70 | 45 | 60 | 40 |
| Cultural Institutions | 180 | 115 | 140 | 100 | 120 | 85 |
| Sports and Recreation Centres | 110 | 70 | 80 | 65 | 50 | 35 |
| Religious / Place of Worship | N/A | | | | | |
| Industrial | | | | | | |
| High Tech Industrial | N/A | | | | | |
| Light Industrial | | | | | | |
| Warehouses, Workshops and Others | | | | | | |

* DCS (District Cooling System) is the supply of chilled water for cooling purpose from a central source to multiple buildings through a network of pipes. Individual users purchase chilled water from the district cooling system operator and do not need to install their own air-conditioning plant.

Pathway 2. Fixed metrics

Pathway 2.

Based on key performance

metrics that make an energy efficient project. All aspects must be met individually.

- Any shortfall in performance can be made up with onsite renewables.

- For projects utilising a District Cooling System the airside performance is used.

| Energy Savings Pathways | Reduced Heat Gain (EETV) (W/m ²) New development only | | |
|--|---|---------------------|----------------|
| | Gold Plus EE >50% | Platinum EE >55% | SLE EE >60% |
| Office, Institute of Higher Learning, Hospitals, High Tech, Community/Civic/Cultural/Religious | 40 | 38 | 38 |
| Retail, Private Schools | 40 | 38 | 35 |
| Hotel, MOE Primary-Secondary Schools /Junior College, Polyclinics, Nursing Homes, Light Industrial, Warehouses, Sports Buildings | 40 | 40 | 40 |

**An artificial-intelligence (AI) enabled energy calculator is being developed to facilitate data-driven contextualised simulation and demonstration of compliance*

| | Fixed Metrics | | |
|--|----------------------|---------------------|----------------|
| | Gold Plus EE >50% | Platinum EE >55% | SLE EE >60% |
| Total System Efficiency (kW/RT) | | | |
| Non-residential Data Centers & Industrial | 0.8 | 0.74 | 0.68 |
| Healthcare Facilities | 0.8 | 0.75 | 0.7 |
| Schools | 0.8 | 0.75 | 0.7 |
| Air Side Efficiency (DCS supply) | 0.2 | 0.18 | 0.16 |
| Fan System Efficiency (W/CMH) | | | |
| Motor Power > | 0.32 | 0.28 | 0.25 |
| Motor Power > | 0.17 | | |

| Energy Savings Pathways | Non AC Areas | | | On-Site Renewables |
|------------------------------|----------------------|---------------------|----------------|---------------------|
| | Gold Plus EE >50% | Platinum EE >55% | SLE EE >60% | Platinum EE >55% |
| Commercial | | | | |
| Office | - | 10% | 25% | 1.1 |
| Retail | - | 5% | 15% | 1.1 |
| Hotel | - | 10% | 30% | 1.5 |
| Educational | | | | |
| MOE Primary-Secondary School | 30% | 50% | 70% | 1.5 |
| MOE Junior College | 20% | 40% | 60% | 1.5 |
| Private Schools | - | 20% | 40% | 1.2 |
| Institute of Higher learning | - | 20% | 50% | 1.2 |
| Healthcare | | | | |
| Hospitals | - | - | 15% | 1.1 |
| Polyclinics | 10% | 30% | 50% | 1.3 |
| Nursing / Youth Homes | 10% | 40% | 60% | 1.5 |
| Industrial | | | | |
| High Tech | - | - | 10% | 1.1 |
| Heavy Industrial | - | 15% | 30% | 1.2 |
| Warehouses | - | 30% | 40% | 1.4 |
| Other Non-Residential | | | | |
| Civic / Sports Buildings | - | 15% | 30% | 1.2 |
| Community Buildings | 10% | 30% | 40% | 1.2 |
| Cultural Buildings | - | 10% | 20% | 1.2 |
| Religious Buildings | - | 15% | 25% | 1.5 |

*Replacement for deficiencies from other requirements with safety factor.

| Integrated Energy Management & Control Systems | | | | |
|--|--|---|--|---|
| | Lighting controls in accordance with SS 530: 2014. | Control device in every guestroom to switch off lighting and reduce air-conditioning loads when room is not occupied. | Energy consumption monitoring and benchmarking system. | Automatic air-condition control to respond to periods of non-use, or reduced heat load. |
| Gold Plus EE >50% | | Hotel | | |
| Platinum EE >55% | Office | Hotel | Private Schools, Institute of Higher Learning, Hospitals, Polyclinic | |

*For non-landed residential and Lighting Power budget, refer directly to GM: 2021 EE.

Pathway 3. Energy Savings

Pathway 3.

Demonstrated energy savings

following the Green Mark Energy Modelling guideline which looks at holistic energy performance against a reference model.

The default pathway for projects not covered in Table 1A.

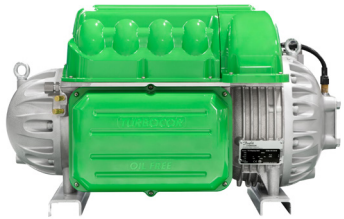
| | Pathway 3 - Energy Savings | | |
|---|----------------------------|---------------------|----------------|
| | Gold Plus EE >50% | Platinum EE >55% | SLE EE >60% |
| Savings from BAU (2005 code) | 50% | 55% | 60% |
| Savings from current reference (including DCS supply) | 30% | 35% | 40% |



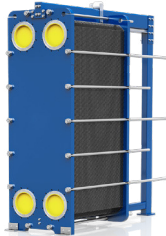
Photography by Andrew Tew

Sustainability — The 5 Sections

| | Sustainability Section | Repeating requirements (GM 2015 Section) | New requirements |
|-----------|---|---|---|
| In | <p>Intelligence Adoption of smart systems in the building design, construction, retrofit and operation that enable a fully integrated, automated, intelligent, responsive and aware building.</p> | 4.3 Smart Building Operations. | <p>Creation of a digital twin of the building for performance and asset management.</p> <p>Analysis of user experience with building's performance.</p> |
| Hw | <p>Health and Wellbeing Design, construction, operation and retrofit of buildings that facilitate mental, physical, and social wellbeing of their occupants.</p> | 4.0. Smart and Healthy Buildings. | <p>Health & Wellness programmes for both mental and physical wellness.</p> <p>Restorative & Communal Spaces for workers and occupants.</p> |
| Cn | <p>Whole Life Carbon Embodied carbon of a project, use of sustainable construction or retrofit materials and the role of tenancies in the fitting out of their spaces. Also evaluates building owners on their transition towards carbon neutrality.</p> | 3.0 Resource Stewardship. | <p>Delivery of plan to reach building carbon neutrality by 2030.</p> <p>Encourage conservation of buildings and resource recovery from demolished ones.</p> |
| Mt | <p>Maintainability Scores buildings on their Design for Maintainability (DfM), which refers to designing buildings for their safe and effective maintenance to optimise lifecycle performance of the asset. Uses MiDAS evaluation tool and translates this into Green Mark points.</p> | | New focus for the GM standard. |
| Re | <p>Resilience Evaluates buildings on their resilience and adaptation to climate change and use of nature-based or natural climate solutions with actions to protect, sustainably manage, and restore natural or modified ecosystems.</p> | 1.0. Climatic Responsive Design. | Resilience strategy based on an adaptation assessment to climate change. |



**Turbocor® Compressors
(TT & TG Series)**
Application: Compressor



Gasketed Heat Exchanger
Application: Heat Exchangers



VLT® HVAC Drive FC 102
Application: Pumps
Fans
Chillers
AHU
Cooling Tower



Danfoss-Novenco EC+®
Application: AHU / FCU



AB-QM with NovoCon® Digital Actuator
Application: FCU
AHU
Heat Exchangers

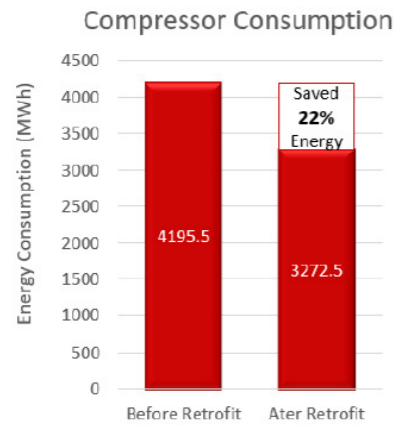
| |
|---------------------|
| 0.03 - 0.06 kW / RT |
| 0.02 - 0.03 kW / RT |
| 0.03 - 0.03 kW / RT |
| 0.09 - 0.15 kW / RT |
| 0.35 - 0.45 kW / RT |

- Cooling Tower Fans
- Chilled Water Pumps
- Condenser Water
- Pumps
- AHU

VLT® HVAC Drive FC 102



Designed to deliver high reliability and lower total cost of ownership across chillers, AHUs, pumps, cooling towers and ventilation fans.



ASM technology Singapore PTE LTD (ATS)

- VSD retrofitting for 14-year-old compressors.
- Achieved Energy savings of 22%.
- Total system Energy Savings of 4%.
- Payback period of 0.86 years.

Singapore Green Building Product Rating

Leader ✔✔✔✔

Score

EE

- Implementation of Danfoss VLT® HVAC Drive FC102 allows system to exceed target energy reduction.
- Can be equipped with the VLT® PTU 025 Pressure Transmitter that fulfils the Ecodesign Directive ErP, EC Regulation 1253/2014/EG to improve AHU/RTU energy consumption.
- Optimized for building automation systems with best-in-class efficiency standards up to 98%.

In

- Use of Singapore Green Building Council's Smart Building products that allows integration with the Common Data Environment (CDE).
- Use of smart IoT based platform to optimize the workflow, productivity and service delivery.

Our feature:

- IoT and smart cloud solution that allows MQTT connections & WIFI LCP for instant data access & sharing.
- Real-time motor and application condition based monitoring, allowing early detection, alert and action on faults.

Mt

- Provide open communication protocol (e.g. BACnet, MODBUS).
- Use life cycle cost (LCC) approach to identify solutions with better economic and maintainability benefit throughout the building life span.

Our feature:

- Plug & play IP55 Variable Frequency Drives (VFD) with disconnect switch. Lower cost as no need for additional panels or cabinet.

Other

- Listed in the Singapore Green Building Council's Smart Building products
- In-built RFI Class B filter up to 50m.
- In-built harmonic filters up to 1MW.

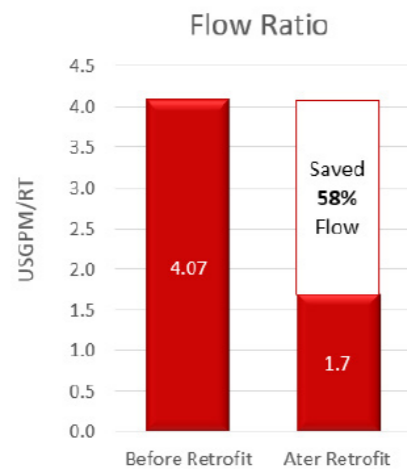
0.5
Up to 3

Prerequisite
Up to 2

AB-QM with NovoCon® Digital Actuator



Danfoss AB-QM PICV with NovoCon® digital actuators are designed to provide high-accuracy pressure independent flow control and exchange valuable data with a BMS system via BACnet or Modbus communication. They establish the perfect connection between superior hydronic HVAC system performance and smart building automation solutions.



NovoCon®

- System has Danfoss Turbocor® and VSDs.
- Improvement in overall chilled water air-conditioning system performance.
- Achieved energy savings of 26%.
- Achieved 99% energy transfer efficiency.

Singapore Green Building Product Rating

Good ✔

Score

EE

- Implementation of NovoCon® PIBCV/PICV improve the performance of chilled water pumps, condenser water pumps and chiller
- Reduced energy consumption in pumps and chillers, by avoiding over-flow at partial loads
- Energy monitoring and management through the use of controls and limit-ers
- Energy efficiency levels reached match the SLEB requirements

In

- Breakdown of energy consumption by system. Efficiency metrics tracking and analytics for real time optimisation.

Our feature:

- Modbus communication and predictive maintenance data transparency

Mt

- Provide open communication protocol (e.g. BACnet, MODBUS)
- Use life cycle cost (LCC) approach to identify solutions with better economic and maintainability benefit throughout the building life span
- Integration across multiple systems to optimize resource deployment/ utilization across multiple systems services
- Provision of automated and schedule exports of data points to commonly used file formats which enables exchange of data between systems

Our feature:

- Reduced number of products and installation time as balancing and control valve combined into one
- Built-in energy management features such as min. delta T monitoring/control
- Reduced IO points of BMS setup, simplify wiring installation and reduce potential human error during installation/commissioning

Other

- Enhanced Return on Investment (ROI), payback period of less than 3 years

1

Prerequisite
Up to 2

Up to 3

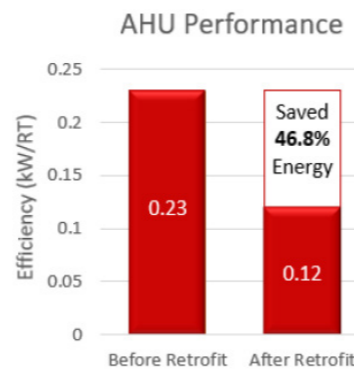
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Danfoss-Novenco EC+®

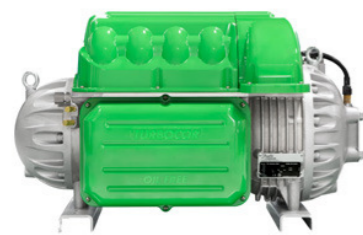


Danfoss VLT® drive coupled with permanent magnet (PM) motor, NOVENCO ZerAx® fan and Danfoss EC+® platform.

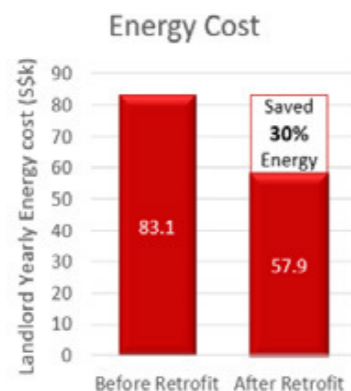
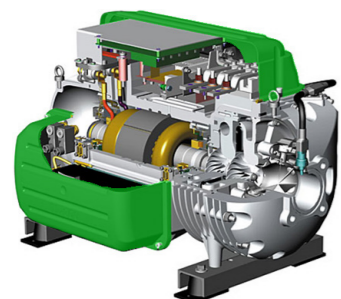
- Retrofit of existing belt-driven motor.
- Achieved energy savings of 46.8%.
- Building reached SLE ratings.



Turbocor® Compressors - TT & TG Series



Danfoss Turbocor compressors are the pioneers in oil-free compressor technology. These compressors have no oil in the system which means there is no performance degradation due to oil contamination. This, along with the contact-free operation enabled by magnetic bearings means the performance remains consistent over the life of the compressor.



- Alexander Point Chiller
- Retrofit of current system
- Achieved energy savings of 30%
- System current efficiency of 0.59kW/RT (AHU not included)

EE

- Highest total AHU system efficiency in the market (85%) due to optimal efficiency of individual components.
- Facilitates SLE energy efficiency requirements.
- Can be equipped with the VLT® PTU 025 Pressure Transmitter.

Score

In

- Provision of permanent calibrated air quality monitoring system with zonal controls
- Our feature:**
- Intelligence through VLT® HVAC Drive FC 102.

1

Mt

- Specify AHU fan system with less moving parts for enhanced reliability and reduced downtime.
 - Note: Points shall be prorated for buildings which are served predominantly (≥75%) by FCUs.
- Our feature:**
- Maintenance free
 - Motor life of 100000he

1

Other

- Manufacturer independence on choice of technology & retrofit of existing systems possible

EE

- Implementation of Turbocor® improve system efficiency and greatly decreased the system maintenance costs.
- Oil-Free technology that achieves highest efficiencies through magnetic bearings, variable-speed centrifugal compression and digital electronic technologies.
- Integrated variable frequency drive adjusts the speed to optimize the performance under all loads while keeping the compressor in safest part of the operating envelope.
- No oil in the system means there is no performance degradation due to oil contamination. This, along with the contact-free operation enabled by magnetic bearings means the performance remains consistent over the life of the compressor.
- Energy efficiency levels reached match the SLEB requirements.

Score

In

- Use of Singapore Green Building Council's Smart Building products that allows integration with the Common Data Environment (CDE).
- Our feature**
- Onboard intelligent electronic controls enable monitoring, control and self-diagnosis of system operation.

0.5

Mt

- Use life cycle cost (LCC) approach to identify solutions with better economic and maintainability benefit throughout the building life span.
- Our feature**
- Current Refrigerant Landscape is uncertain. Danfoss Turbocor® Oil-Free Compressors allow for promotion of 'Future Proof' solutions where chillers can potentially be converted with R1234ze.
 - Oil-Free operation eliminates expensive service costs for oil maintenance and compressor overhauls.

Up to 2

Other

- Exceptional low-noise operation with no vibration.

The new **Green Mark** **Standard for Singapore**

The opportunity is here: to accelerate towards carbon neutrality and mark this moment as a historical turning point. The solutions are ready and proven. Now, it all comes down to the scale and speed of implementation.

The economic upside of investing in a low carbon economy is clear. So, let's focus on driving energy efficiency in our buildings and industry. To accelerate electrification of transport systems – moving goods and people on land and at sea, while also enabling smart sector integration in our cities. All in addition to creating the green jobs of the future, and ensuring we move closer to achieving our goals.

This is where the transformation starts.

Join the transformation and continue the conversation on danfoss.com

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