

ICREPQ'07  
Seville

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ABB



Development,  
innovations and  
transformer  
solutions



# Transformer Development, Innovations and Solutions

- **Energy is precious.**
  - Energy conservation and reliability of supply are actual topics these days.
  - Efficient and environmentally sound operation of power plants, distribution networks and industrial processes.
- **Reliable systems for cost-effective and secure power supply**
  - The classical objective triangle for power supply consisting of economy, reliability and environmental impact.
- **Innovations for utilities and industry.**
  - To use the existing operating resources to maximum effect, and thus ensure secure returns on investment.



# Transformer Development, Innovations and Solutions

- **Transformers** are one of the most important and costly components and the critical nodes in the electricity networks.



- Utilities have to use their existing equipment more efficiently ensuring **high reliability** and an adequate level of **quality** in the service provided.

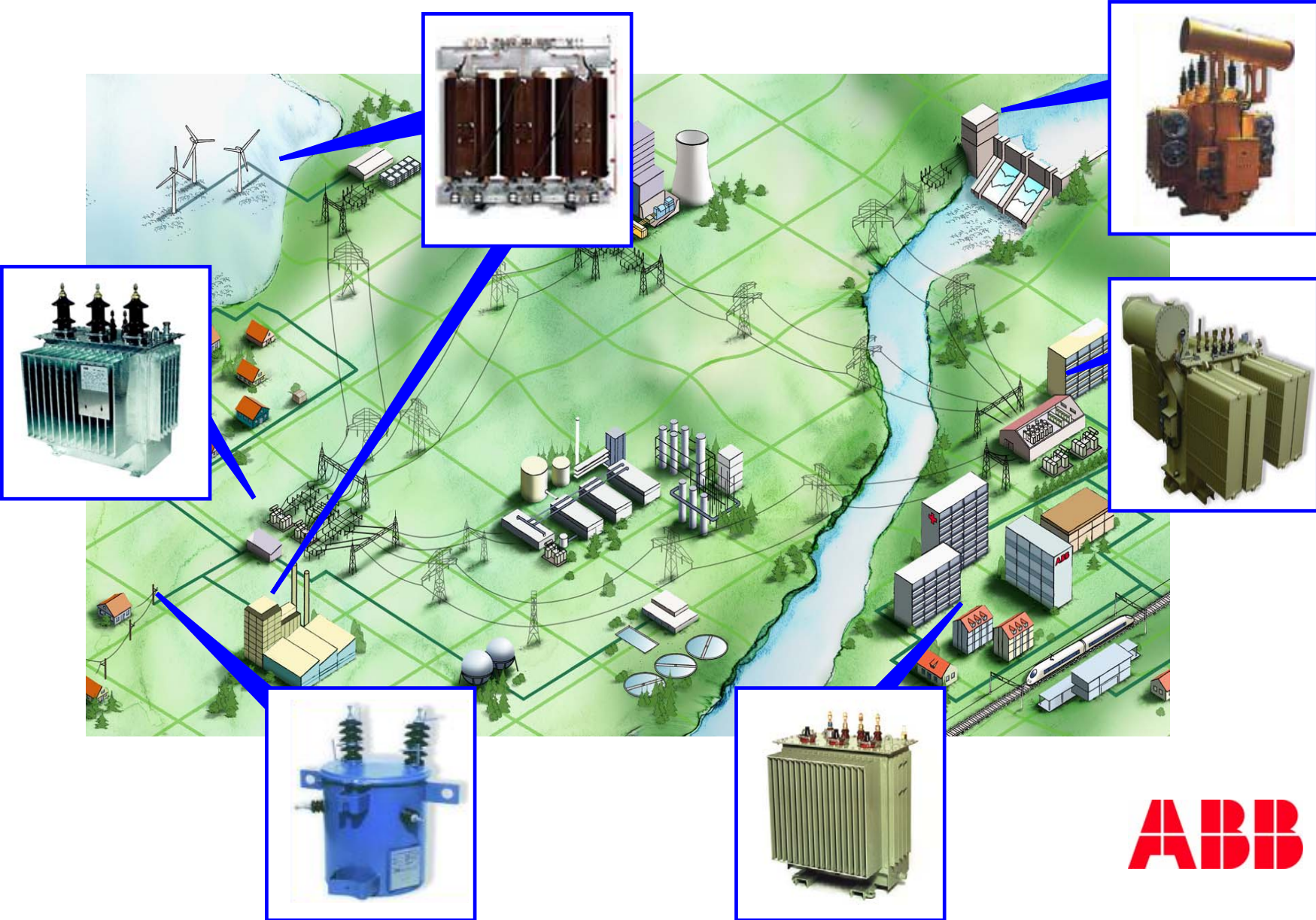


# Transformer Development, Innovations and Solutions

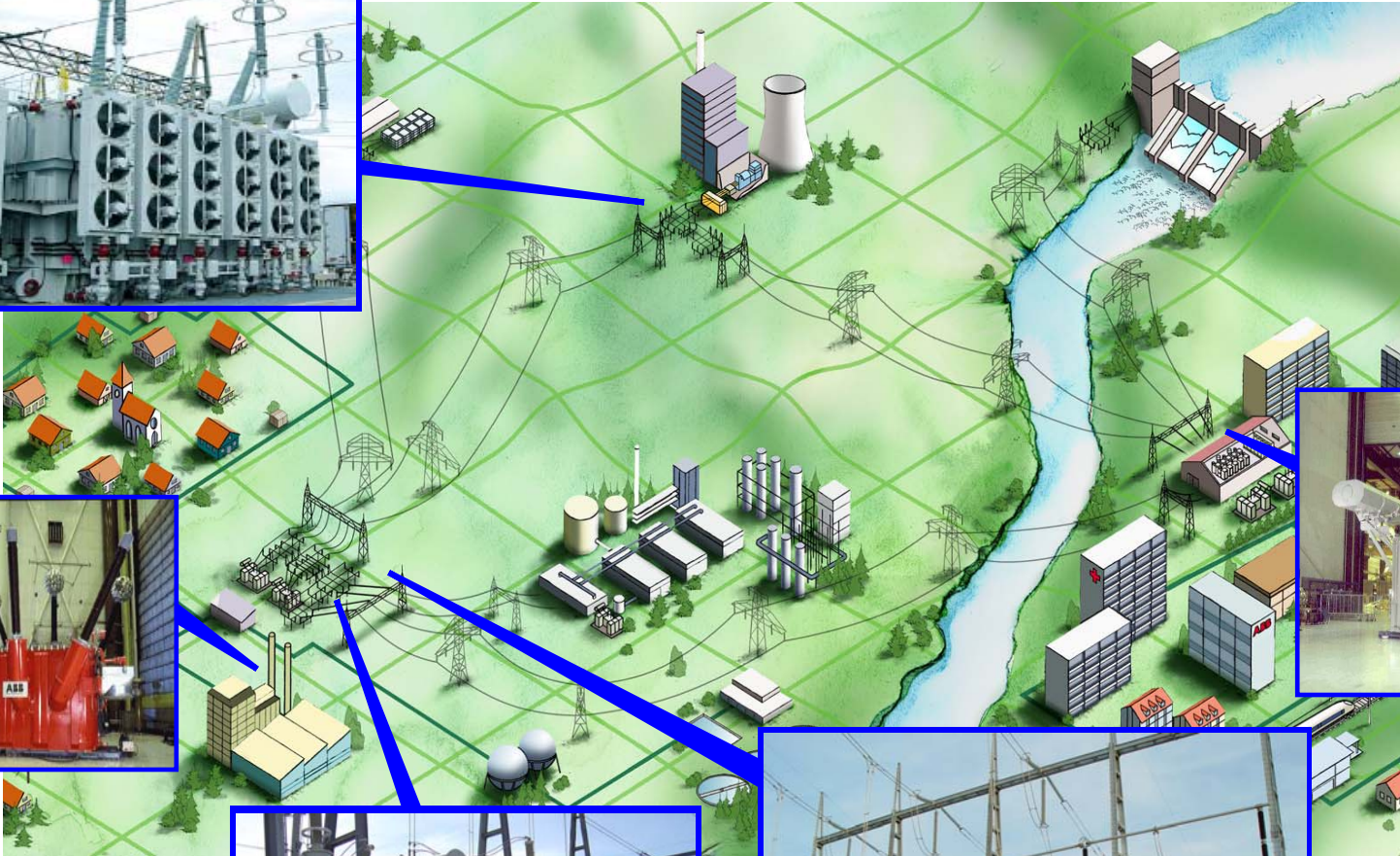
- **Energy efficiency, environmental care, reliability and secure supply of electricity.**
  - **Innovation and development:**
    - Efficiency: Reduction of losses.
    - Noise level reduction.
    - Dry type transformers of higher voltages.
  - **Transformer solutions:**
    - Polytransformers and universal GSU's.
    - On field repair and upgrading.
    - HV testing on site.



# Distribution Transformers



# Power Transformers



# Transformer Innovation and Development

## Cooling system

- Cooling systems
- Cooling design

## Insulation system

- 800 kV HVDC
- Safe Insulation
- Diagnostics
- Processing

## Mechanical design

- Design/materials
- Manufacturing
- Short circuit strength

## Acoustic - Noise

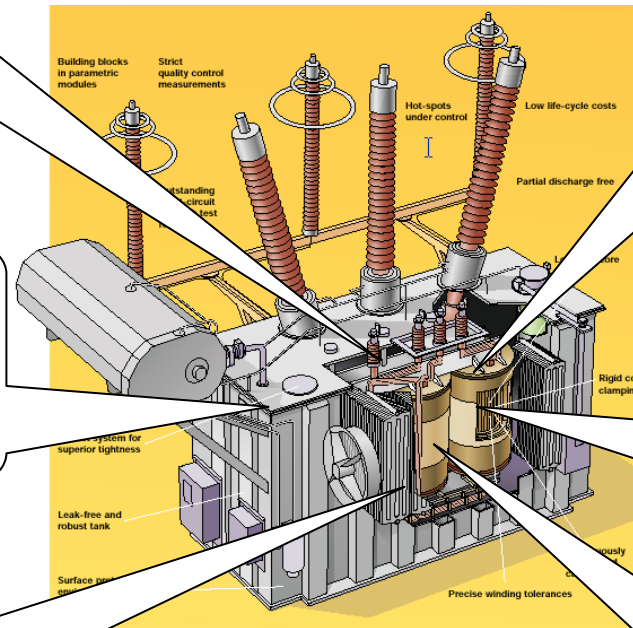
- Higher requirements and regulations.

## Core & magnetics

- Core optimization
- Magnetic materials

## E&M modelling

- Hf transient sim & network interaction
- Losses

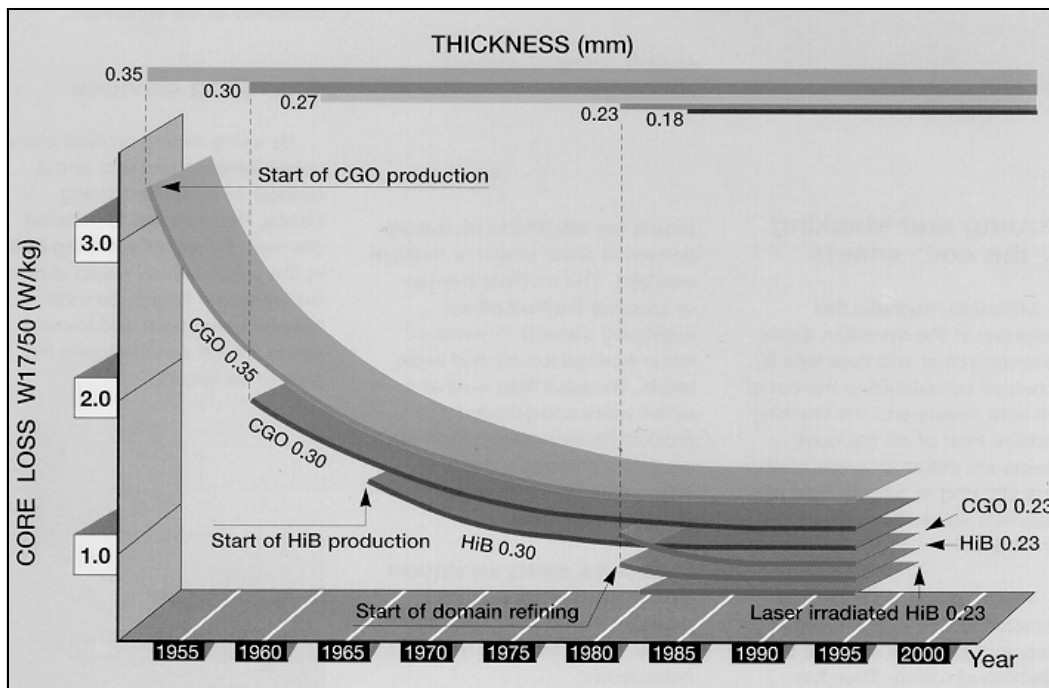


Reduction in losses.  
Noise level reduction.  
Dry type transformers of higher voltages.



# Efficiency: Reduction of Losses

- No load losses: Different material grades.
  - RGO: Regular grain oriented.
  - HIB: Highly oriented – High permeability.
  - DR: Domain Refined (Laser scribed).



Designation	Typical long term iron loss P17/50 (W/kg)
30R122	1,22
27R115	1,15
23R101	1,01
30H102	1,02
27D084	0,84
23D078	0,78
23D083KSC	0,83



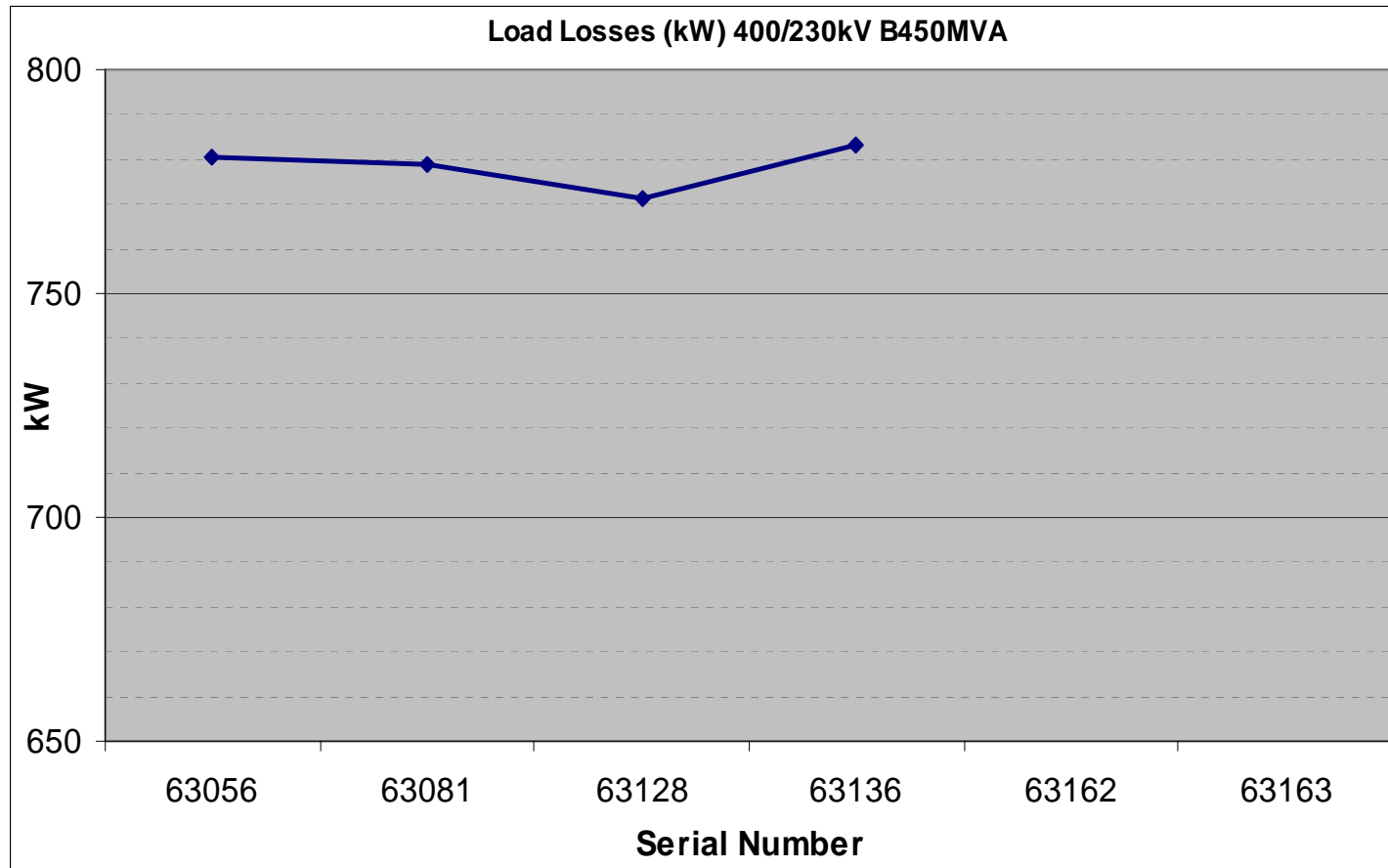
# Efficiency: Reduction of Losses

- Load losses reduction:
  - The use of 3D magnetic field calculation tools allow to reduce load losses.
  - Circulating current losses: Optimum location of transpositions.
  - Stray losses: By an adequate location and dimensioning of magnetic shielding.



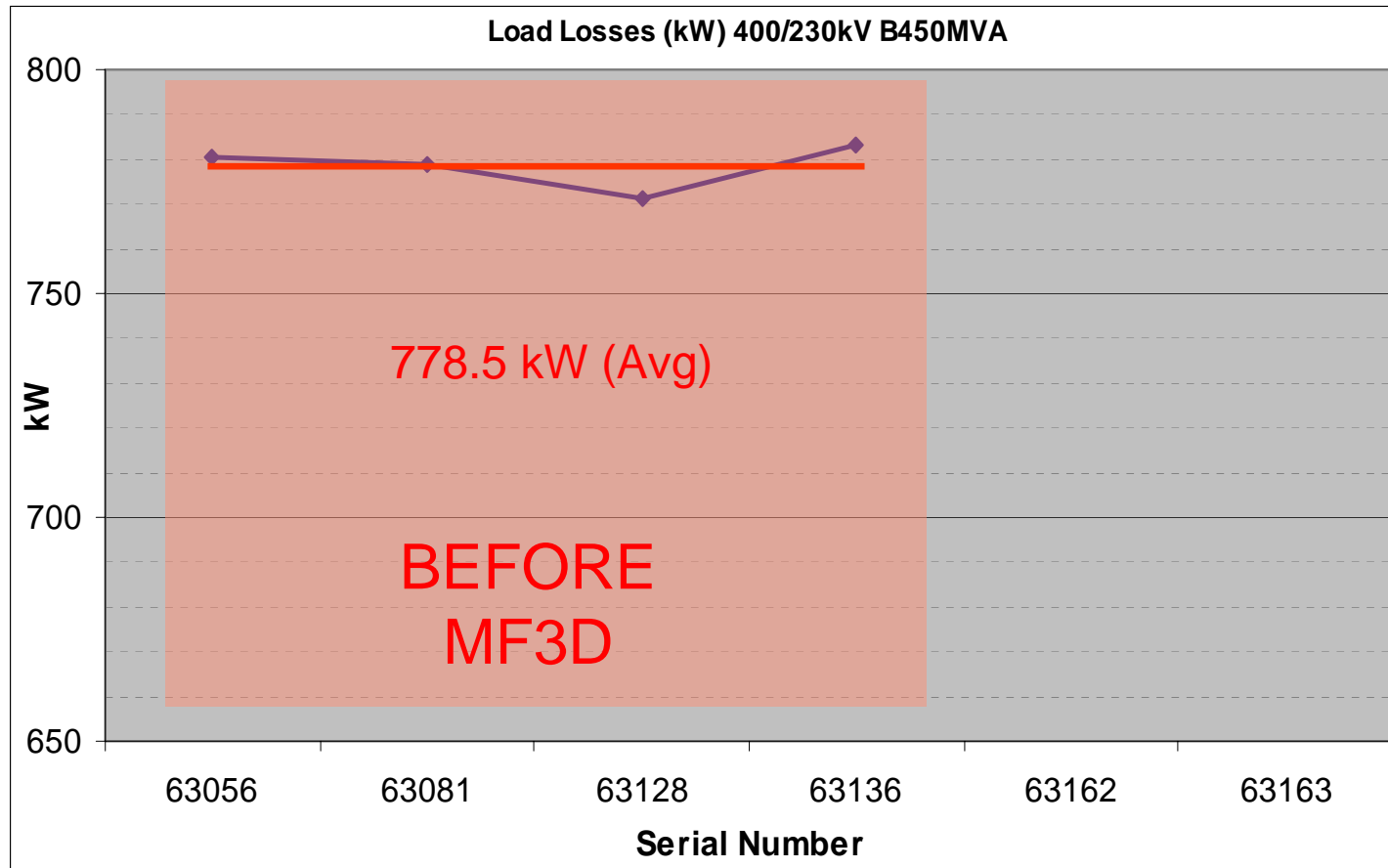
# Efficiency: Reduction of Losses

- Use of 3D magnetic field calculation tools to reduce Load losses:



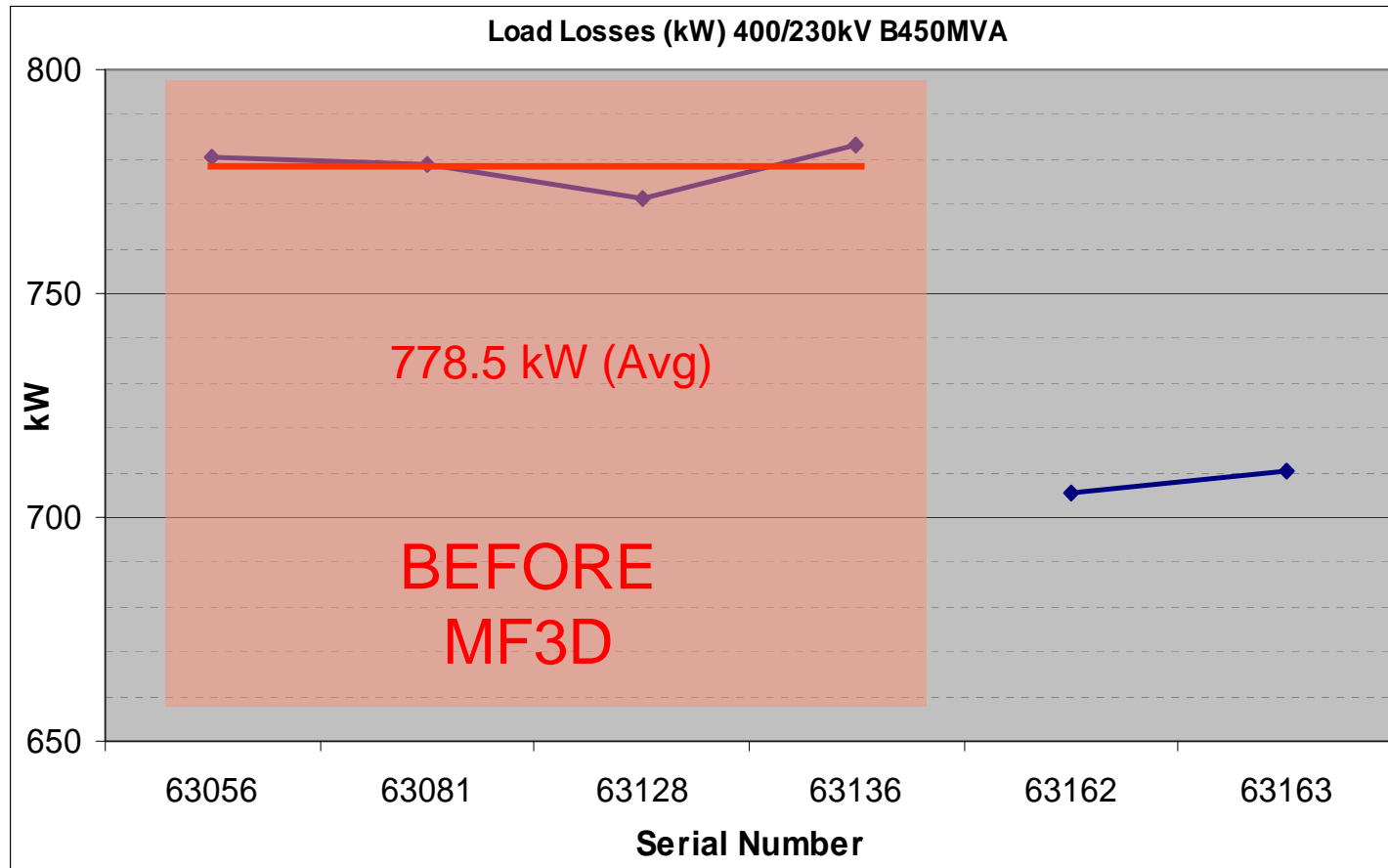
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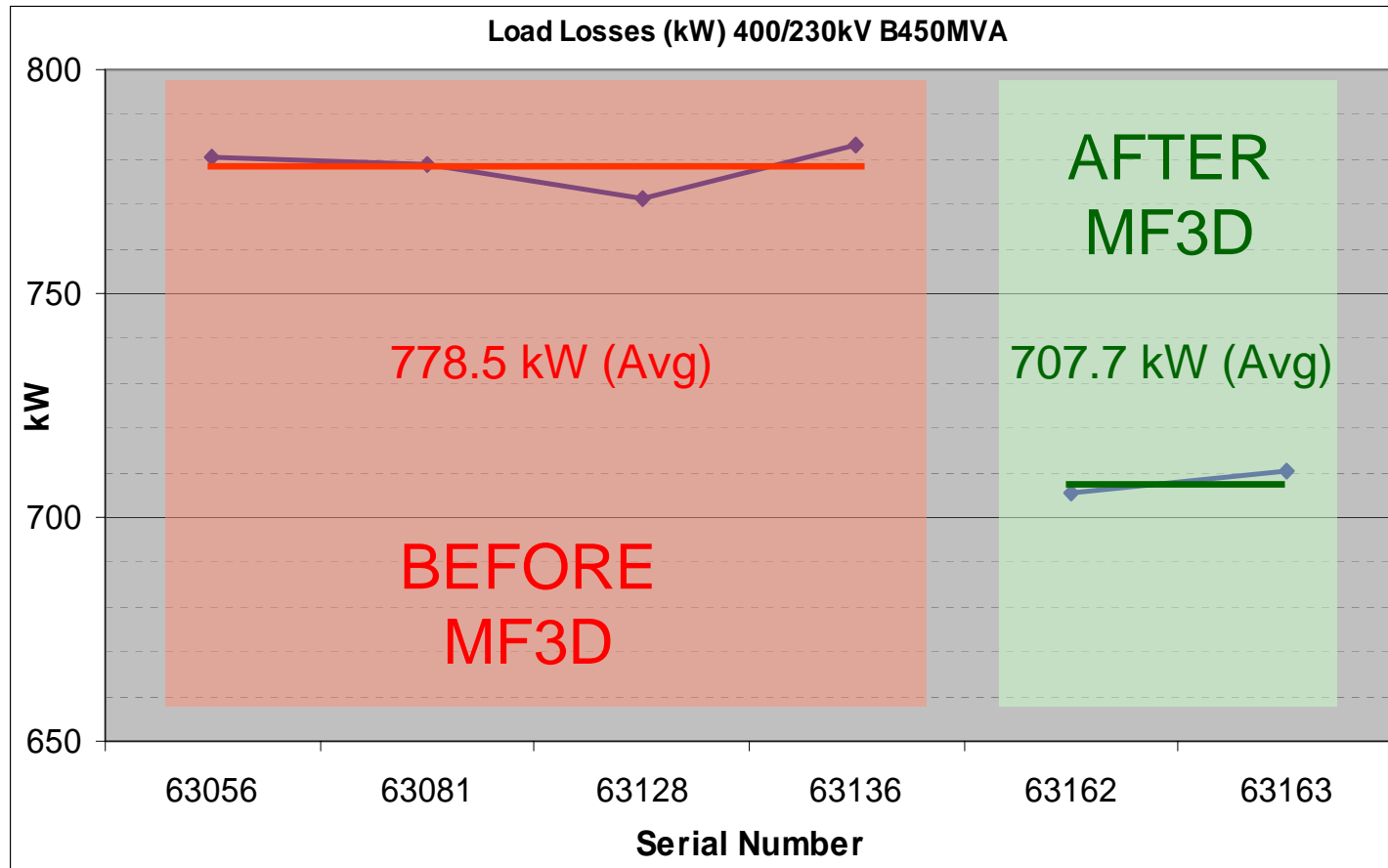
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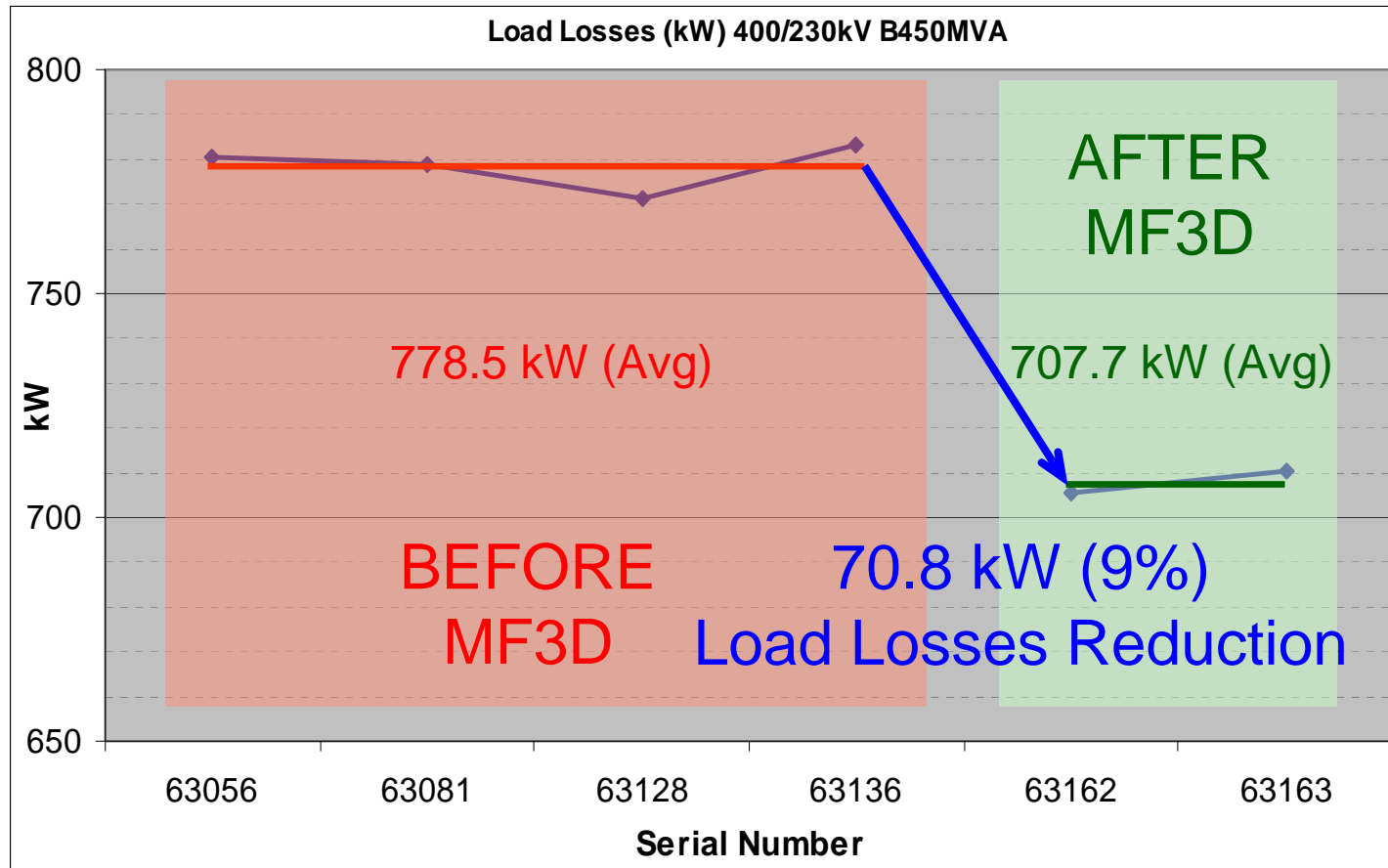
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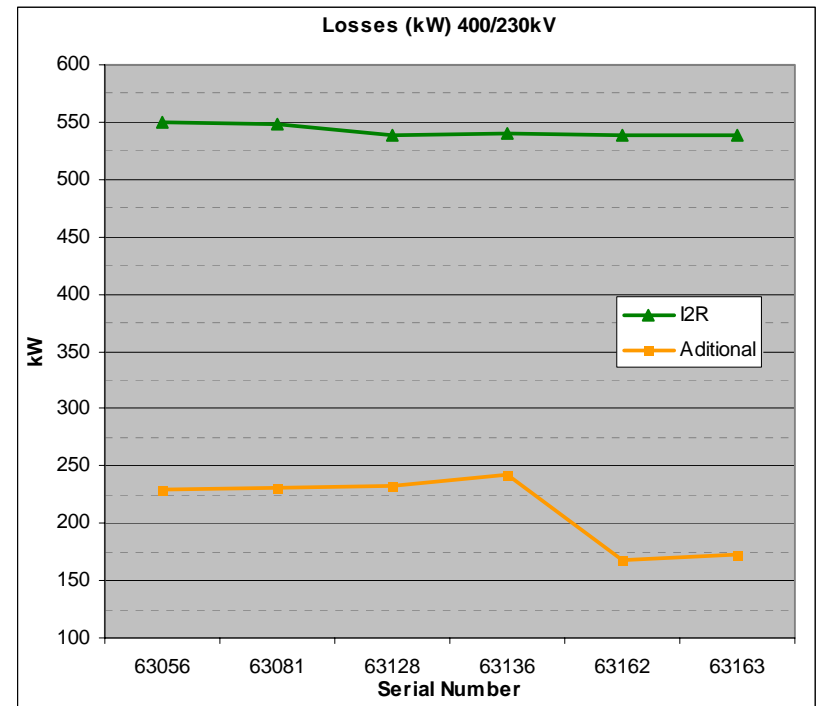
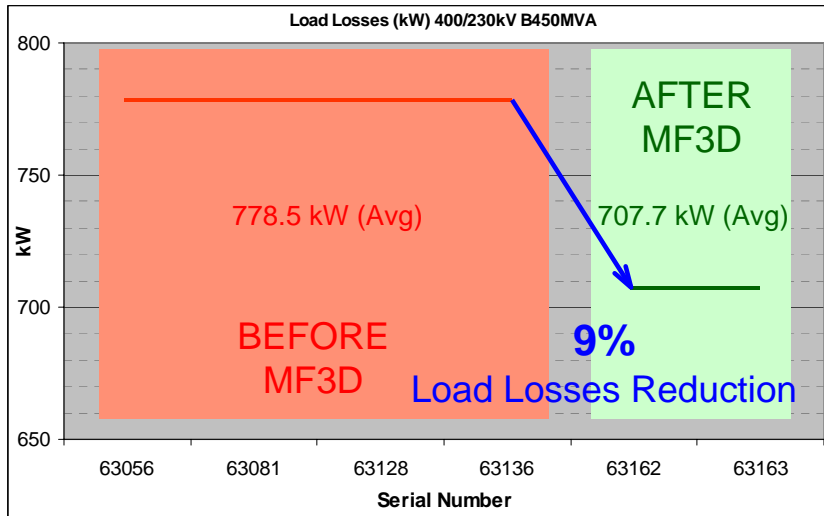
# Efficiency: Reduction of Losses

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# Efficiency: Reduction of Losses

- Use of 3D magnetic field calculation tools to reduce Load losses:



I2R Losses: Constant (1% difference)

**Additional Losses (Eddy, CC, Stray):**

Before: 234kW (Avg.)

After: 170kW (Avg)



**27% Reduction**

# Sources of Noise from Power Transformers

- **No - Load Noise**

- Core Noise.

- Caused by Magnetostriction of core material.

- Cooling Equipment Noise.

- Caused by Fans and Pumps.

- **Load Noise**

- Leakage Flux.

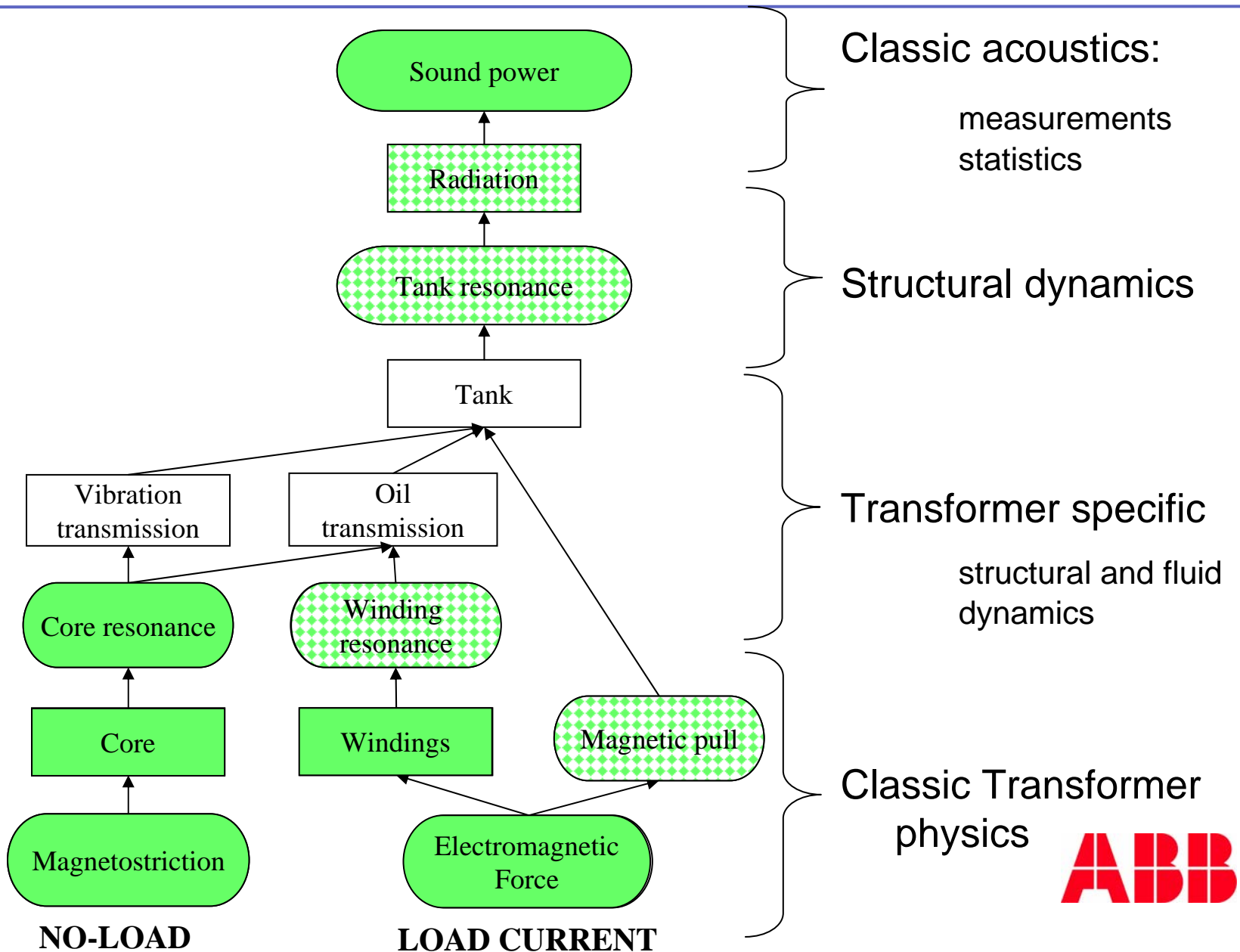
- Produced by vibrations of the windings and tank.

- Exclusively 100 Hz or 120 Hz.

**Total Noise = No-Load Noise + Load Noise**



# Noise level reduction



# Noise level reduction

- Vibration isolation between core and tank
  - Combined with evacuated membrane cells.
  - Most effective for No-load sound.
- Membrane absorbers
  - Combined with vibration isolated core supports.
- Sound panels



110 MVA transformer

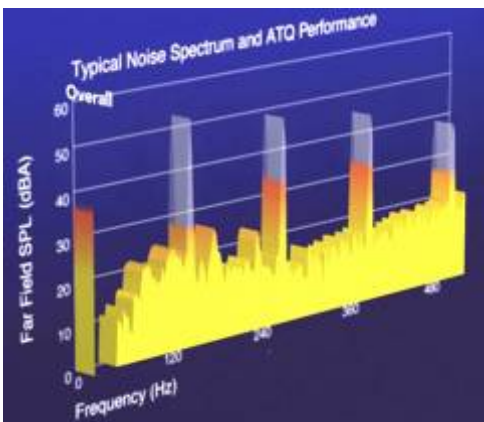
Tank-mounted sound panels  
covering 4 walls and top

Reduction: 11 dBA

Sound pressure level 60 dBA



# Noise level reduction: Active noise control



## ■ Active Noise Control

- Reduce tonal components of the noise spectrum.

## ■ Features

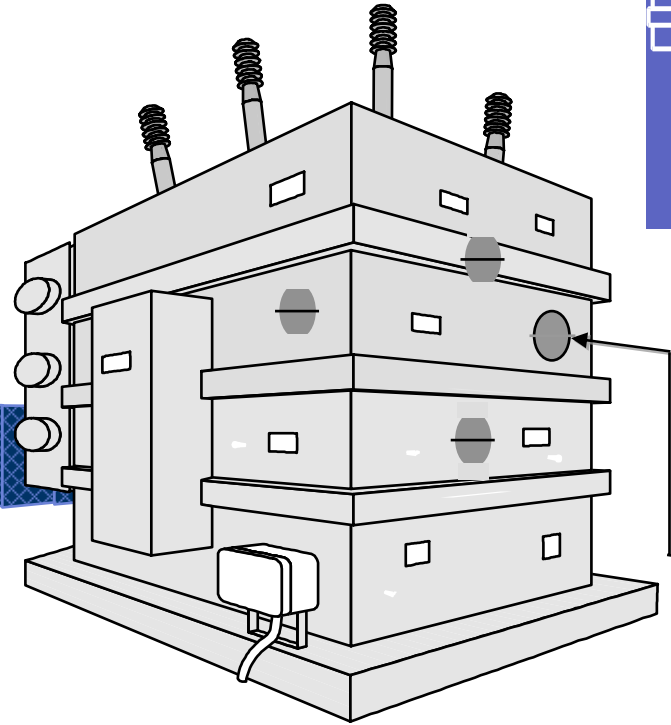
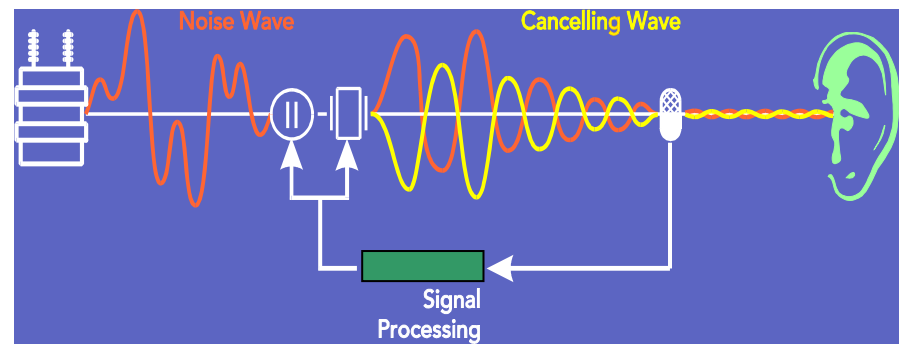
- Reduce low frequency tones in several directions.
- It can be applied to existing transformers.

## ■ Benefits

- Up to 15 dB reduction @ 100/120 & 200/240 Hz
- No cooling perturbation
- Free access to the transformer for maintenance
- System could be reused on other transformers
- Allows to build houses closer to substations
  - Increased value of the surrounding land

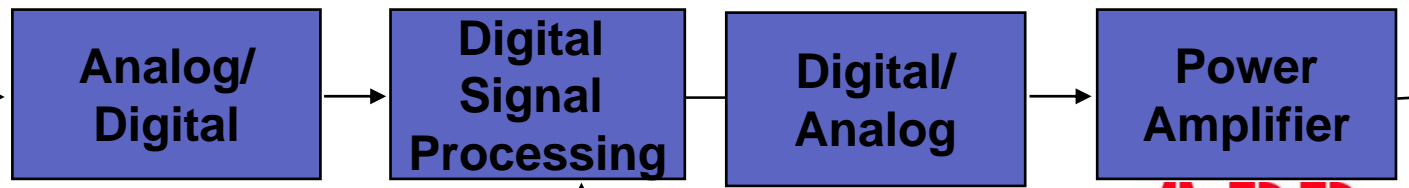


# Noise level reduction: Active noise control



Microphone

**Resonant Acoustic Device**  
applied wave, equal in magnitude and 180° out of phase



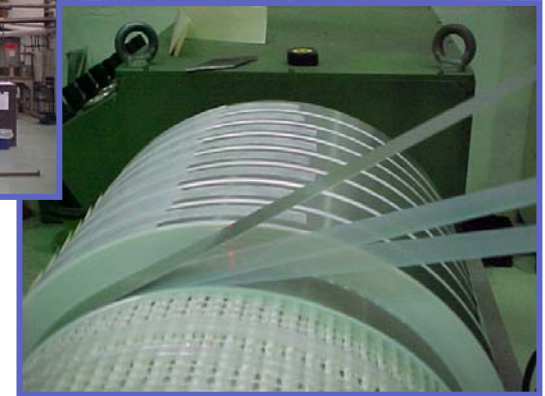
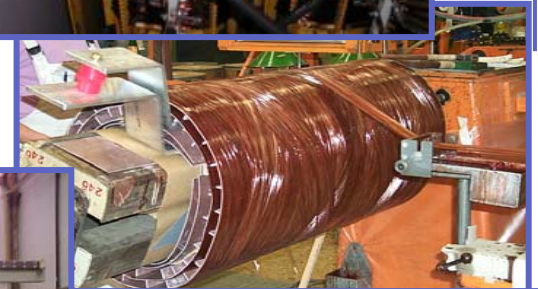
Line Frequency



# Dry type transformers

## Continuous technology advances

- Dry type transformer technology, although well proven is relatively new and is in continuous development.
- New manufacturing processes.
- New insulation materials.
  - Class F, Class H, Class C.
  - Less size for the same power.
- New applications concept.
  - Low losses.
  - Green transformers.
  - Low temperature designs.
  - Special application designs.



# Large Power & Large Voltage levels in Dry

- Dry type transformers have been historically been limited to MV applications
- Conventional voltage/power ranges in Dry type transformers
  - HV up to 36 kV – 170 kV BIL level
  - Up to 10 MVA
- New power demands require larger transformers
  - On Load Tap Changer Transformers
  - Power above 40 MVA
  - Voltage high level up to 52 kV series
    - Higher voltages under development



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# Dry type transformers for Windmill applications

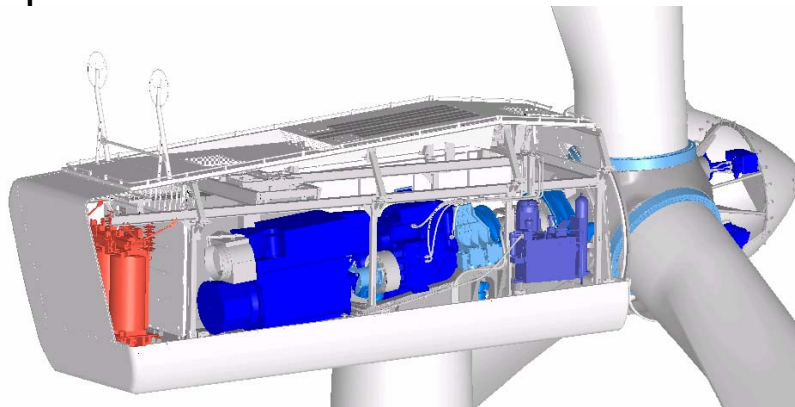
## Environmentally friendly

- Ecological: no risk of oil spillage.
- No visual impact of transformer located outside.
- Eliminates fire hazard.
- Safety for people and property.



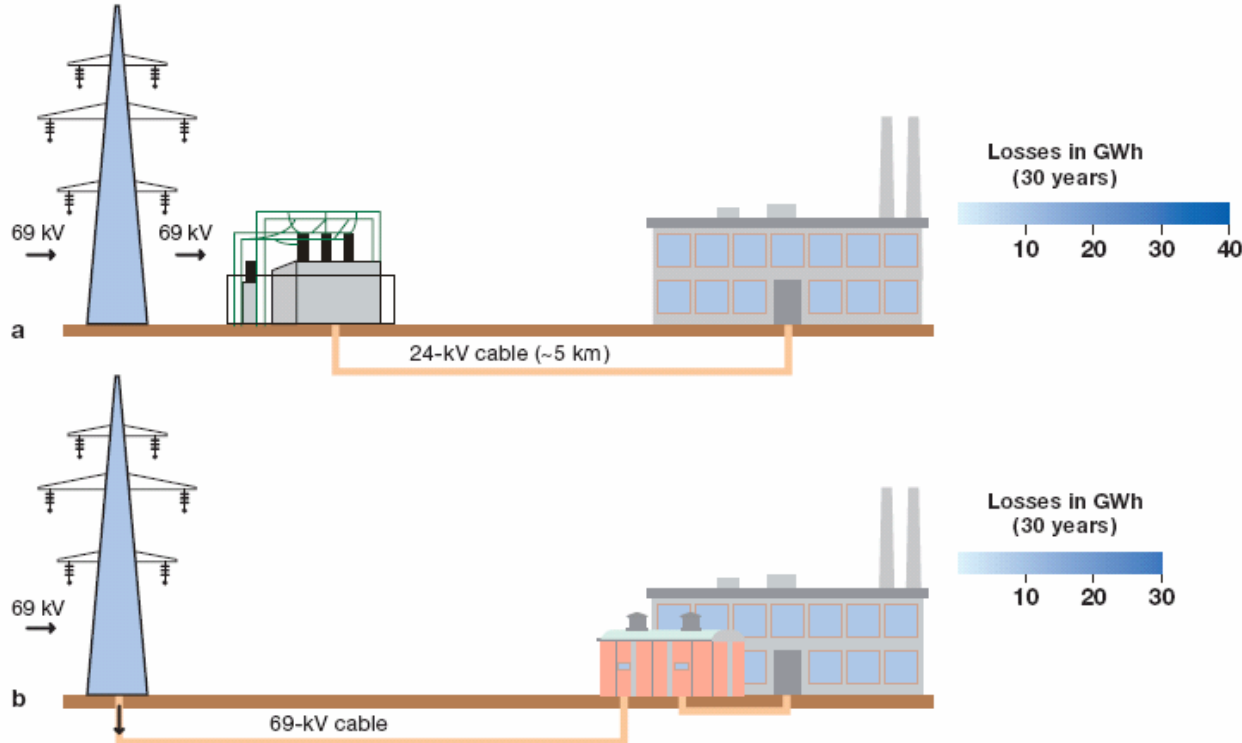
## Special designs

- Reduced dimensions to enter through the door.
- Up to 4500 KVA Transformer installed in the Nacelle.
- Prototypes up to 6000 KVA.



# Applications dry type – Urban Substations

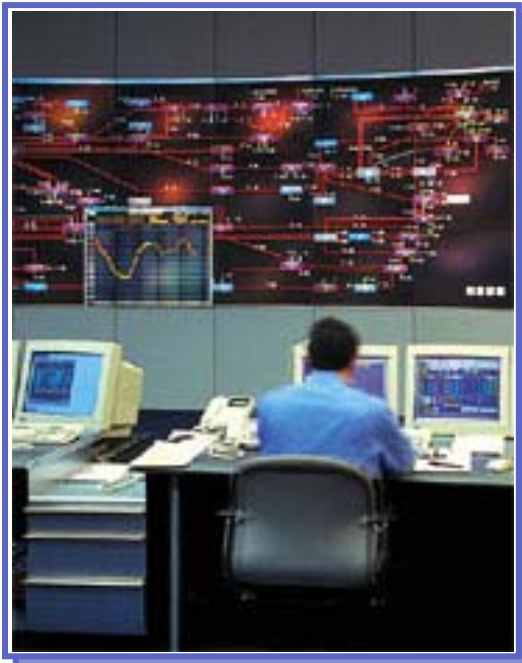
- **Saving in losses with Dry transformers. Sitting the power transformers five km closer to the load enables 69 kV cable to be used (instead of 24 kV cable) for the extra distance. Quantified over a 30-years period, the total saving is 8.5 Gwh or 280 MWh per year. The saved losses can be also expressed in terms of reduced emissions (CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>)**



# Transformer solutions to secure the supply

- In today's competitive environment, it is imperative to assure a **secure supply of electricity** with:

- Strict cost control.
- Reliability and Quality.



- As a consequence, there is a need of:
  - Increased equipment utilization.
  - Reduction of forced outages.
  - Reduction of failure rates.



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# Transformer solutions to secure the supply

- Large power transformers reliability is very important:
  - They are critical for the operation of the system.
  - Their replacement implies considerable time and cost.
- Actions to optimize performance and reliability:
  - (1) Scheduled and predictive maintenance operations:
    - To determine and follow up the actual condition of the transformers.
    - Minimizes incidences.
    - Optimises performance.
  - (2) Contingency planning:
    - Arrangements in case of a transformer failure that results in a prolonged outage.
    - To mitigate risks. It includes:
      - Redundant transformers.
      - Spare units.



# Polytransformer

## The Multivoltage Substation Power Transformer

- Different voltage levels both in HV and LV.
- Multiple voltage levels on tertiary winding.
- Designed to be connected to different transmission systems.
- Compact easy to transport.
- Designed to be used as universal spare.
- Minimizes number of spare units even in case of complicated networks.



# Polytransformer

The Polytransformer may be used for several applications:

## (1) Spare Transformer:

The Polytransformer may replace a wide number of different transformers from several substations.

The Polytransformer is a multi-voltage spare transformer that can be used as a universal spare unit.

## (2) New Substations:

The standardized design allow the Polytransformer to be used in new substations. It can be installed permanently on-site or used as temporary replacement of other units.



# Polytransformer

## (3) Valuable asset:

It can be rented, leased or lent to others in case of emergency or temporary need to cover the requirements of other utilities.

## (4) Peaks of load:

It could be used to provide additional power in the network during seasonal or emergency consumption peak periods. This reduces the risk of black outs, and will prevent other installed units from being overloaded.

## (5) Reduction of inventory and maintenance cost:

As the Polytransformer can take the place of different transformers, the total fleet of transformers in a system could be reduced, reducing the inventory, investments and maintenance costs.



# Polytransformer

All available transformation ratios (REE, Politrafo)

HIGH	LOW	TERTIARY
400 kV	230 kV	33 kV
400 kV	138 kV	33 kV
400 kV	110 kV	33 kV
400 kV	230 kV	26.4 kV
400 kV	138 kV	26.4 kV
400 kV	110 kV	26.4 kV
400 kV	230 kV	24 kV
400 kV	138 kV	24 kV
400 kV	110 kV	24 kV
230 kV	132 kV	19 kV
230 kV	107 kV	19 kV
230 kV	132 kV	15 kV
230 kV	107 kV	15 kV
230 kV	132 kV	13.8 kV
230 kV	107 kV	13.8 kV





# Universal GSU's

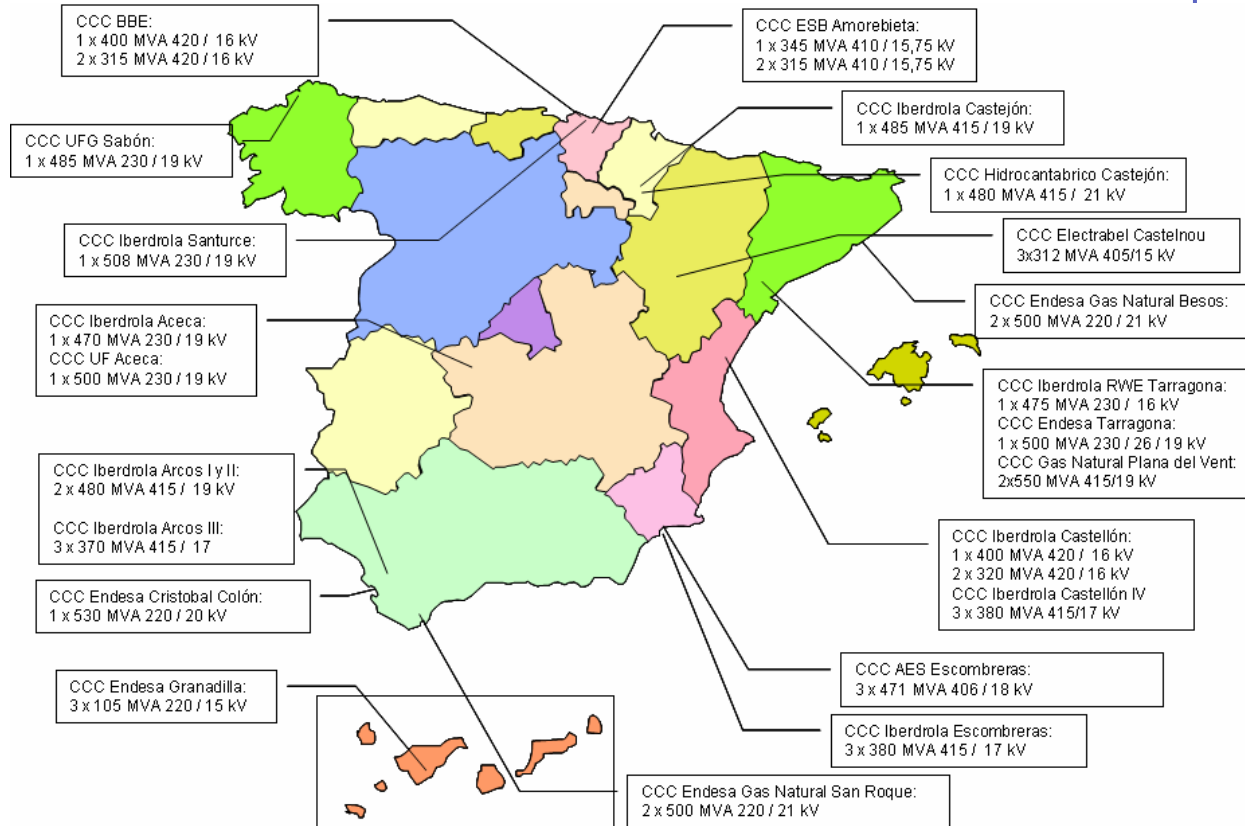
- In a generating power plant, the transformer may become the fuse.
- In a 500 MVA power plant, 1 day of outage means 500 k€.
- The time to deliver a new transformer today could be higher than 12 months.
- The universal GSU is a unit designed to substitute several transformers in different power plants.
- One single spare transformer:
  - To work on the highest power range.
  - To work on with all different voltages on high and low.
  - Transported to any of the power plants.
  - Compatible with all installation constrains in each plant.



# Application of universal GSU to Spanish CCC

**Uds MVA unit MVA total Tensión AT**

Uds	MVA unit	MVA total	Tensión AT
1	400	400	420
2	320	640	420
2	500	1000	220
2	500	1000	220
1	480	480	400
1	400	400	420
2	315	630	420
1	485	485	415
1	475	475	230
1	500	500	230
1	508	508	230
3	105	315	230
2	480	960	415
1	345	345	410
2	315	630	410
1	530	530	220
3	370	1110	415
1	470	470	230
3	471	1413	406
3	312	936	405
1	500	500	230
3	380	1140	415
2	550	1100	400
1	485	485	230
3	380	1140	415



# Application of universal GSU to Spanish CCC

Uds	MVA unit	MVA total	Tensión AT
1	400	400	420
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1	400	400	420
2	315	630	420
1	485	485	415
1	475	475	230
1	500	500	230
1	508	508	230
3	105	315	230
2	480	960	415
1	345	345	410
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3	380	1140	415
2	550	1100	400
1	485	485	230
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<b>44</b>		<b>17592</b>	

Universal GSU Type 1  
230/19-20-21  
4 Power Plants  
4 Transformers  
2030 MVA

Universal GSU Type 2:  
400/15-17-19  
8 Power Plants  
15 Transformers  
5875 MVA

Universal GSU Type 4:  
230/17-19-21  
2 Power Plants  
2 Transformers  
985 MVA

Universal GSU Type 3:  
230/17-19-21  
2 Power Plants  
2 Transformers  
978 MVA

4 Universal Generator Step Up will cover:

- 9868 out of 17592 MVA (56%)
- 23 out of 44 Transformers (52%)
- 16 out of 25 Power Plants (64%)

For 3 different utilities.



# On field repair and upgrading

## ■ Transformers repairs.

### ■ Field repairs provide:

- A reduced cost solution.
- Shorter total repair time.
- Proved quality and reliability of the final result.

### ■ Some advantages and key points are:

- Reduced cost and shorter repair time compared to shipment to a repair facility.
- Possibility to follow the same process than in a manufacturing facility, including change of windings and hot oil spray processing.
- HV dielectric testing (induced test with PD measurements) using portable testing equipment provides additional verification of an adequate repair quality.



# On field repair or upgrading and HV testing

State of the art equipment and processes to repair and upgrade transformers on site providing:

- Clean environment.
- Heavy lifting capacity.
- Experienced teams of skilled workers.
- Special tools and fixtures.
- Drying capabilities.
- Testing capabilities.



# On field repair or upgrading and HV testing



# On field repair or upgrading and HV testing



- **Generator Step Up transformer:**
  - 3ph, Core type, 500 MVA 220/19 kV
- **Scope of repair at site:**
  - Untanking and dismantling of the unit
  - Exchange of High Voltage winding
  - Core refurbishment
  - Reassembly
  - Drying out
  - HV Tests
  - Commissioning



- **Time challenge:**
  - Site total repair time: **3 months**
  - Factory repair: **5 months + Trans. risk**
  - **New unit: production time ~ 14 months + transportation time**



# Transformer Development, Innovations and Solutions

## Innovation and development:

- Efficiency: Reduction of losses.
- Noise level reduction.
- Dry type transformers of higher voltages.

## ■ Transformer solutions:

- Polytransformers and universal GSU's.
- On field repair and upgrading.
- HV testing on site.



# Transformer Development, Innovations and Solutions

Thank you for your attention!

Questions?



Questions or comments:  
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