DOOSAN SKODA POWER OVERVIEW

2015
• Introduction to Doosan Group

• Doosan Škoda Power Overview & Product Portfolio

• Doosan Škoda Power Retrofit & Modernisation

• Doosan Škoda Power Industrial Steam Turbines

• Doosan Škoda Power New Build
DOOSAN GROUP

One of the top 10 conglomerates in Korea, active in the engineering and manufacturing of power plants, industrial facilities, engines and construction.

The oldest company in Korea (112 years). The founding family is still a major shareholder and responsible for corporate governance.

Management has strong aspirations of accelerated global growth, with a focus on the infrastructure support businesses.
DOOSAN – BUSINESS AREAS

- Power
- Water
- Construction
- Machine Tools
- Engines
- Engineering & Construction
- Industrial Vehicle
- Electro Material
THE DOOSAN FAMILY

Doosan Group

- Doosan Corporation
- Doosan Mecatec
- Doosan Heavy Industries and Construction
- Doosan Engine
- Doosan Industrial Develop.
- Doosan Infracore
Doosan Heavy Industries & Construction owns core technologies and ongoing performance with the three core components of the power generation business - Boilers, Turbines and Generators. The acquisition of Babcock of the U.K. and Skoda Power of the Czech Republic further consolidated our competitiveness. Doosan is also making substantial inroads into the eco-friendly power generation business including wind power and fuel cell.
DHI&C > GLOBAL NETWORK

- **Branches**: 31
- **Subsidiaries**: 10
- **R&D Centers**: 5

- **Doosan Power Systems**
- **Doosan Škoda Power**
- **Doosan E&S**
- **Doosan IMGB**
- **Doosan VINA**
- **Doosan Chennai Works**
- **Doosan Hydro**
Key milestone of turbine generator technology

- **1904**: SKODA POWER
- **1959**: 110 MW Turboset
- **1978**: 1000 MW Turboset for Nuclear
- **1992**: USC 660 MW
- **1991**: Established Own Design Capability
- **1985**: Design License with GE for STG
- **1976**: Manufacturing License with GE for STG
- **1962**: Established
- **1959**: First steam turbine - 550 HP
- **2007**: Established Gas Turbine Product Line-up
- **2009**: Škoda Power Acquisition
- **2007**: Established Gas Turbine Product Line-up
- **OEM Capability through Technology Integration**

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**Doosan’s Full Turbine and Generator Product Line-up Established**
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DOOSAN SKODA POWER PRODUCTS - INTRODUCTION

Long Company Heritage with Global References of ŠKODA steam turbines

• Leading manufacturer and supplier of modern turbine/generator systems, components and services
• Designs, manufactures and installs power generation equipment
• Significant service expertise for OEM equipment and third-party equipment producers
Heritage of Doosan Škoda Power Turbine


Emil Škoda found the engineering workshop

Rateau turbine system were replaced by turbines own design Škoda

Doosan acquired Škoda Power


23 MW Reheating Steam Turbine
220 MW Turboset (Nuclear)
USC unit 660 MW
2009 2013


1000 MW Turboset (Nuclear)
R&D Center of excellence for steam turbine Doosan Group

Doosan Škoda Power
DOOSAN SKODA POWER PRODUCTS AND APPLICATIONS

Steam turbine & generator → Complete machine-hall

New Build

Retrofits & Modernization

Service & Maintenance

Fossil fuel
Cogeneration
Combined cycle
Nuclear
Waste incineration
Biomass
Solar
Sugar
Metal
Pulp & Paper
Steam Turbine Experience

Through worldwide presence Doosan Škoda Power represents a rich tradition, long experience and professional knowledge, with innovative approaches to project management.

Total Records ~ 115 GW = 594 Units
ADVANCED PRODUCTION TECHNOLOGY

CNC Machining Centre WACO PMC 5000 AG

- CNC Lathes up to dia. 4,000 mm and length 15,000 mm
- CNC Vertical lathes up to dia. 5,000 mm
- CNC and NC Horizontal boring machines
- Vertical Lathes up to diameter 8,000 mm
- 5 axes CNC machining centers for blade machining

Vertical rotor welding stand POLYSOUDE PC 600

- (TIG hot/cold wire)
- rotors up to weight 135t, length 12m, diameter 2 050 mm

Welding capability (SMAW, GTAW, GMAW, FCAW, SAW)

- Forming/bending capability,
- Rotor alignment using high-frequency heating method
- Heat treatment capability, submerged arc welding

Vacuum high-speed balancing tunnel

- Rotors up to weight 140t, length 18 000 mm, diameter 4 700mm
- Pedestals SCHENCK DH 11 and DH 70
Our steam turbine development is focused on:

• Raising the steam temperature and pressure at the inlet
• Enhancing efficiency of steam path
  ✓ Through flow path optimization
  ✓ Through new design and technology solution of flow path
  ✓ Improved sealing of rotating parts
• Selection of new non-metallic and metallic materials and spray layers
• Operating flexibility and reliability

Theoretical conclusions are always verified in our well equipped experimental laboratory

Doosan Škoda Power is the owner of original technology since 1904 with reference range between 10 to 1,200 MW.
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• Doosan Škoda Power Overview & Product Portfolio
R&M results:

- Lifetime extension or renovation
- Availability and reliability improvement
- Improved thermodynamic efficiency
- Electric output increase
- Reduced heat consumption
- Reduced operating and maintenance costs
- Reduction of harmful emissions
- Improved environmental performance
3D optimized blading
- Reduction of aerodynamic losses in turbine stages
- Increased efficiency compared to previously used types of blading
- Improved specific heat consumption

Solid-forged and welded rotors
- Use of materials with optimal properties for different parts of rotor at given operating conditions
- Reduced weight of welded parts, which can be forged more precisely than large parts
- Higher metallurgical accuracy, economically attractive solution
- Reduced heat load, faster start-up

LP last stage blade solution
- Improved profile efficiency
- Optimised aerodynamics
- Selection from wide family of last stage blades, based on project-specific cold end conditions
- Using of approved module solution
- High availability
- And long lifetime
Labyrinth sealing with abradable coating

- abradable coating sprayed on seal segments
- improved efficiency of labyrinth seals, reduced clearance between hard parts and segment base material
- minimized damage or wear of sharp edges on rotor seals during contact with other parts

LP diaphragms

- welded design
- moisture removing among last LP stages
- hollow stationary blade provided by groove for water separation on suction and pressure surface

HP / IP assembled design diaphragms

- precise assembly
- high performance honeycomb sealing
REVERSE ENGINEERING – 3D Scanning and its utilization

Existing turbine → Scanning → Point cloud → Processing → Mesh model → Reversing → 3D model

Retrofitted turbine → Production drawings → Retrofit 3D design → Basic design (skeleton)

Production and execution → Detail design → Designing → Design data from reused parts

FEM analysis, Inspections, Operation data, Maintenance, Experiences
Reverse Engineering – Machine hall scanning

*Non-contact scanning system* for obtaining 3D model of machine room.

**LASER SCANNER LEICA**

**Laser Scanner Leica - Possibilities**
- Maximal measuring distant: 0.4 - 120 m
- 3D position accuracy: ±3 mm / 50 m
- ±6 mm / 100 m
- Angle accuracy: 0.002° / 0.002°
- Horizontal / Vertical angle: 360° / 270°
ON SITE MACHINING – MACHINING EQUIPMENT

Modular Mobile Milling Machine LM6200
• Machining of the parting plane
• Machining surfaces for fixing of inner casing

Modular Mobile Boring Machine BB8100
• Boring inner diameters for glands
• Boring inner grooves for carriers and for diaphragms

Possible machining dimensions
• Max length: 4400mm
• Max width: 3000mm

Possible machining dimensions
• Min diameter: 600mm
• Max diameter: 2500mm (plan 3000mm)
• Length: 5000mm

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SERVICE and AFTERMARKET CAPABILITY

Erection and Commissioning
- Technical advisory
- PT6 performance test support if needed

LTSA – Long Term Service Agreement
- Remote monitoring system
- Availability guarantee

Planned Maintenance
- Spare parts supply and management
- Technical advisor support during outage
- Technical advisor support during outage
- Access to fleet operational experience for spares planning and outage interval to optimize lifecycle cost

Unexpected Outages/Operation
- Expert services applying advanced diagnostic tools
- Service “HOTLINE“ in case of emergencies for troubleshooting
- 24 hour dispatchable emergency technical support

Life Extension/Performance Improvement
- Residual lifetime assessment
  - Material analysis for lifetime consumption
  - Typically after 15 to 20 years of operation
- Performance degradation assessment
- Steam-path modernization (i.e. 3D blading)
### SELECTED REFERENCE R&M

<table>
<thead>
<tr>
<th>Name of Project</th>
<th>Salmisaari 1 x 175 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>Finland</td>
</tr>
<tr>
<td>Customer / Final Client</td>
<td>Helsinki Energy</td>
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</table>
| Benefits | Reliable operation  
Air-cooled generator instead of Hydrogen cooled  
Increasing of power output by 10MW by internal efficiency improvement |
| Scope of Supply | New turbine flow path (colored parts)  
New LP outer casing  
New Generator |
| Delivery Date / COD | 06/2012 |
| Application | Heating Power Plant |

<table>
<thead>
<tr>
<th>Original Turbine</th>
<th>After Retrofit</th>
</tr>
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<tbody>
<tr>
<td>150 MW - designed</td>
<td>177/169 MW</td>
</tr>
<tr>
<td>130bar; 535°C; 710t/h</td>
<td>130bar; 535°C; 710t/h</td>
</tr>
<tr>
<td>3000rpm</td>
<td>3000rpm</td>
</tr>
<tr>
<td>reaction</td>
<td>impulse</td>
</tr>
<tr>
<td>1983</td>
<td>2012</td>
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</table>
**Fossil power plant**

**Naantali 125 MW**

**Country**
Finland

**Customer / Final Client**
FORTUM / TSE Naantali

**Benefits**

<table>
<thead>
<tr>
<th>Orig. HP Turbine</th>
<th>After Retrofit</th>
<th>Orig. IP Turbine</th>
<th>After Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>76%</td>
<td>&gt; 86.2%</td>
<td>88.5%</td>
<td>&gt; 94.1%</td>
</tr>
<tr>
<td>180,6bar; 517°C; 411,5t/h</td>
<td>179bar; 520°C; 403t/h</td>
<td>33,4bar; 520°C; 299t/h</td>
<td>33,5bar; 520°C; 295,2t/h</td>
</tr>
<tr>
<td>3000rpm</td>
<td>3000rpm</td>
<td>3000rpm</td>
<td>3000rpm</td>
</tr>
<tr>
<td>impulse</td>
<td>impulse</td>
<td>impulse</td>
<td>impulse</td>
</tr>
</tbody>
</table>

**Application**

**Scope of Supply**
New HP flow path and new IP turbine flow path, front part of outer casing new control valve steam chest (coloured parts)

**Delivery Date / COD**
9/2015
## SELECTED REFERENCE R&M

<table>
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<tr>
<th>Name of Project</th>
<th>Gardanne 1x160 MW</th>
</tr>
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<tbody>
<tr>
<td>Country</td>
<td>France</td>
</tr>
<tr>
<td>Customer/Final Client</td>
<td>EON / Societe Nationale d'Electricite et de Thermique</td>
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</tbody>
</table>
| Benefits        | Heat Rate optimization  
Reliable operation  
Lifetime extension 20 years |
| Scope of Supply | New turbine flow path (colored parts)  
Condenser re-tubing  
New LP, HP heaters  
New Generator  
BOP lifetime extension  
Feed water turbine retrofit |
| Delivery Date / COD | 2015 |
| Application     | Biomass |

<table>
<thead>
<tr>
<th>Orig. Turbine</th>
<th>After Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 MW designed</td>
<td>160 MW</td>
</tr>
<tr>
<td>163bar; 565°C; 453.02t/h</td>
<td>163bar; 565°C; 441.41t/h</td>
</tr>
<tr>
<td>22bar; 565°C; 440t/h</td>
<td>32bar; 565°C; 404t/h</td>
</tr>
<tr>
<td>3000rpm</td>
<td>3000rpm</td>
</tr>
<tr>
<td>impulse</td>
<td>impulse</td>
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</table>
### Torrent Power 2x110 MW

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<tr>
<th><strong>Country</strong></th>
<th>India</th>
</tr>
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<tr>
<td><strong>Customer/ Final Client</strong></td>
<td>DHIC &amp; DPSI / Torrent Power Limited</td>
</tr>
<tr>
<td><strong>Benefits</strong></td>
<td>Output increased from 110 MW to 120MW Heat rate improvement from 2120Kcal/ kWh to 1999 Kcal/KWh</td>
</tr>
<tr>
<td><strong>Scope of Supply</strong></td>
<td>Replacement of HP, IP &amp; LP rotors and inner casings Up-gradation of C&amp;I system</td>
</tr>
<tr>
<td><strong>Delivery Date / COD</strong></td>
<td>6/2013 and 1/2014</td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td>Coal power plant</td>
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</tbody>
</table>
### SELECTED REFERENCE R&M

<table>
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<tr>
<th>Name of Project</th>
<th>Bandel 210 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country</strong></td>
<td>India</td>
</tr>
<tr>
<td><strong>Customer/ Final Client</strong></td>
<td>DHIC &amp; DPSI / West Bengal Power Development Ltd.</td>
</tr>
</tbody>
</table>
| **Benefits**      | Output increased from 210 MW to 215 MW  
Heat rate improvement from 2456 Kcal/ kWh to 2009 Kcal/KWh |
| **Scope of Supply** | New HP, IP turbine, LP turbine  
New turbine valves  
HP hydraulic system  
BOP rehabilitation |
| **Delivery Date / COD** | 09/2014 |
| **Application**   | Fossil Power Plant |
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Doosan Škoda Power New Build
### INDUSTRIAL STEAM TURBINES PRODUCT RANGE – MTD FAMILY

<table>
<thead>
<tr>
<th>Type</th>
<th>MW</th>
<th>Speed (rpm)</th>
<th>bar - °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTD 10</td>
<td>Up to 7</td>
<td>12,000</td>
<td>50bar 450 °C</td>
</tr>
<tr>
<td>MTD 20</td>
<td>15-30</td>
<td>8,000</td>
<td>140bar 540 °C</td>
</tr>
<tr>
<td>MTD 25</td>
<td>25-40</td>
<td>6,500</td>
<td>140bar 540 °C</td>
</tr>
<tr>
<td>MTD 30</td>
<td>20-55</td>
<td>5,500 / 6,000</td>
<td>140bar 540 °C</td>
</tr>
</tbody>
</table>

**Key advantages of MTD turbine design:**

- High efficiency
- High reliability
- Easy operation and maintenance
- Short installation time
MTD 20

Output Range: 15-30MW

MTD 20 C
- Condensing
- Radial

MTD 20 CE
- Condensing
- 1xExtraction

MTD 20 CA
- Condensing
- Axial

MTD 20 B
- Backpressure
MTD25

Output Range  25 - 40MW

MTD 25 C
- Condensing
- Radial

MTD 25 CE
- Condensing
- 1xExtraction

MTD 25 CEE
- Condensing
- 2xExtractions

MTD 25 CA
- Condensing
- Axial

MTD 25 B
- Backpressure
MTD30

Output Range: 20-55MW

MTD 30 C
Condensing
Radial

MTD 30 B
Backpressure

MTD 30 CA
Condensing
Axial

MTD 30 C(B)E
Condensing
Extraction

Lund, Sweden
Biomass, 44 MW
MTD30BE

Sleaford, GBR
Biomass, 44 MW
11.5 MW MTD30CA
LP SINGLE CASING and HP DOUBLE CASING DESIGN

Modern, Efficient Steampath for both Industrial and Combined Cycle Applications

- Outer casing for LP modules includes nozzle chamber
- Inner casing for HP modules
Control valves are mounted on the top of front turbine casing

- Four control valves
- HP hydraulic actuator for each valve
- Better control response and flexibility by setting in comparison with camshaft design
- Standardized for MTD20 – 30 - 40
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• Doosan Škoda Power New Build
# MODULAR DESIGN OF SKODA STEAM TURBINES

<table>
<thead>
<tr>
<th>MTD Type</th>
<th>Capacity output (MW)</th>
<th>Nominal turning speed (rpm)</th>
<th>Steam parameters pressure (MPa) / temperature (°C)</th>
<th>No. of casings</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTD40</td>
<td>30 - 200</td>
<td>3,000 / 3,600</td>
<td>3 – 14 / 300 - 580</td>
<td>1</td>
</tr>
<tr>
<td>MTD50</td>
<td>50 - 210</td>
<td>3,000 / 3,600</td>
<td>6 – 18 / 450 - 580</td>
<td>2</td>
</tr>
<tr>
<td>MTD60</td>
<td>80 - 400</td>
<td>3,000 / 3,600</td>
<td>8 – 18 / 450 - 600</td>
<td>2</td>
</tr>
<tr>
<td>MTD70</td>
<td>200 - 800</td>
<td>3,000 / 3,600</td>
<td>12 – 18 / 500 - 580 USC: 26 – 30 / 600 - 620</td>
<td>3+</td>
</tr>
<tr>
<td>MTD80</td>
<td>200 - 1200</td>
<td>3,000 / 3,600</td>
<td>4 - 7 / saturated steam</td>
<td>3+</td>
</tr>
</tbody>
</table>

Key advantages of MTD turbine design:

- High efficiency
- High reliability
- Easy operation & maintenance
- Short installation
STEAM TURBINE: MTD FAMILY – MTD 40

MDT40

Characteristics
• Single casing condensing or backpressure turbines directly connected with the generator
• With or without steam reheating
• Possibility to apply controlled steam extractions
• Common or separate foundation frame possibility
• Possibility of axial or radial outlet to the condenser

Technical specification
• Capacity output: 30 – 200 MW
• Turning speed: 3000 / 3600 rpm
• Steam pressure: 3 – 14 MPa
• Steam temperature: 300 - 570°C

MTD40C
Condensing type
Radial outlet

MTD40CA
Condensing type
Axial outlet

MTD40B
Backpressure type

MTD40C(B)E
Condensing type
1 controlled extraction

MTD40C(B)R
Condensing type
with reheating

EVI Europark Germany
Waste to energy 80 MW MTD40CA

Doosan Škoda Power
Characteristics
- Double casing condensing with single flow HP and LP part
- With or without steam reheating
- Possibility to apply controlled steam extractions
- Possibility to apply high-speed HP part with a gear to synchronous turning speed of the LP part
- Possibility of axial or radial outlet to the condenser

Technical specification
- Capacity output: 80 - 210 MW
- Turning speed: 3000 / 3600 rpm
- Steam pressure: 6 - 18 MPa
- Steam temperature: 450 - 580°C

MTD50C
Condensing type
Radial outlet

MTD50CA
Condensing type
Axial outlet

MTD50B
Backpressure type

MTD50C(B)E
Condensing type
1 controlled extraction

MTD 50 C(B)R
Condensing type with reheating
STEAM TURBINE: MTD FAMILY – MTD 60

**MTD60**

**Characteristics**
- Double casing condensing turbines with combined HP-IP part and double flow LP part with steam reheating
- With or without steam reheating
- Possibility to apply controlled steam extractions
- Radial outlet to the condenser

**Technical specification**
- Capacity output: 80 - 400 MW
- Turning speed: 3000 / 3600 rpm
- Steam pressure: 8 - 18 MPa
- Steam temperature: 450 - 600°C

**MTD60C**
Condensing type
Radial outlet

**MTD60C(B)E**
Condensing type
1 controlled extraction

**MTD60C(B)R**
Condensing type
with reheating

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Doosan Škoda Power
STEAM TURBINE: MTD FAMILY – MTD 70

**Characteristics**

- Multi casing condensing turbines with steam reheating
- Possibility to apply controlled steam extractions
- Radial outlet to the condenser

**Technical specification**

- Capacity output: 200 - 800 MW
- Turning speed: 3000 / 3600 rpm
- Steam pressure: 12 - 18 MPa
- Steam temperature: 500 - 580°C

**MTD70C**
- Condensing type
- Radial outlet

**MTD70C(B)E**
- Condensing type
- 1 controlled extraction

**MTD70C(B)R**
- Condensing type
- with reheating

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*Shen Tou, China, Russia*
*FPP* 500 MW, MTD70CR

*Ledvice, Czech Republic*
*FPP* 660 MW, MTD70CR

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*Doosan Škoda Power*
**STEAM TURBINE: MTD FAMILY – MTD 70 for USC parameters**

**MTD70 / USC**

### Characteristics
- Multi casing condensing turbines with steam reheating
- Possibility to apply controlled steam extractions
- Radial outlet to the condenser

### Technical specification
- **Capacity output:** 200 - 800 MW
- **Turning speed:** 3000 / 3600 rpm
- **Steam pressure:** Upto 30 MPa
- **Steam temperature:** 600 - 620°C

**MTD70C**
- Condensing type
- Radial outlet

**MTD70C(B)E**
- Condensing type
- 1 controlled extraction

**MTD70C(B)R**
- Condensing type
- with reheating

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- Ledvice
  - Czech Republic
  - FPP
  - 660 MW
  - MTD70CR

- Shen Tou
  - China
  - Russia
  - FPP
  - 500 MW
  - MTD70CR

- Ledvice
  - Czech Republic
  - FPP
  - 660 MW
  - MTD70CR

Doosan Škoda Power
STEAM TURBINE: MTD FAMILY – MTD 80

**Characteristics**

- Multi casing condensing turbines for nuclear power plants
- Inlet steam parameters on saturated limit
- Turbine with steam reheat and moisture separation
- Possibility to apply controlled steam extractions i.e. for district heating

**Technical specification**

- Capacity output: 200 - 1200 MW
- Turning speed: 3000 rpm
- Steam pressure: 4 - 7 MPa
- Steam temperature: Saturated steam

**MTD80C**
- Condensing type
- Radial outlet

**MTD80C(B)E**
- Condensing type
- 1 controlled extraction

**MTD80C(B)R**
- Condensing type
- With reheating

Bohunice, Slovak Republic
NPP 4x 252 MW

Temelin, Czech Republic
NPP 2x 1000 MW
MTD80CR
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Address</th>
<th>Email</th>
<th>Phone</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adam Bajer</td>
<td>Head of Department Turbine Retrofit &amp; Modernization</td>
<td>Tylova 1/57, 301 28 Plzeň The Czech Republic</td>
<td><a href="mailto:adam.bajer@doosan.com">adam.bajer@doosan.com</a></td>
<td>+420 739 589 005</td>
<td><a href="http://www.doosanskoda.com">www.doosanskoda.com</a></td>
</tr>
<tr>
<td>Martin Doležel</td>
<td>Sales Manager Industrial Steam Turbines</td>
<td>Vídeňská 63, 639 00 Brno The Czech Republic</td>
<td><a href="mailto:martin.dolezel@doosan.com">martin.dolezel@doosan.com</a></td>
<td>+420 739 348 926</td>
<td><a href="http://www.doosanskoda.com">www.doosanskoda.com</a></td>
</tr>
<tr>
<td>Martin Baxa</td>
<td>Head of Sales - Asia New Build</td>
<td>Tylova 1/57, 301 28 Plzeň The Czech Republic</td>
<td><a href="mailto:martin.baxa@doosan.com">martin.baxa@doosan.com</a></td>
<td>+420 733 697 680</td>
<td><a href="http://www.doosanskoda.com">www.doosanskoda.com</a></td>
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