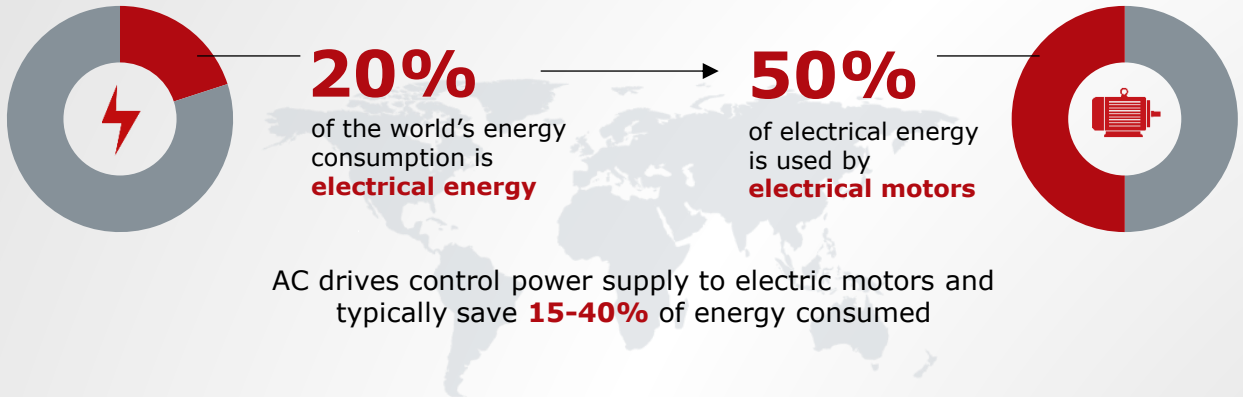




Latest technologies in power conversion to improve reliability & efficiency to achieve decarbonization

By : -
Gopal Kanani

Reducing energy optimization using power conversion



TODAY:
75%
of AC drives are used on pumps, fans and compressors



TOMORROW:
AC drives have the potential to save **8%** of global electricity consumption by 2040

Source: IEA World Energy Outlook 2016

57% of the Global Plant ageing from **8- 24 years of operations** has the potential to decarbonize the plant and limit **global warming to 1.5 °C**

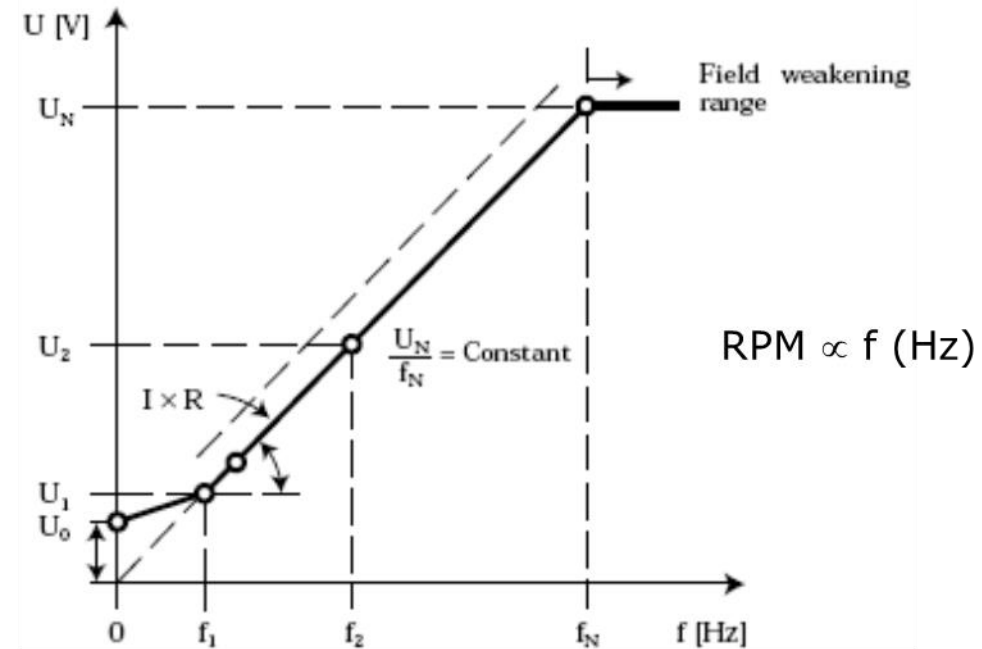
For example by deploying AC drives in Fans and Pumps can reduce 30% of energy saving



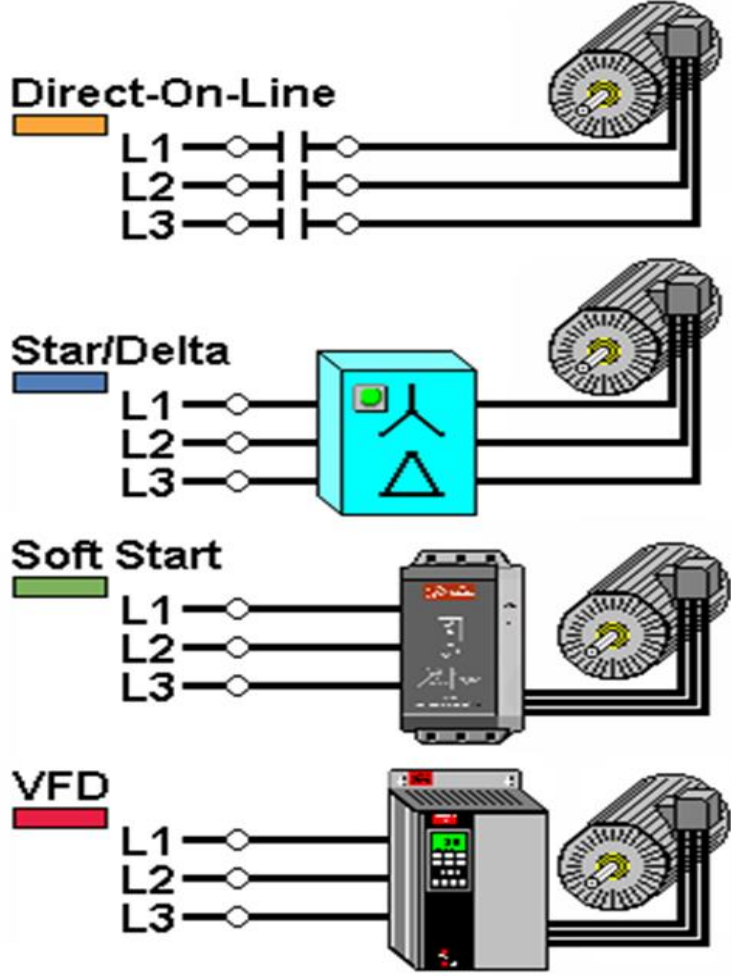
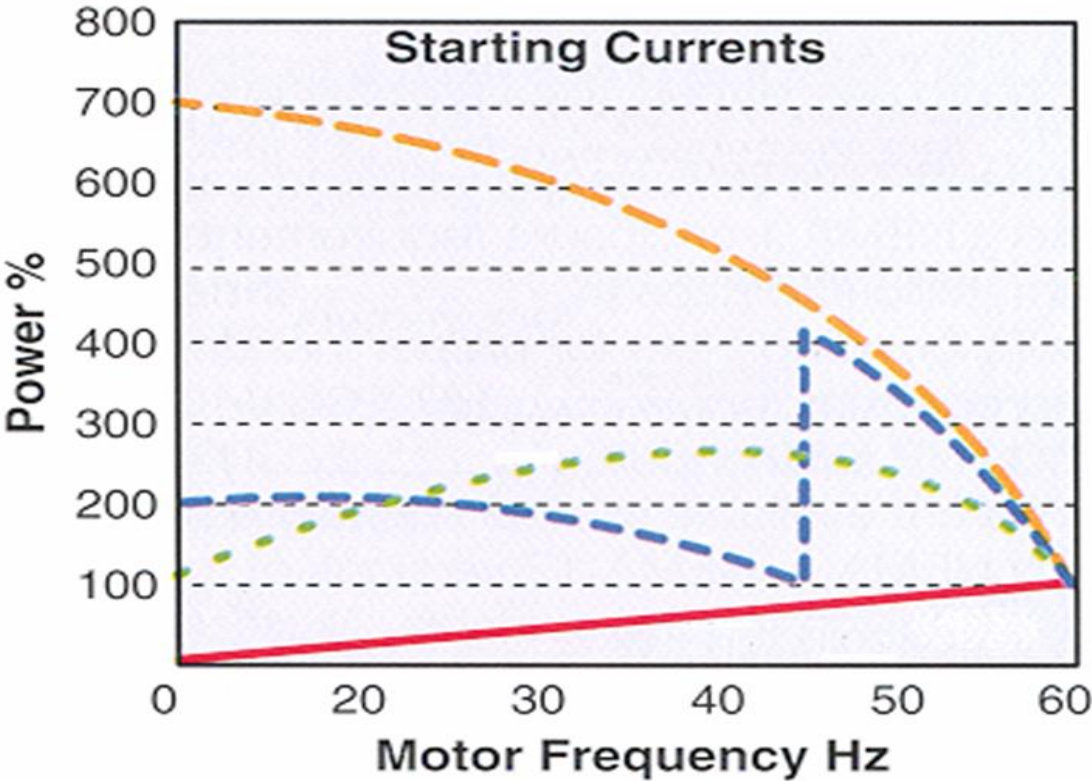


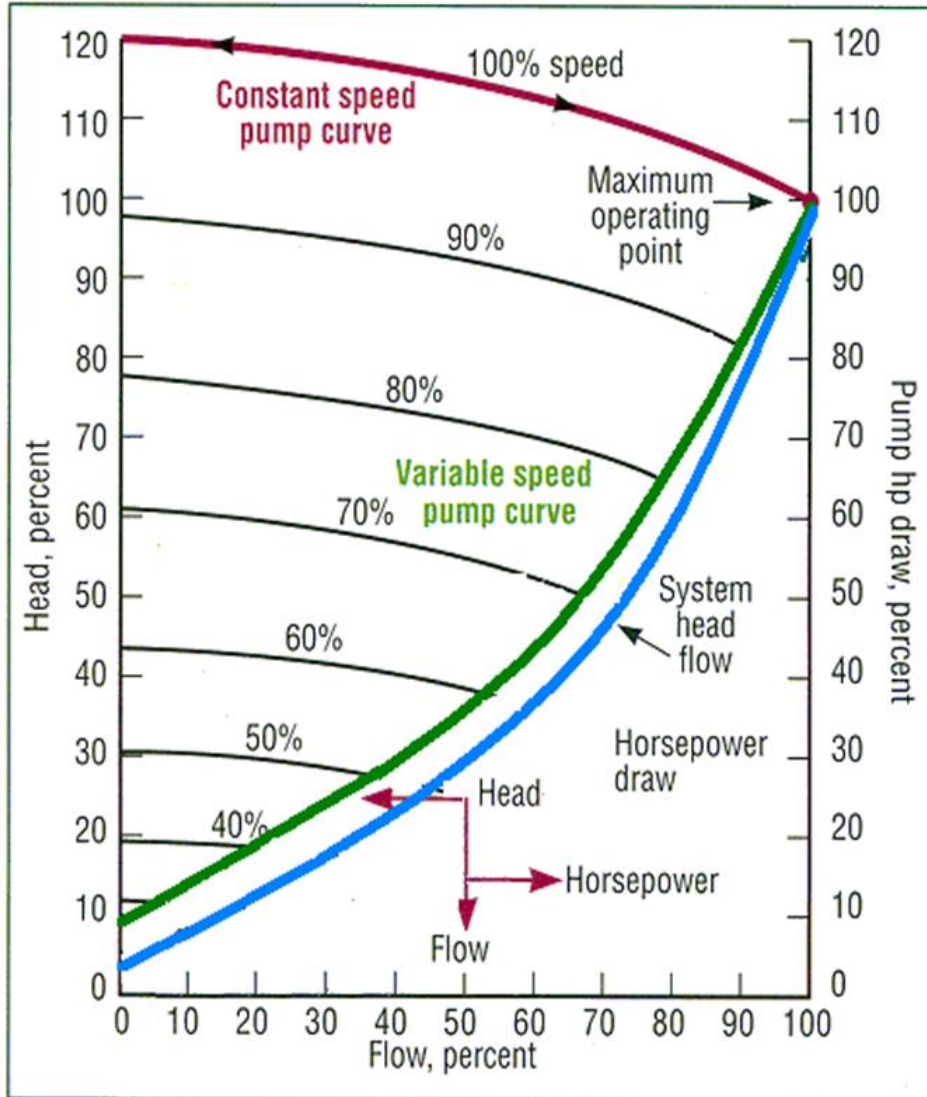
Variable Frequency Drives

- Control the speed of electrical motors by varying the frequency and voltage while maintaining torque.



Reducing motor in-rush current...





Affinity laws for pumps and fans

- $FLOW \propto RPM$
- $HEAD \propto RPM^2$
- $POWER \propto RPM^3$

10% speed reduction = 27% energy savings

RPM	FLOW	HEAD	POWER
100%	100%	100%	100%
90%	90%	81%	73%
80%	80%	64%	51%
70%	70%	49%	34%
60%	60%	36%	22%
50%	50%	25%	13%
40%	40%	16%	6%

Original system vs. new system



- 5x370 kW pumps
- Pressure requirement: 15 mWC to ensure flow to WTP.
- Actual pump can lift 33 mWC (Meter of water column)

Original system:

- 3 pumps ON/OFF controlled by soft-starters.
- 2 pumps in stand-by

New system:

- 4 pumps in operation controlled by VLT AQUA Drive w. cascade controller. **Reduced speed.**
- 1 pump in stand-by
- PI-controlled with level control. Decreasing the speed of pumps when the level in the tank becomes higher -> Energy saving

40% energy savings

Original setup: Three 370kW pump (50-50 duty cycle):

- $370\text{kW} \times 12\text{hrs} \times 3 \times 365\text{d} \times 0.12 \text{ USD/kW} = \mathbf{583.41 \text{ TUSD/yr}}$

New setup: Four 370kW pumps @ 75% speed (50-50 duty cycle)

- $370\text{kW} \times 12\text{hrs} \times 4 \times 365\text{d} \times 0.12 \text{ USD/kW} \times (0.75)^3 = \mathbf{328.17 \text{ TUSD/yr}}$

(Rounded to 350 TUSD/yr considering that pump efficiency decreases and other factors)

Result (verified by customer):

Total Energy Savings: **233,41 TUSD/yr**

Payback time: **about six months!!**

Benefits using VFD's for Fan and Pumps

- Massive energy savings – short pay back time.
- Low in rush current / low torque surges = less mechanical stress
- Reduction of water hammering of pumping system
- Precise pressure control leads to less water leakage and reduced demand on the piping system.
- Exclusive "Cascade Control" software allows total control of systems with up to 5 pumps or fans in parallel



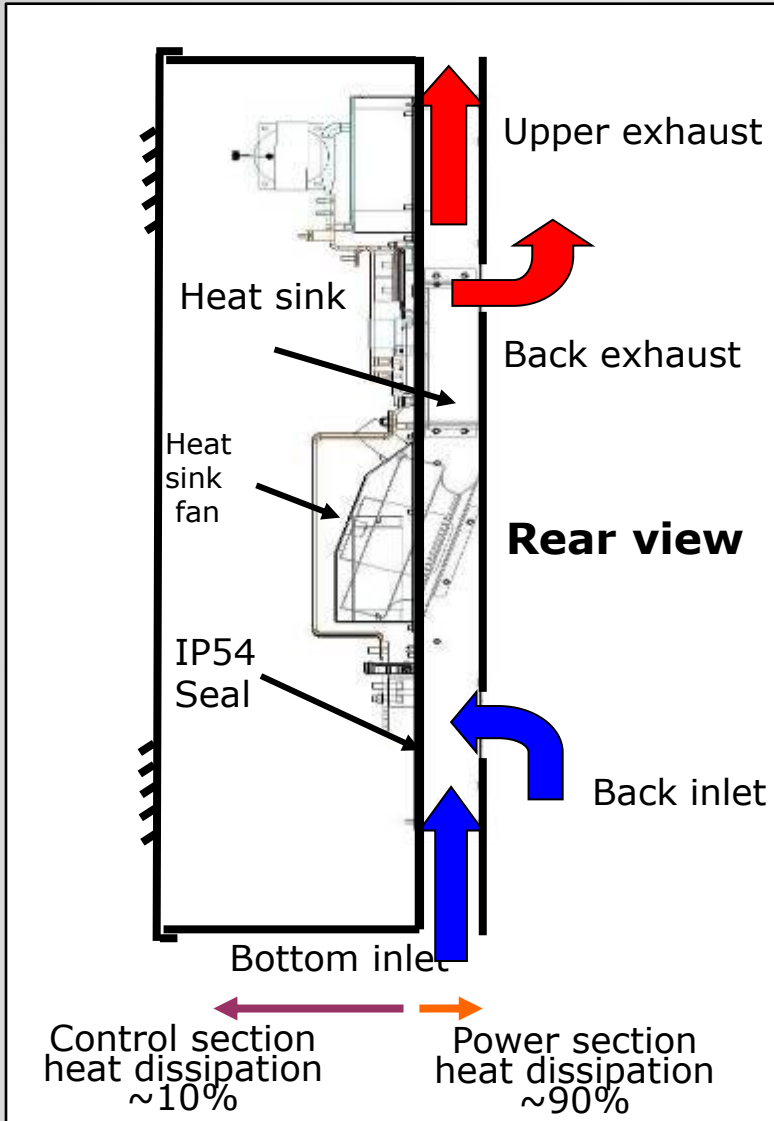
Benefits using VFD's for Fan and Pumps

- Maintain same operating hours for all connected pumps and fans
- System shuts off and goes to standby in case of low flow /No flow demand
- Deragging feature of the drive senses the pump clog and will reverse spin the pump to ensure a clear path for the water
- Reduced maintenance and operating costs.



Intelligent back-channel cooling design

42.6Minr
Savings in five
years through the
Back Channel
Cooling



Case Story

- ✓ Installed at "45MLD RO" Plant in India
- ✓ Power ratings 110KW ~ 450KW: 27no's
- ✓ AC Power Consumption w/o BCC : 91 KWH
- ✓ AC Power Consumption with BCC : 19.2 KWH
- ✓ Savings AC Tonnage with BCC ~ 61 ton
- ✓ CAPEX Savings on AC Installation : 11.6 minr
- ✓ OPEX Savings on AC Usage(5 years): 31 minr

" 2500Tons of CO2 Emission Reduced by Danfoss solutions"

- **Separate cooling path** for power and control components
- VFD system with special **ducting provision** at bottom, top & backside
- Higher reliability in harsh environment, **Conformal Coating 3C3 PCB Protections**
- **~50% reduction** in investment for air cooling system to remove heat from the drives
- Great savings on **Capex & Opex** of Air-conditioning system for High Power Drives
- Help achieve **environment sustainability goals** by reducing **CO₂** emissions

Energy storage topologies

Basic idea is always to **solve issues in power demand** with the most **cost effective and suitable manner**. Depending on customer and system, the solution for the same problem can be different. There is no ultimately right or wrong method or approach for certain applications.

1

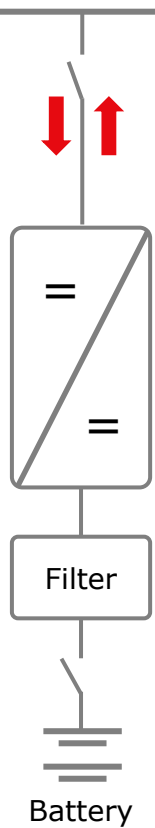
DC-grid or DC-link

DC/DC solution,
DC/DC-chopper, filter
and battery / Capacitor

Time shift of
production



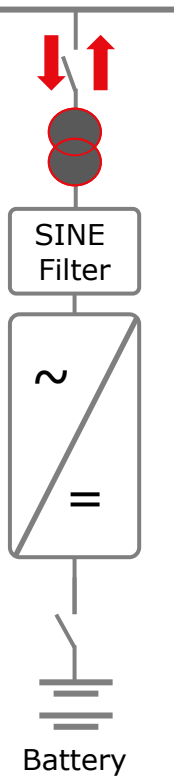
Peak load
shaving for
incoming
power



2

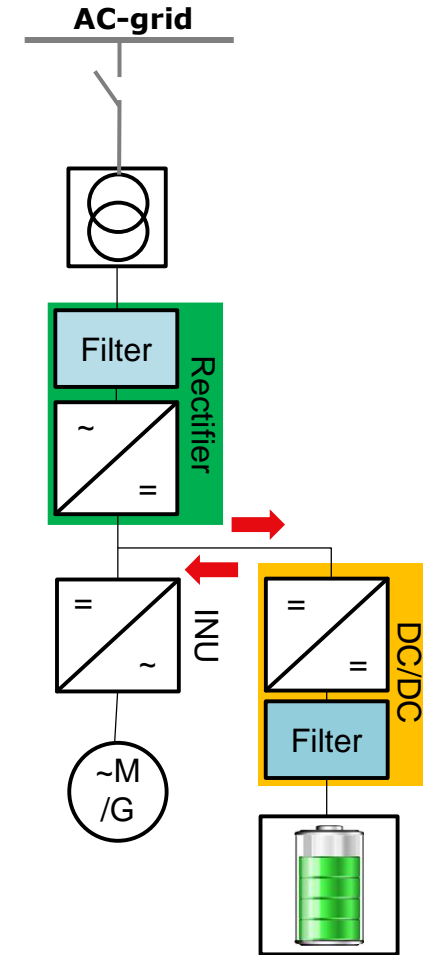
AC-grid

AC/DC solution,
Transformer, LC-filter,
AFE and battery /
Capacitor

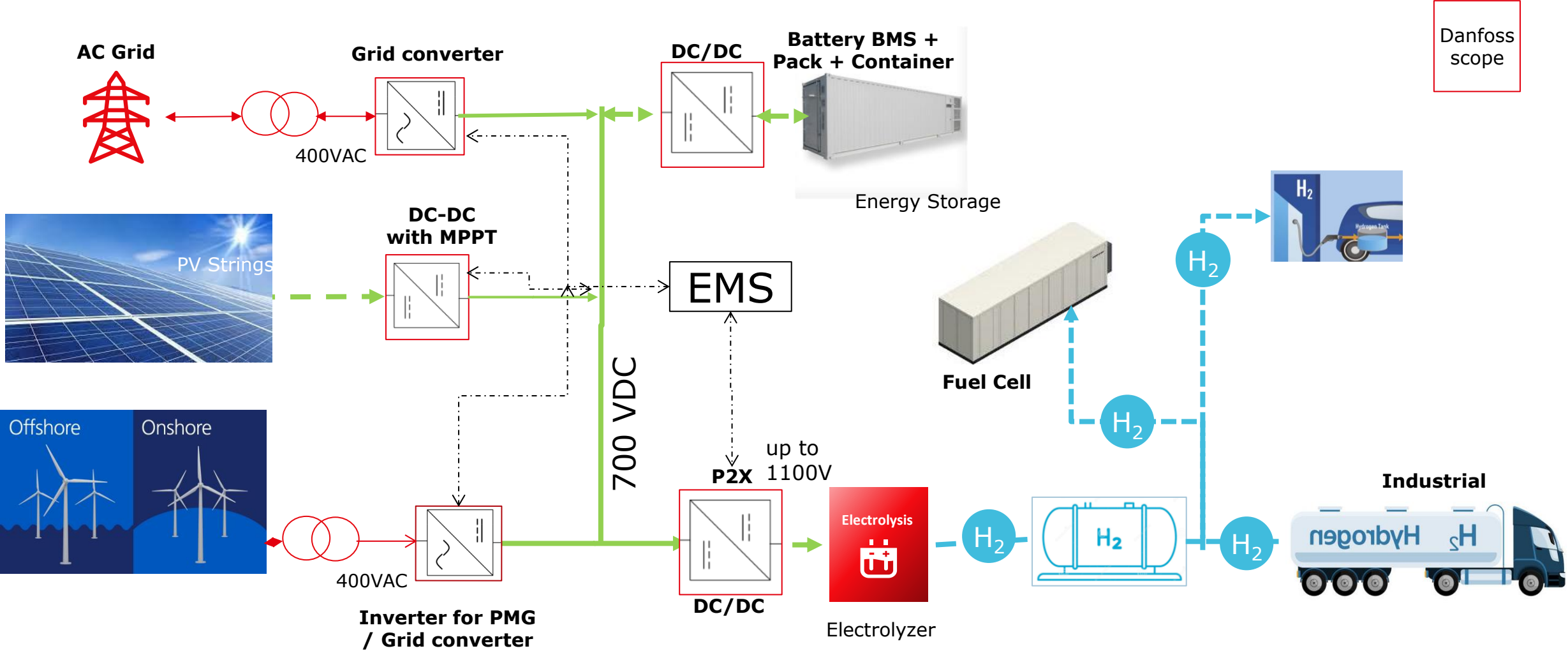


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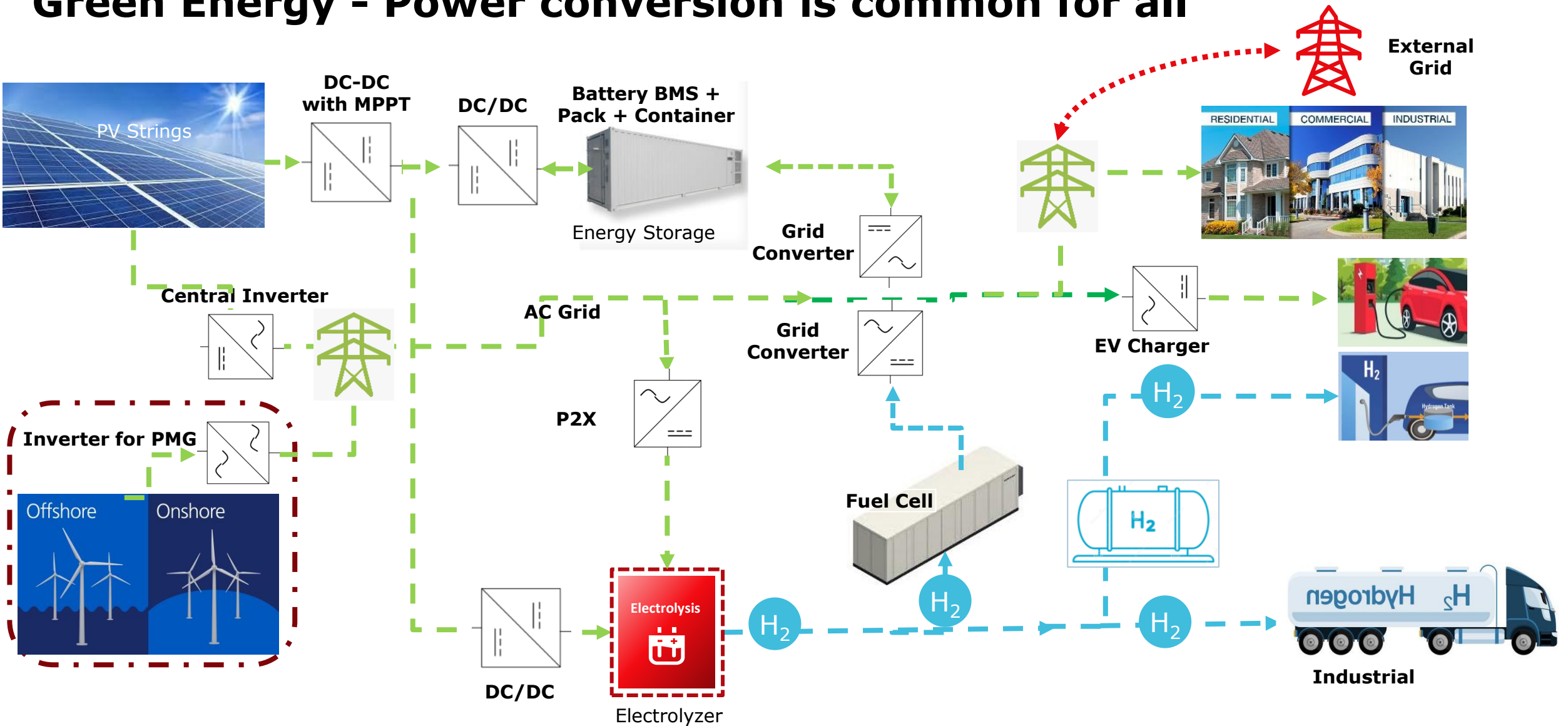
Direct DC solution,
LCL-filter, AFE, INU
and battery/ Capacitor
connected to DC-link



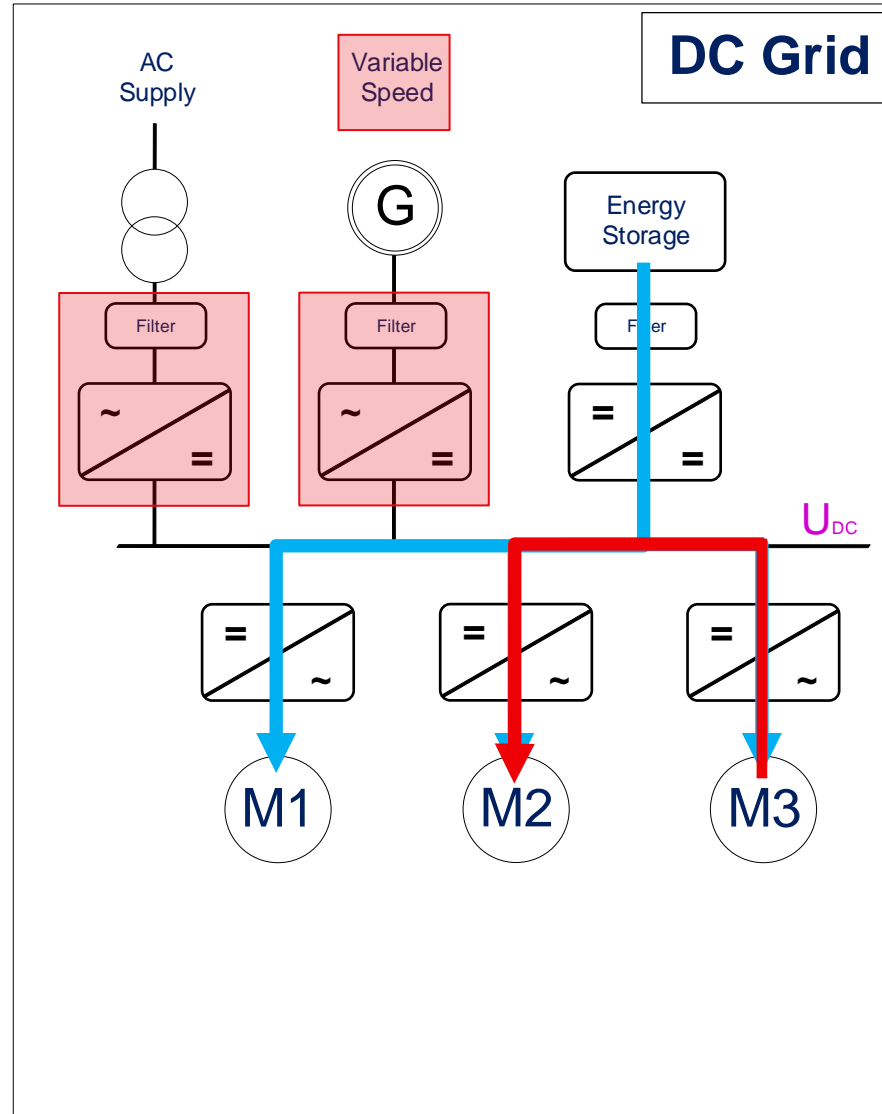
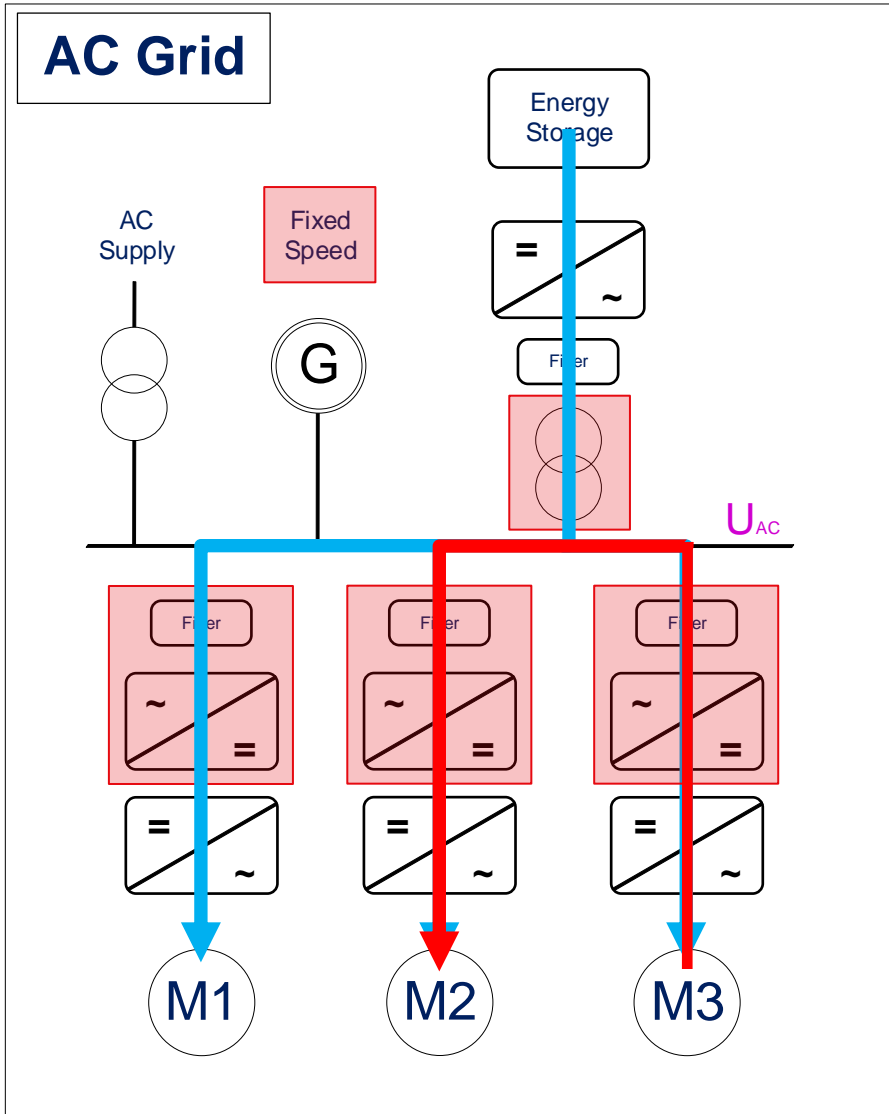
Power conversion is common for all



Green Energy - Power conversion is common for all



AC Grid vs DC Grid



DC Grid benefits

Variable speed generators

Less filters and transformers

10-20% improved system efficiency

10-20% reduced system foot print

Efficient reuse of regenerative energy

No reactive power
No synchronization needed
Easier service access

Our efforts at Chennai Campus

12,000 T Co2 reduced!



Danfoss India is **LEED Platinum** rated campus



Campus uses **95%** of its energy demand from renewable resources (wind + solar)



1.12 MW of in campus solar power plant



Car parking has **Solar panels**. Serve purpose of providing shade and generate electricity



270 kWh of Energy Storage which stores solar energy produced on weekends

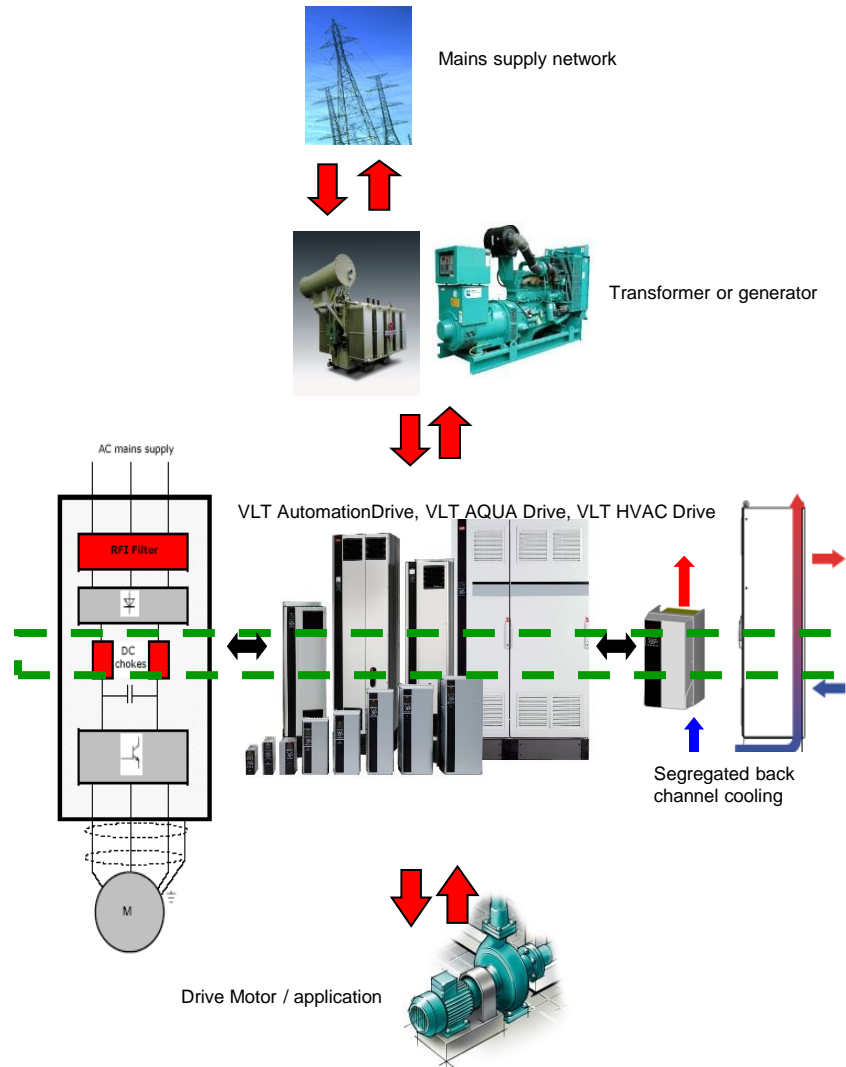


Bi-cycles & EVs for internal transportation



1650 TR of Airconditioning equipment with highly efficient **Magnetic Bearing compressors**

Key design consideration of VFD



- Integrated Class-A2 RFI filter = lower losses
- Integrated twin DC bus harmonic chokes = smaller transformers / switchgear and no need for extra filters in most cases = lower initial cost, no extra voltage drop and lower losses
- Compact enclosures with segregated back channel cooling = lower panel / switchroom capital costs, plus initial air conditioning & ongoing operating costs
- PCB protection as per IEC61-721-3-3 Class 3C3 = lower initial capital & whole of life operating (maintenance) costs
- At least VFD should support 50 degree C ambient temp = No derating required and hence lower losses and initial cost
- At least VFD should support 150m shielded motor cable capability without need for extra output filters = lower initial cost, no extra voltage drop and lower losses
- Input and output choke increase increases power losses and hence additional voltage drop = Can not get full motor power voltage, with need of de-rating / risk of over temperature and optimum service life = lower initial capital and whole of life operating costs



**ENGINEERING
TOMORROW**