ENERGY SAVING SOLUTIONS FOR MOTORS

TMEIC Corporation

Tokyo, Japan

No disclosure to third parties

February 2025
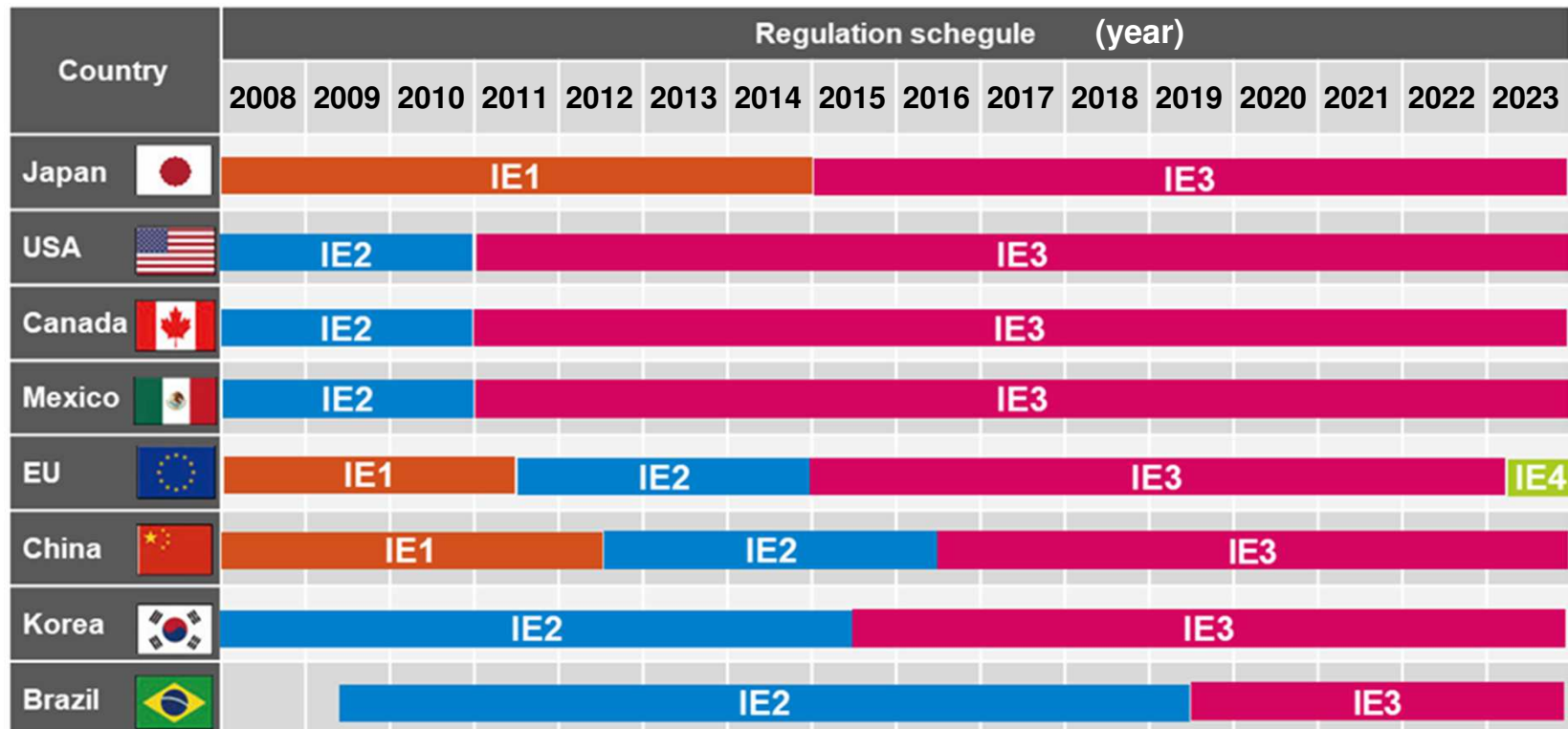
INTRODUCTION

1. Most of the power consumption comes from motors in the world. JEMA (The Japan Electrical Manufacturers' Association) reports that it is 40 to 50%.

2. For this reason, it is very important to reduce and save energy consumption of the motors.

3. There are two major countermeasures.
   1) To apply motors with higher efficiency.
   2) To control motor speed by VFD (Variable Frequency Drive)

4. Two countermeasures are nowadays very common in the world.

MOTOR WITH HIGHER EFFICIENCY

- **Old induction motor efficiency class is IE1.**

- **Higher efficiency IE3 motors have been common and compulsory in major countries.**

- **Recently IE4 motors are available.**

- **Replacement of old motors with higher efficiency ones will save energy and reduce operation cost.**

Country		Regulation schegule (year)														
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Japan		IE1	IE1	IE1	IE1	IE1	IE1	IE1	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3
USA		IE2	IE2	IE2	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3
Canada		IE2	IE2	IE2	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3
Mexico		IE2	IE2	IE2	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3
EU		IE1	IE1	IE1	IE2	IE2	IE2	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE4
China		IE1	IE1	IE1	IE1	IE2	IE2	IE2	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	
Korea		IE2	IE2	IE2	IE2	IE2	IE2	IE2	IE3	IE3	IE3	IE3	IE3	IE3	IE3	IE3	
Brazil			IE2	IE2	IE2	IE2	IE2	IE2	IE2	IE2	IE2	IE2	IE3	IE3	IE3	IE3	

MOTOR EFFICINECY SERIES

- **Motors from IE1 to IE4 are of induction squirrel cage type.**
- **IE5 motors are special synchronous (reluctance motors) and require VFD.**
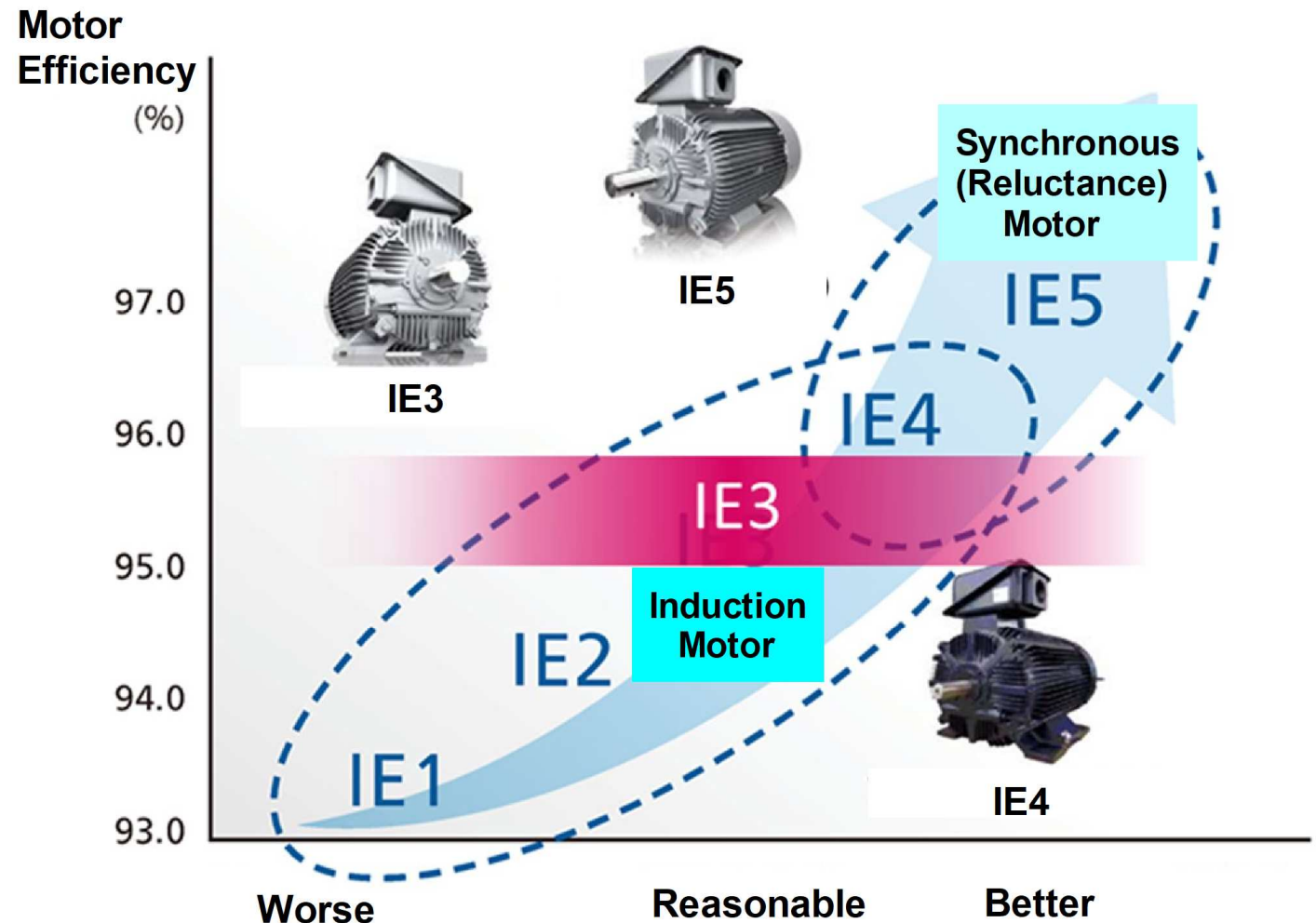
COMPARISON OF MOTOR PERFROMANCE

- **The table shows difference of efficiency and loss based on TMEIC standard design.**

Rating	4P-75kW-400V-50Hz		
Class	IE1	IE3	IE4
Efficinecy	92.6%	95.1%	96.1%
Motor Loss	5994W	3864W	3044W

Rating	4P-90kW-400V-50Hz		
Class	IE1	IE3	IE4
Efficinecy	93.2%	95.3%	96.2%
Motor Loss	6567W	4439W	3555W

- **Higher efficiency and smaller loss will save energy.**

ENERGY AND COST SAVING

IN CASE OF REPLACEMENT OF IE1 MOTOR WITH IE4 ONE

Rating	4P-75kW-400V-50Hz
Power	23.7 MWh/year/motor
Electricity Bill	3364 USD/year/motor
CO2 Reduction	10.5 ton/year/motor

Rating	4P-90kW-400V-50Hz
Power	24.2 MWh/year/motor
Electricity Bill	3435 USD/year/motor
CO2 Reduction	10.7 ton/year/motor

Conditions)
* Operating hour:
  8040 hours (24 hours/day, 365 days/year)
* Electricity bill:
  14.2 cents/kWh (Estimated in Japan)
* CO2 reduction coefficient:
  0.441 ton/MWh (By Ministroy of the Environment of Japan)
* Exchange rate:
  155 JPY/1 USD

PRINCIPLE OF VFD

- ● **Converter converts AC power to DC power (voltage).**
- ● **Inverter converts DC voltage to variable voltage and variable frequency AC power.**

CONVERTER

INVERTER

3-phase
AC POWER

AC -> DC

DC
VOLTAGE

DC -> AC

Variable Voltage
Variable Freq.
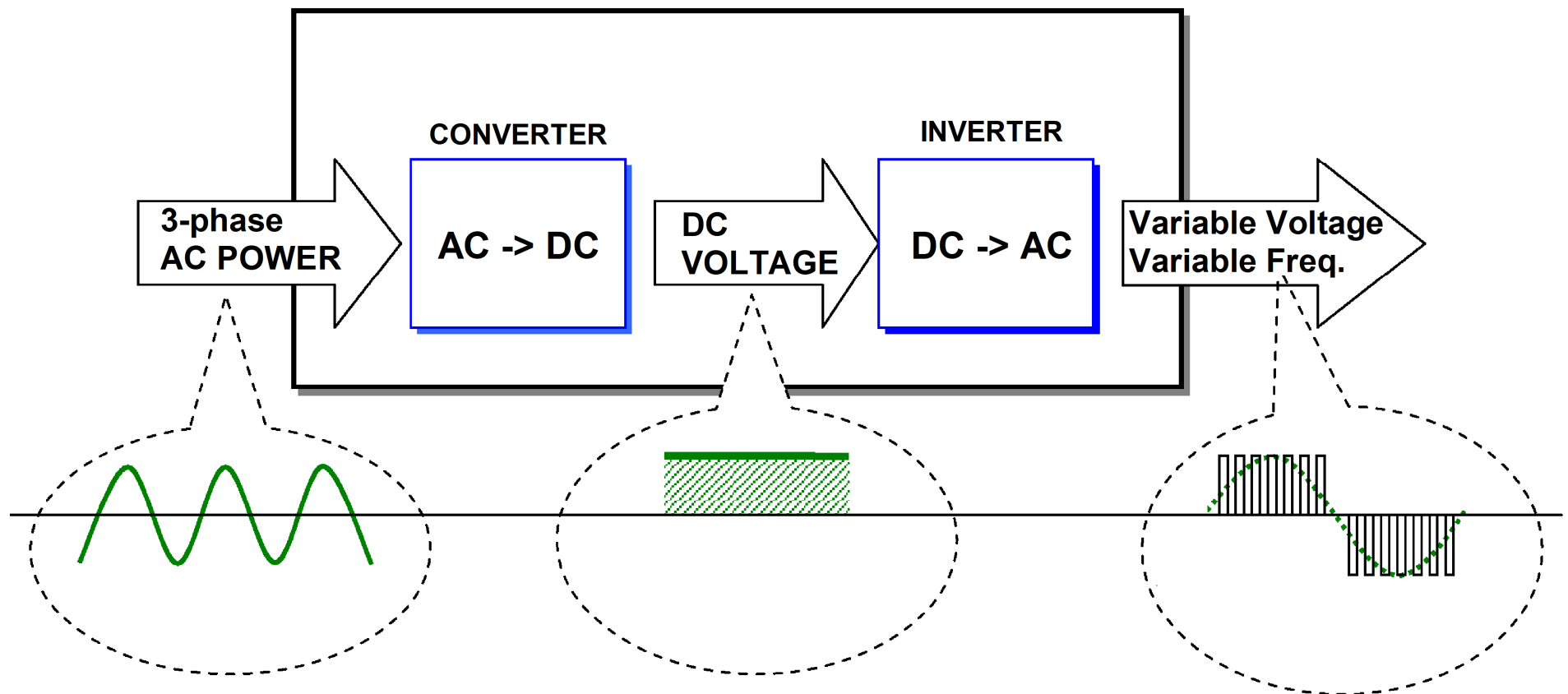
VOLTGAE SOURCE INVERTER (VSI)

- ● VSI is the most popular VFD in the world.

- ● Average of output voltage is close to sine wave because of PWM (Pulse Width Modulation) control.

- ● Available from low voltage to medium and high voltage.

SINUSOIDAL PWM CONTROL
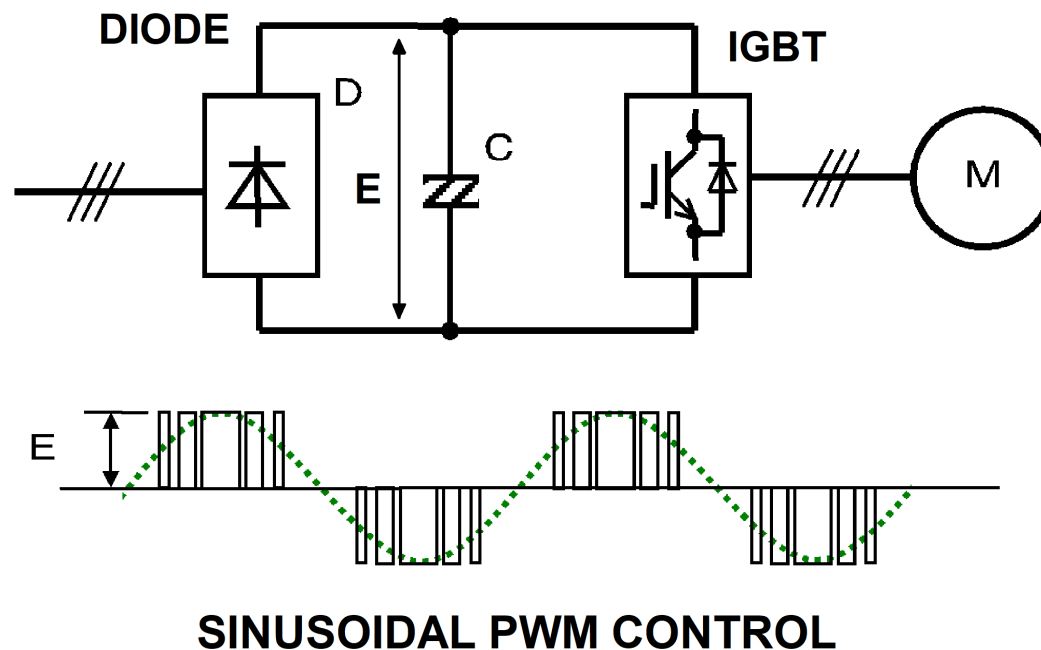
ENERGY SAVING BY VFD

1. The Pumps are driven by electric induction motors, which will be speed-controlled by variable frequency drive (VFD) to control water flow with valves open.
2. Speed control by VFD will save energy.
3. VFD will improve power factor of a pump station.
4. An electrical room is required for new VFDs.
5. **Theoretical power at 80% speed will be 0.8^3=0.512.**

Theory:
1) Flow is proportional to pump speed.
2) Head is proportional to the square of pump speed
3) Power is proportional to the cube of pump speed

PUMP POWER

Hydraulic Power (Ph)

$$Ph = \rho\, Q\, g\, H\, /\, 3600 \ \text{[kW]}$$

ρ ; Density of Fluid (ton/m^3)

Q ; Flow capacity (m^3/h)

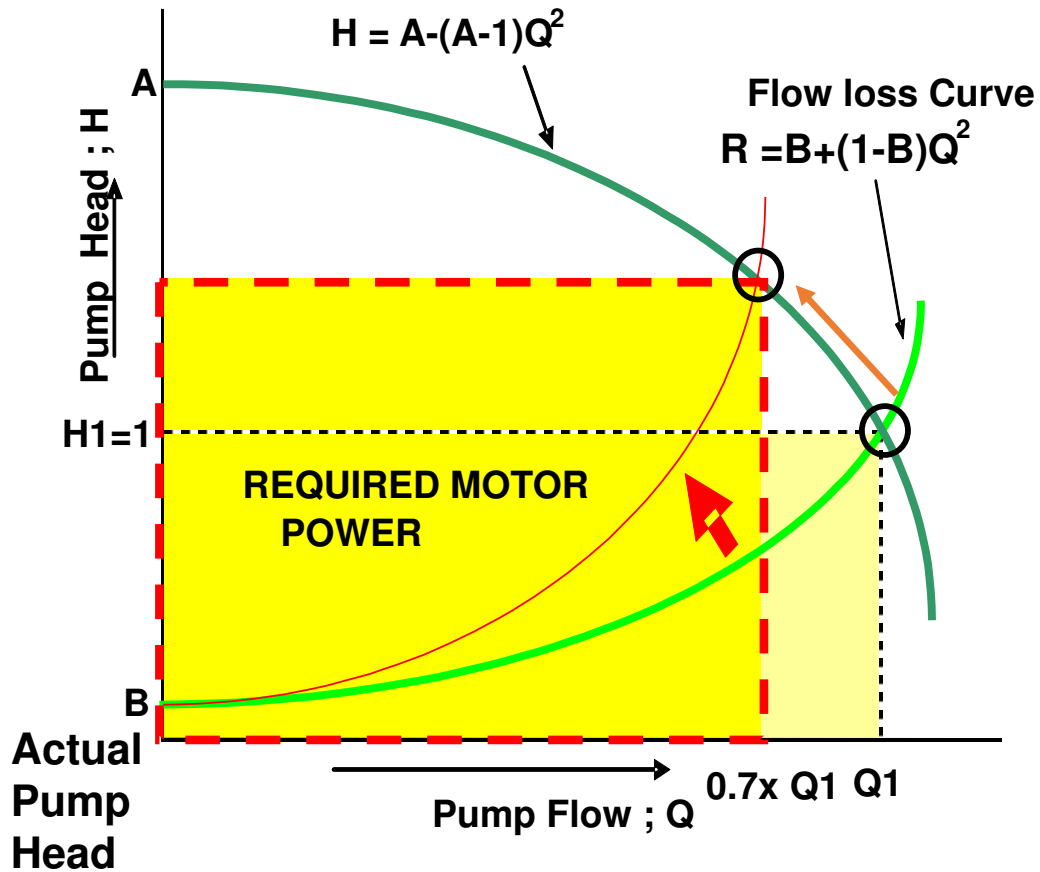g ; Acceleration of Gravity (9.8 m/s^2)

H ; Head (m)

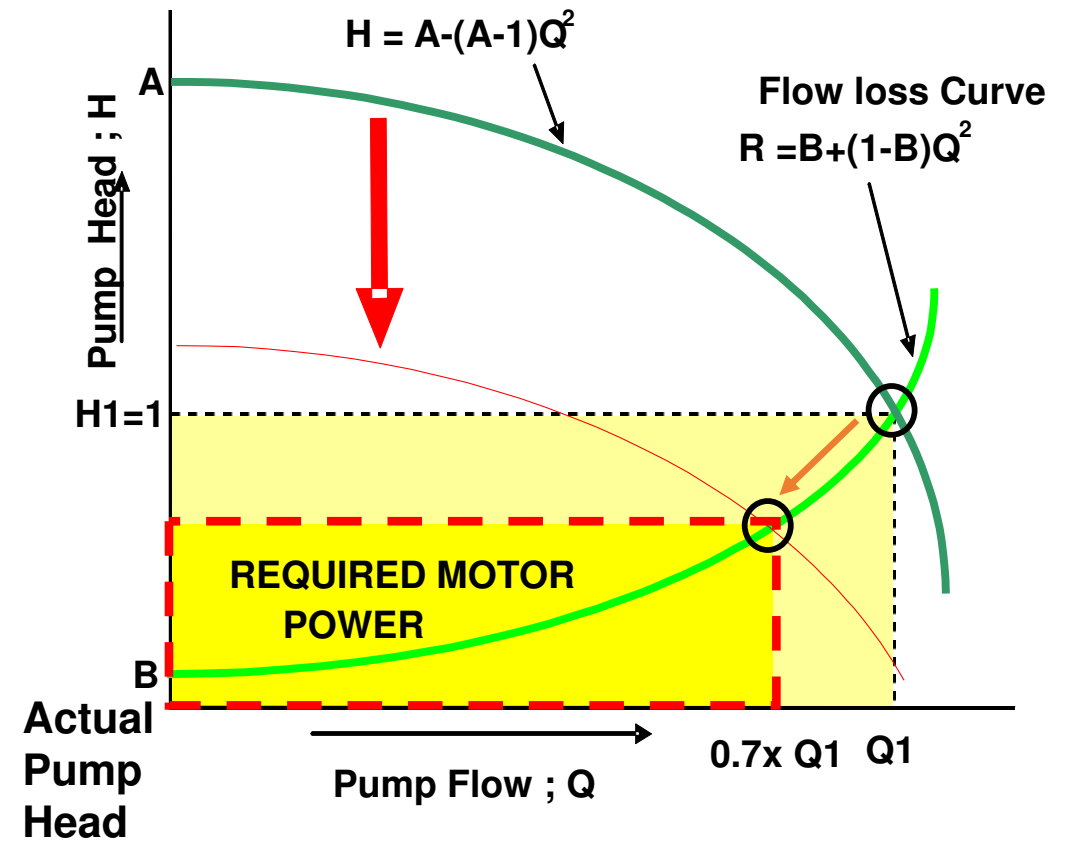## Shaft Power (Ps)

$$Ps = Ph\, /\, \eta \ \text{[kW]}$$

η ; Pump Efficiency

PUMP Q-H CURVE

$$H = A-(A-1)Q^2$$

Flow loss Curve
$$R = B+(1-B)Q^2$$

Running point

H1=1

REQUIRED MOTOR CAPACITY

Actual Pump Head

B

Q1

Pump Flow ; Q

Pump Head ; H
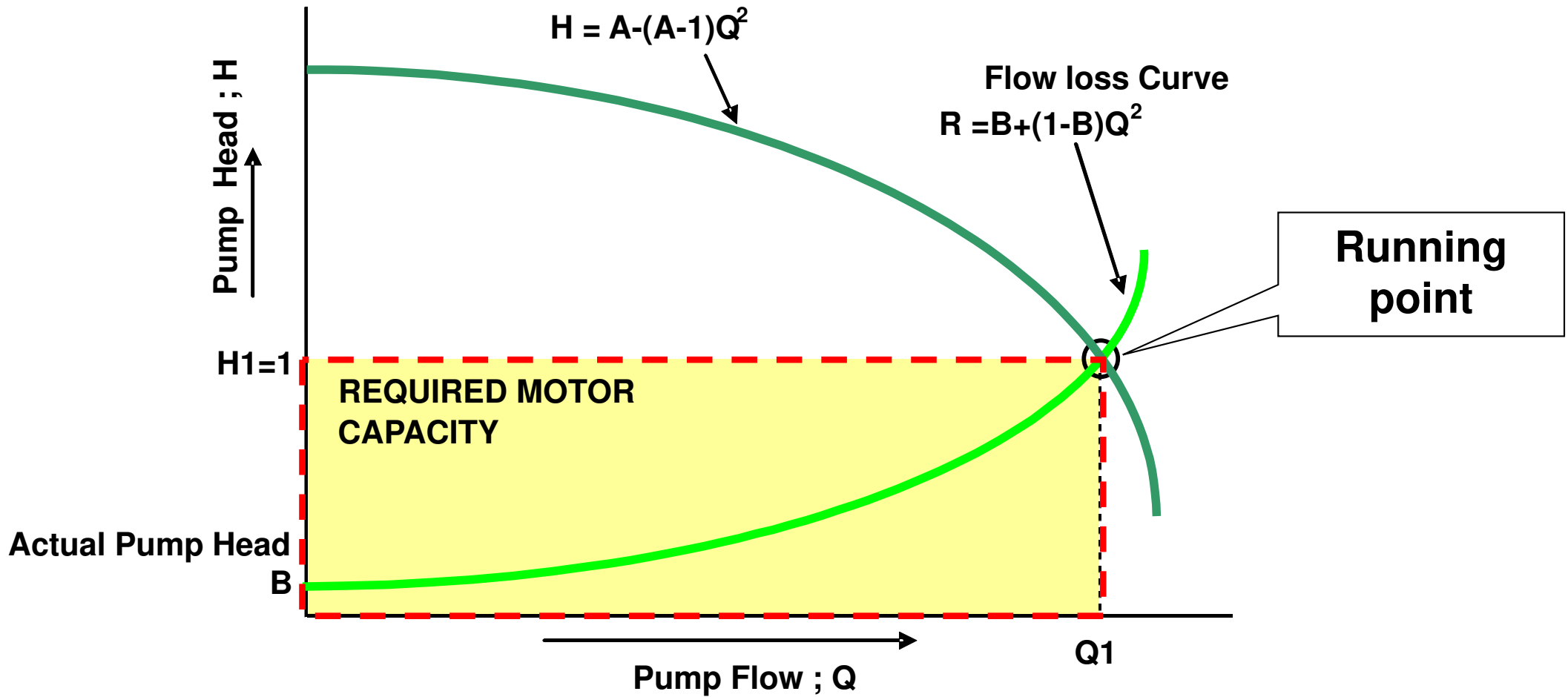
VALVE CONTROL vs SPEED CONTROL

Valve Control

Speed Control

$H = A-(A-1)Q^2$

Flow loss Curve $R = B+(1-B)Q^2$

Pump Head ; H

REQUIRED MOTOR POWER

H1=1

Actual Pump Head

Pump Flow ; Q

0.7x Q1   Q1

Energy Saving Applications

INDUSTRIAL FIELDS

- Petrochemical Plant
- Water Treatment
- Rubber & Film Plant
- Cement Plant
- Steel Plant
- Pulp & Paper
- Thermal power station
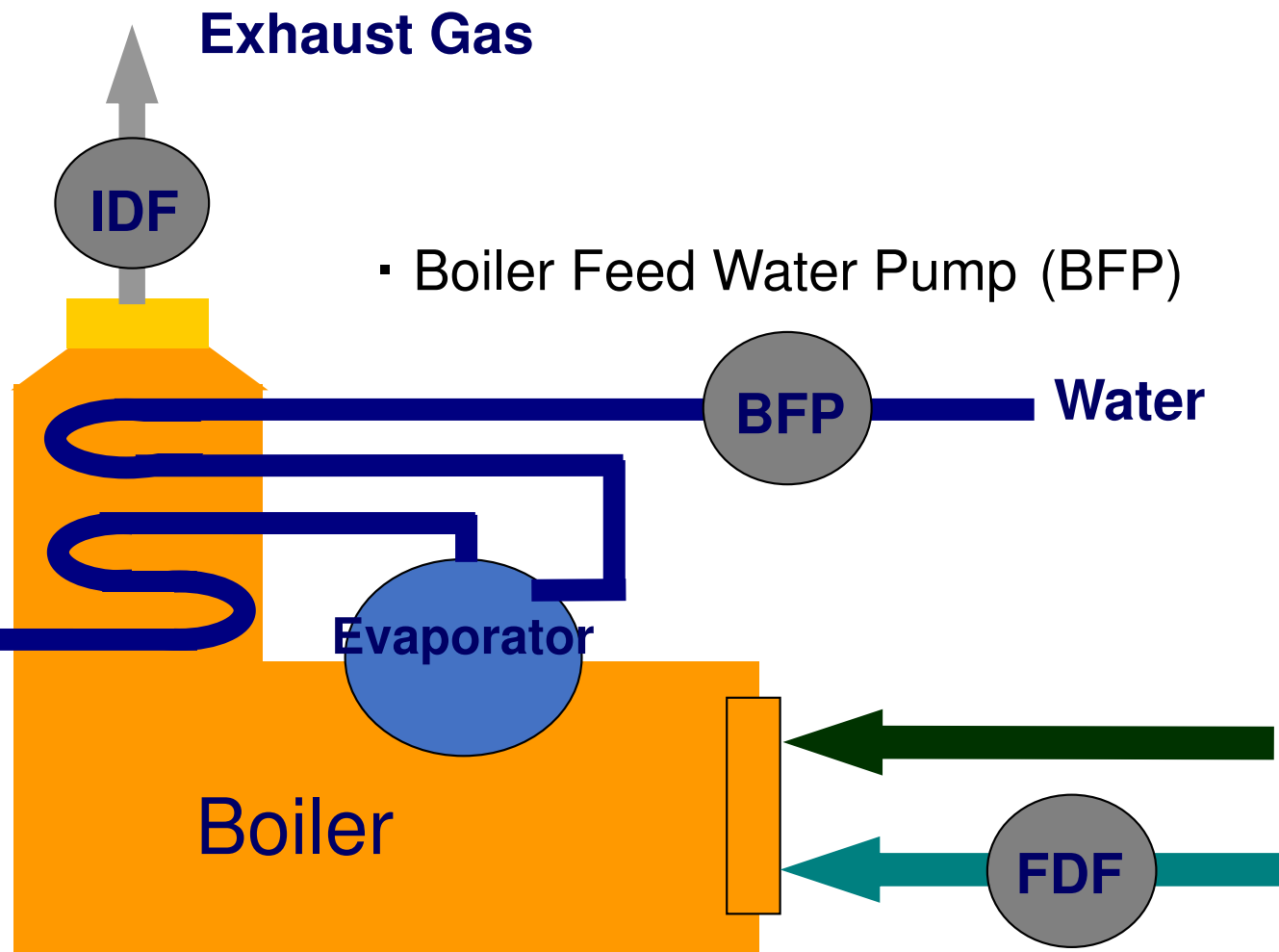- Mining

APLICAPTIONS

- Fans
- Blowers
- Pumps
- Compressors

Auxiliary drive for boilers

Exhaust Gas

・ **Induced Draft Fan (IDF)**

IDF

・ Boiler Feed Water Pump （BFP）

BFP Water
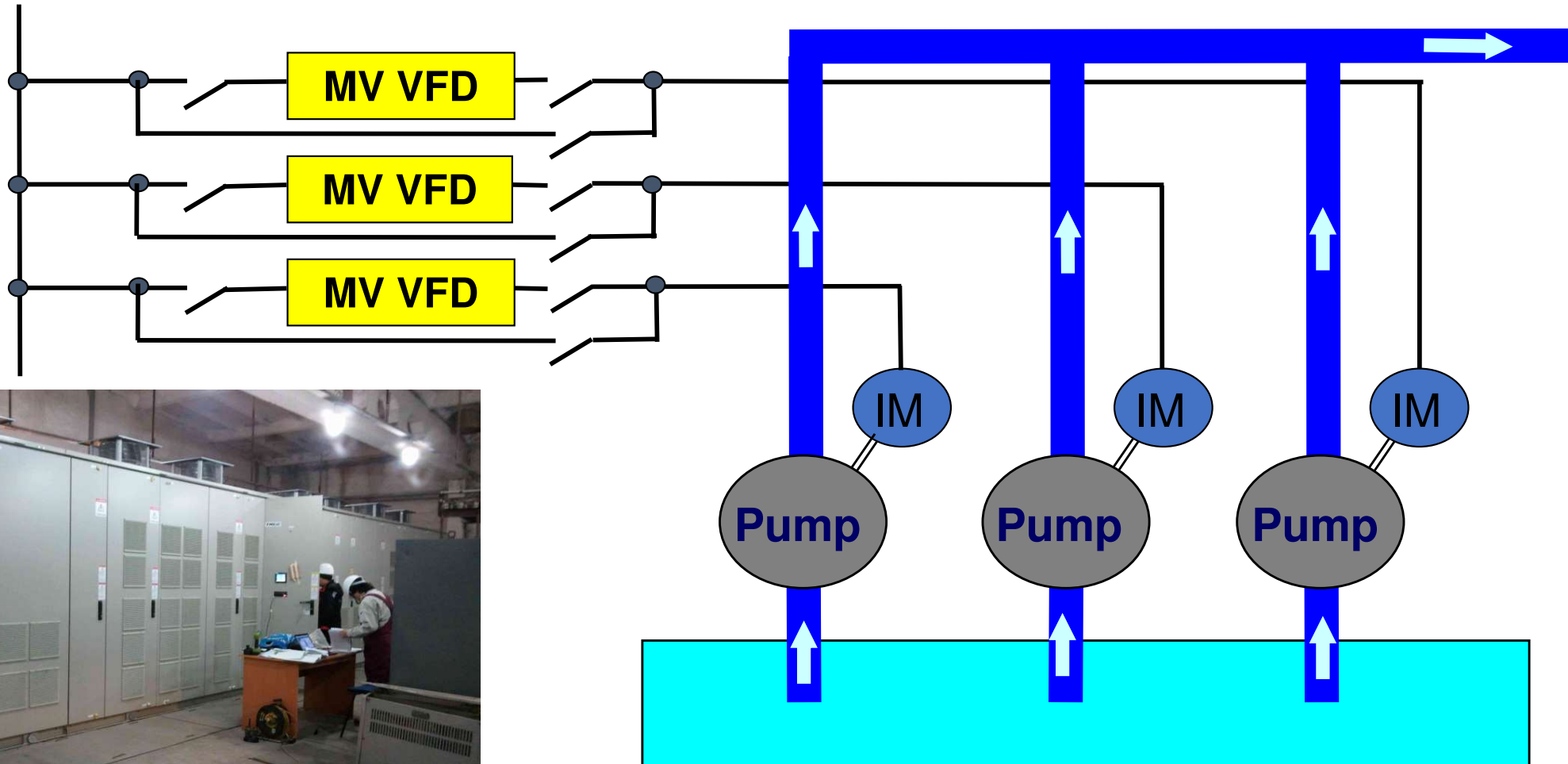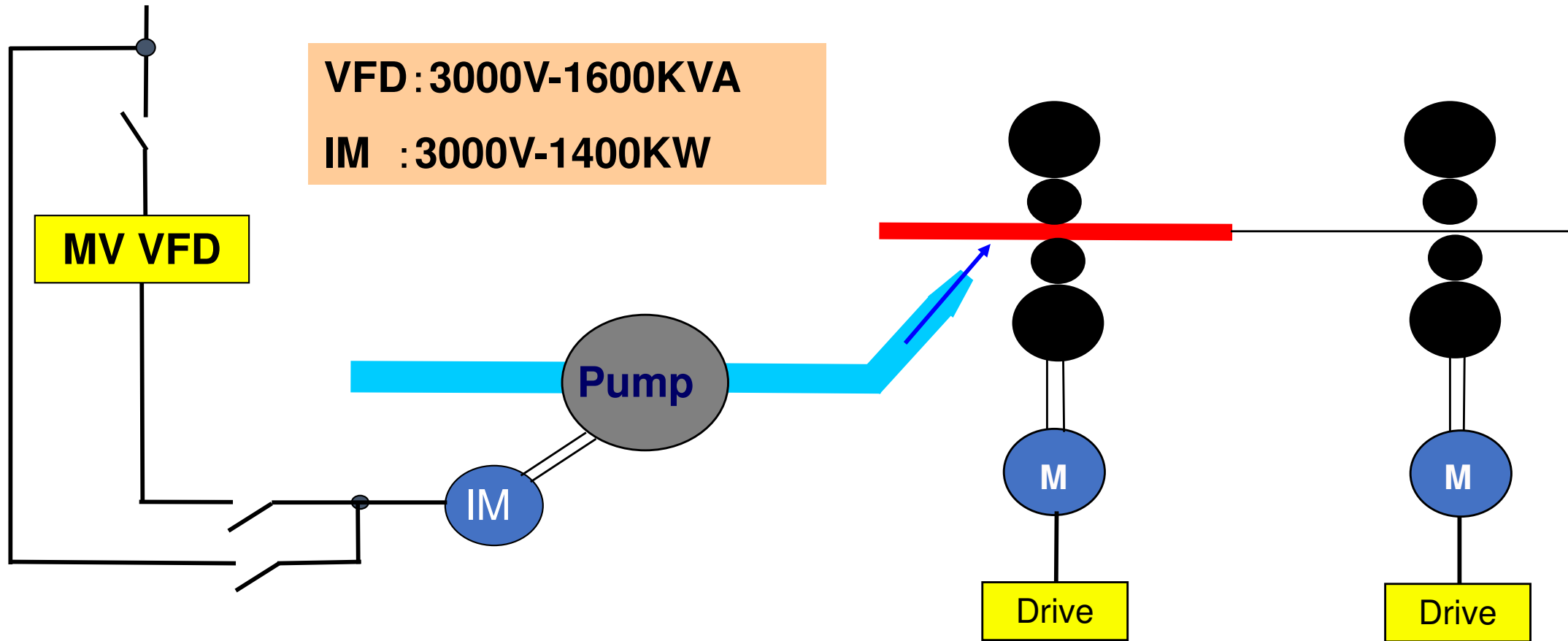
Steam

Evaporator

Boiler

FDF

・ **Forced Draft Fan （FDF）**

Pumps for water supply

Water pump drive system in Kazakhstan
(11kV/2650kVA MVG2)

De-scaling water pump for Steel mill

MV VFD

VFD：3000V-1600KVA

IM ：3000V-1400KW

Pump

IM

M

M

Drive

Drive

TMEiC   *We drive industry*

Centrifugal Compressor

- **Conversion from a steam turbine to an electric motor with VFD**
- **Efficiency of motor and VFD is higher than boiler and turbine.**
- **Optimization of energy consumption and balance in a plant.**

Conversion of Wound rotor motor to Squirrel cage motor for VFD operation

- **If a wound rotor motor is speed-controlled by a liquid rheostat, it can be converted for a squirrel cage motor for speed control by VFD.**

- **The rotor circuit will be short-circuited and VFD will be applied for speed control.**

- **In case that a wound rotor motor speed is fixed, and flow is controlled by a valve, VFD can be applied as well.**
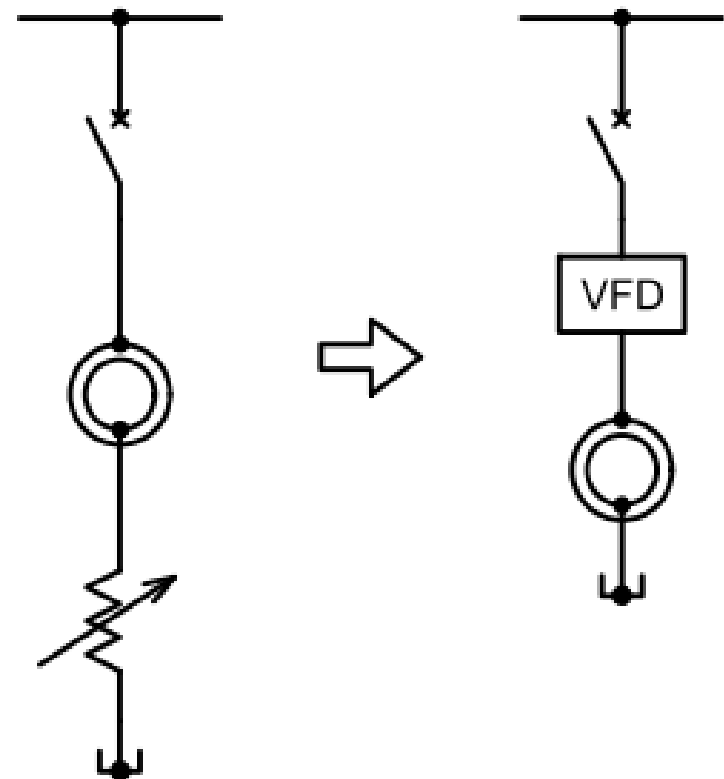
SUMMERY OF ENERGY SAVING SOLUTION

1. Higher motor efficiency will reduce power consumption and save energy.

2. VFD for speed control of motors will save energy.

3. VFD can basically be applied to the existing motors with consultation of a motor supplier.

4. A combination of a motor with higher efficiency and VFD speed control will save energy consumption much more.

5. Conversion of steam turbines to motors will reduce energy consumption and GHG (Greenhouse gas).

Thank for your kind attention

INTRODUCTION

- **Name**
  Yoshihiko Kawabata

- **Company**
  TMEIC Corporation

- **Title**
  Senior Fellow

- **Speciality**
  Motor & Drive (VFD) system engineering

- **E-mail**
  KAWABATA.Yoshihiko@tmeic.co.jp