ABB R&D Overview and Vision
Electrical Machines and Energy Efficiency
Outline

- Group overview
- Energy efficiency
- Motors and Generators (Business and portfolio)
- ABB R&D
  - Corporate Research (Västerås)
  - Corporate R&D in Electrical Machines and Drives
    - Energy efficiency topic!
A global leader in power and automation technologies
Leading market positions in main businesses

- 135,000 employees in about 100 countries
- $38 billion in revenue (2011)
- Formed in 1988 merger of Swiss and Swedish engineering companies
- Predecessors founded in 1883 and 1891
- Publicly owned company with head office in Switzerland

Source: ABB Ltd
Power and productivity for a better world

ABB’s vision

As one of the world’s leading engineering companies, we help our customers to use electrical power efficiently, to increase industrial productivity and to lower environmental impact in a sustainable way.

Source: ABB Ltd
How ABB is organized
Five global divisions

- **Power Products**
  - $10.3 billion
  - 35,000 employees

- **Power Systems**
  - $7.7 billion
  - 19,500 employees

- **Discrete Automation and Motion**
  - $8.4 billion
  - 27,500 employees

- **Low Voltage Products**
  - $5.0 billion
  - 21,000 employees

- **Process Automation**
  - $7.8 billion
  - 28,500 employees

(2011 revenues, consolidated)

- **ABB’s portfolio covers:**
  - Electricals, automation, controls and instrumentation for power generation and industrial processes
  - Power transmission
  - Distribution solutions
  - Low-voltage products
  - Motors and drives
  - Intelligent building systems
  - Robots and robot systems
  - Services to improve customers productivity and reliability

Source: ABB Ltd
Tackling society’s challenges on path to low-carbon era
Helping customers do more using less

ABB power and automation solutions are:

- Meeting rising demand for electricity
- Increasing energy efficiency and reducing CO₂ emissions
- Improving productivity to raise competitiveness of businesses and utilities

Rise in electricity demand by 2035 (under current policies)
Source: IEA, World Energy Outlook 2011

Electricity demand is calculated as the total gross electricity generated less own use in the production of electricity and transmission and distribution losses.

Source: ABB Ltd
Fashioning the world we will live in tomorrow
Tackling challenges with customers and partners

- R&D programs focus on incremental and breakthrough developments to address challenges including:
  - Integrating renewable power sources into the grid
  - Enhancing power network efficiency, reliability and flexibility
  - Improving industrial resource efficiency and asset productivity
  - Optimizing flexibility and reliability

Source: ABB Ltd
Well-balanced business and geographic portfolio
Capturing growth opportunities, wherever they arise

Orders by division
of total orders 2011 (non-consolidated)

- Process automation: 20%
- Power products: 25%
- Low voltage products: 12%
- Discrete automation and motion: 22%
- Power systems: 21%

Orders by region
of total orders 2011

- Europe: 38%
- Asia: 30%
- Middle East and Africa: 9%
- Americas: 23%

Share of employees
2011

- Emerging markets: 47%
- Mature markets: 53%

Source: ABB Ltd
Energy Efficiency
Today’s energy challenge
Rising demand

IEA scenario 2008-35

Growth in primary energy demand
Growth in electricity demand

China
98% 210%

EU and North America
7.1% 25%

India
148% 292%

M. East and Africa
66% 128%

Latin America
61% 89%

values calculated by ABB from data in Current Policies Scenario in IEA’s World Energy Outlook

Source: ABB Ltd
Today’s energy challenges
Cut link between growth, energy use and emissions

Meeting these challenges requires the world to:

- Reduce the correlation between economic growth and energy use
- Reduce the correlation between energy use and emissions

Energy efficiency
Renewable sources of energy

Source: ABB Ltd
Energy efficiency in utilities
Power generation, transmission and distribution

- Power plants consume 5 percent of the electricity they generate.
- This can be cut by 10 to 30 percent by optimizing operations and auxiliary systems using sophisticated control systems and energy-efficient equipment.
- In transmission and distribution, ABB technologies enable more power to travel over existing networks and reduce power losses.

Source: ABB Ltd
Energy efficiency in industry
Other industries accounts for 33% of global energy use

- Modern control solutions, automation products and electrical equipment run plants productively and efficiently
- Key technologies include controls, enterprise software, instrumentation, low-voltage products, drives, motors, robots and turbochargers
- ABB’s energy consultants are experts at identifying energy waste

Source: ABB Ltd
Energy efficiency in transportation

ABB helps ship and rail operators reduce consumption

- Azipod ship propulsion system brings savings of 5 to 15 percent, while turbochargers boost diesel engine output four-fold.

- In rail, ABB technologies transfer power efficiently from grids to railways, while on board components and complete traction packages increase efficiency.

Source: ABB Ltd
Case studies
Transportation

- **Sinorail Bohai Train Ferry Co., China**
  - Three new ferries fitted with Azipod power and propulsion solutions
  - Fuel consumption reduced by ca. 20 percent vs conventional arrangements
  - Saving approximately $2.2 million/year

- **Deutsche Bahn, Germany**
  - New traction converter developed for first fleet of InterCityExpress trains in just 13 months
  - Energy consumption cut by at least 12 percent
  - Operating and maintenance costs reduced

Source: ABB Ltd
Energy efficiency in buildings
Buildings account for 40% of energy consumed

- ABB building control systems adjust temperature, lighting and energy consumption of electric appliances
- ABB is also a leading producer of low-voltage, energy efficient devices for building applications
- High-efficiency ABB motors and drives cut energy consumption of pumps and fans in heating, ventilation and air-conditioning (HVAC) systems

Source: ABB Ltd
Motors and Generators

2012-05-09
BU Motors and Generators

Facts and figures

- World’s leading manufacturer of LV, MV and HV motors and generators, and mechanical power transmission products serving all industries and applications, on all markets

- 4 BU SD revenue

- 15 000 people, 45 factories in 13 countries

- Complete product offering from sub-fractional HP up to 70 MW
  - LV, MV and HV induction motors and generators
  - Synchronous and permanent magnet motors and generators
  - DC motors, servomotors, gear motors
  - Mechanical power transmission products

- About 300 000 motors in 6 central stocks globally

Source: ABB Motors and Generators
# BU Motors and Generators

Unmatched ability to serve global and local customers

## Total offering

<table>
<thead>
<tr>
<th>Total offering</th>
<th>ABB</th>
<th>Baldor</th>
<th>ABB + Baldor</th>
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</thead>
<tbody>
<tr>
<td>NEMA LV</td>
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<tr>
<td>IEC LV</td>
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<tr>
<td>Large &lt; 11000 kW, 15000 hp</td>
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<td>Large &gt; 11000 kW, 15000 hp</td>
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<tr>
<td>Gear</td>
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<tr>
<td>Small generators</td>
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<tr>
<td>Large generators</td>
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<tr>
<td>Gen sets</td>
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<td></td>
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<tr>
<td>Mechanical power transmission</td>
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<tr>
<td>Service</td>
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</tbody>
</table>

Source: ABB Motors and Generators
Manufacturing and logistic center locations

Source: ABB Motors and Generators
Low and high voltage IEC induction motors

<table>
<thead>
<tr>
<th>Output power in kW</th>
<th>LV motors in aluminum frame</th>
<th>LV and HV motors in cast iron frame</th>
<th>LV and HV modular induction motors</th>
<th>HV slip-ring motors</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.06 – 55 kW</td>
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<td>0.25 kW – 2.25 MW</td>
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<tr>
<td>140 kW – 22.5 MW</td>
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<tr>
<td>160 kW – 18 MW</td>
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<tr>
<td>0 – 2 MW</td>
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<tr>
<td>2 – 25 MW</td>
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</tbody>
</table>

Source: ABB Motors and Generators
Low and medium voltage NEMA motors

- Steel frame Open Drip Proof (ODP)
- Fabricated frame Weather protected (WPI, WPII), Totally Enclosed Water Cooled (TEWAC) and Totally Enclosed Fan Ventilated (TEFV)
- Cast iron frame Totally Enclosed Fan Cooled (TEFC)
- Fabricated frame Totally Enclosed Air to Air Cooled (TEAAC)

Output power in HP
- ½ – 5000 HP
- ½ – 4000 HP
- 250 – 15000 HP
- 250 – 11000 HP
- 0 – 15000 HP

Source: ABB Motors and Generators
Low and high voltage synchronous motors and generators, and gen sets

<table>
<thead>
<tr>
<th>Output power</th>
<th>Synchronous motors</th>
<th>LV synchronous generators for diesel and gas engines</th>
<th>HV synchronous generators for diesel and gas engines</th>
<th>Synchronous generators for steam and gas turbines</th>
<th>VHV motors and generators (Motorformer)</th>
<th>Portable, stand-by, prime power and peak-saving generator sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 60 MW</td>
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<tr>
<td>14 kVA – 5 MVA</td>
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<tr>
<td>1 – 60 MVA</td>
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<tr>
<td>2 – 70 MVA</td>
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<tr>
<td>2 – 70 MVA</td>
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<tr>
<td>3 – 2000 kVA</td>
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<tr>
<td>0 – 70 MW</td>
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</tbody>
</table>

Source: ABB Motors and Generators
Wind power generators

Output power

<table>
<thead>
<tr>
<th>Induction</th>
<th>Fixed speed</th>
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</thead>
<tbody>
<tr>
<td>Doubly-fed, semi-variable speed</td>
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<tr>
<td>Full variable speed</td>
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<tr>
<td>Synchronous</td>
<td>Low speed permanent magnet</td>
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<td></td>
<td>Medium speed permanent magnet</td>
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<tr>
<td></td>
<td>High speed permanent magnet</td>
</tr>
</tbody>
</table>

Source: ABB Motors and Generators
Motors and generators for Explosive atmospheres
IEC and NEMA designs

- Flameproof motors Exd and Exd e
- Increased safety motors Ex e
- Non-sparking motors and generators Ex nA
- Pressurized motors and generators Ex px/Ex pxe
- Dust ignition proof motors
- Explosion proof NEMA motors

Output power

- 0.55 kW – 4.5 MW
- 0.25 kW – 7 MW
- 0.25 kW – 60 MW
- 140 kW – 60 MW
- 140 kW – 7.7 MW
- 1 – 800 HP

0–70 MW / 0–70 MVA

Source: ABB Motors and Generators
Motors and generators for all applications

Other types

- Brake motors
- D.C. motors and generators
- Gear motors
- High efficiency, Premium efficiency and Super premium efficiency motors
- Marine motors
- Motors for food and beverage industry (steel frame, washdown)
- Motors for high ambient temperatures
- Permanent magnet motors and generators
- Roller table motors
- Smoke extracting motors
- Single phase motors
- Servo motors
- Severe duty motors
- Traction motors
- Wash-down motors (LV)
- Water cooled motors (LV)
- Variable speed synchronous motor and drive package

Source: ABB Motors and Generators
Mechanical power transmission products
For motor-driven loads

- Mounted bearings
  - Ball bearings
  - Roller bearings
  - Plain bearings

- Enclosed gearing
  - Helical gear
  - Worm gear
  - Shaft Mount

- PT Components
  - Bushings / sheaves
  - Conveyor pulleys
  - Couplings / brakes

Source: ABB Motors and Generators
High efficiency motors

- 65% of total electricity at industrial sites is consumed by electric motors
- Motor purchasing price corresponds to 8 to 12 weeks of its electricity consumption
- The capital cost will represent only 1 percent of the total life cycle operational costs of the motor
- Reliable motors with a high efficiency level ensure the lowest life cycle costs

Source: ABB Motors and Generators
Energy efficiency and carbon footprint reduction

Energy facts about LV motors

If the efficiency level increases with 3 %-units, the reduction of losses is 40%

Annual savings = 2.6 kW x 0.055 EUR x 8760 hrs = 1251 EUR / 11 tonnes CO₂ (0.5 kg/kwh)

Source: ABB Motors and Generators
IEC 60034-30 and IEC 60034-31 define the efficiency classes for low voltage motors

EU sets mandatory deadlines for industrial electric motors (2 to 6 pole, from 0.75 to 375 kW); phased in between 2011 and 2017

ABB welcomes the regulations – has full ranges of IE2 and IE3 motors already today – from stock

Source: ABB Motors and Generators
Since December 19, 2010, an updated mandatory efficiency standard is valid.

It builds on the previous EP Act 92.

Applies now to 1 to 500 HP general purpose three-phase AC motors.

Motors covered by the previous EP Act 92, 1 to 200 HP, must meet Premium class requirements.

Motors not previously covered by EP Act 92 must meet Energy efficient levels.

Source: ABB Motors and Generators
ABB R&D (Short overview)

- Corporate Research
- Electrical Machines and Drives

2012-05-09, Stockholm
Innovation is key to ABB’s competitive advantage
Leadership built on consistent R&D investment

More than $13 billion invested annually in R&D*

- 7,500 scientists and engineers
- Collaboration with 70 universities
  - MIT (US), Tsinghua (China), KTH Royal Institute of Technology (Sweden), Indian Institute of Technology (New Delhi), ETH (Switzerland), Karlsruhe (Germany), AGH University of Science and Technology (Poland)

* Comprises non-order related R&D and order-related development

Source: ABB Ltd
Corporate R&D Expectation

- First, to contribute **technology innovation** in ABB’s **core areas**, both incremental and break-through, helping to secure **existing business** and establishing opportunities for **new business**. In doing so, we must remember to build sound **intellectual property** positions.

- Second, to perform fundamental scientific work that **reduces the uncertainties** for subsequent development efforts, and to provide world-class technology expertise especially in areas that span multiple divisions and BU’s.

- Third, as a lively link with the **scientific community**, enabling us to assess potentially disruptive technologies early, and to attract new world-class members to our teams.

- And fourth, to contribute to ABB’s **strong standing with customers**, standardizing bodies, and society at large.
ABB Corporate R&D – A long tradition
Globally distributed

- Sweden (Norway)
- Switzerland
- Germany
- Poland
- China (Beijing and Shanghai)
- India

Power Technologies
Automation Technologies

Source: ABB Corporate Research
Research Areas – Corporate Research, Västerås

Automation

- Modeling and optimization of industrial systems
- Mechatronics design
- Wireless communication
- Embedded systems design
- Software architecture

Power

- Power systems and HV power electronics
- Electrotechnologies and design
- Electrical insulation systems
- Power apparatus
  - Electrical machines and drives technologies
  - Diagnostics

Technology Support

- Chemical analysis
- Corrosion chemistry
- Structural mechanics
- Mechanical properties of materials

Source: ABB Corporate Research
Resources – Corporate Research, Västerås Competence and Extensive Laboratory

- Employees
  - Scientists and engineers
  - Majority with PhD qualifications

- Power Technologies
  - High Voltage & High Power
  - HV Power Electronics
  - Motor / Machines Test Beds
  - Insulation Systems and Materials

- Technology Support
  - Chemical analysis, Mechanics, Acoustic

- Automation Technologies
  - Robotics
  - Communications
  - Usability

Source: ABB Corporate Research
Electrical Machines and Drives

Key Focuses

- Machine physics and new topologies
- Machine control
- Diagnostics and Prognosis
- Design optimization (efficiency, performance)
- Driver-Machine interaction
- Application areas
- Experimental validation platform
- 3D and 2D FEM modeling and simulations

Source: ABB Corporate Research
Machine and Drive System Development
From Concept to Validation – and back

Machine Design + PE & Drive Control → System Performance

Validations/experimental calibrations

Source: ABB Corporate Research
Experimental Measurements Validations

- Motor and Drive Performance Validations
- Long time/duty cycle test
- Competitor benchmarking
- Machine monitoring and diagnostics
- Control algorithm development platform
- Full scale traction motor and drive system validations
- Calorimetric set-up (loss => efficiency)

Source: ABB Corporate Research
Energy Efficiency

R&D vision

- Motor + Drive => System Application

Source: ABB Corporate Research
Energy Efficiency
Synchronous Reluctance Motor and Drive Package

Traditional induction motor

100%
- 1²R Rotor
- Other

80-90%
- 1²R Stator
- Other

High output SynRM motor

Losses

Source: ABB Corporate Research
Power and productivity for a better world™

ABB