RENEWABLE.
DEPENDABLE.
SUSTAINABLE.

MTU GAS ENERGY SOLUTIONS:
ENERGY YOU CAN COUNT ON

INTERSTATE
PowerSystems

mtu
A Rolls-Royce solution
OUTLINE

1. Interstate Company and MTU History
2. Reciprocating Internal Combustion Engine (RICE) Technology Comparison
3. MTU Gas Generator Set Systems
4. Microgrid Systems
5. MTU Control Systems
6. Maintenance and Lifecycle Costs
7. Questions
Interstate Company and MTU Onsite Energy History
RICE Technology Comparison
RICE TECHNOLOGY VERSE COMBUSTION TURBINES

- Low heat rate
- Low fuel pressure
- No water consumption
- Limited de-rate due to
  - Temperature
  - Elevation
  - Partial load
- Short start cycle time
- Unlimited starts
RICE GAS TECHNOLOGY VERSE DIESEL

- Fuel cost
- Emissions
- Equalized capital costs
- Extended outage operation
- Hybrid generation systems
- Alternative fuel sources
  - Biogas
  - Synthetic gas
  - Hydrogen
- Cogeneration systems
- Trigeneration systems
- Medium speed platforms
MTU Gas Generator Set Systems
HIGH SPEED DIESEL SYSTEMS (>1000 RPM)

**MTU 4000 DS**
- 12/16/20 Cylinders
- 1,125kWe - 3,250kWe

**MTU 2000 DS**
- 12/16/18 Cylinders
- 624kWe - 1,250kWe

**MTU 0080 - 1600 DS**
- up to 12 Cylinders
- 27kWe - 600kWe

**Benefits**
- Outstanding derating behavior
- High load acceptance
- Wide range of predefined scope of supply
- High flexibility for challenging customized solutions
- Low emissions
CONTINUOUS GAS SYSTEMS

Energy Storage

High Speed Gas Systems
(>1000 rpm)

Medium Speed Gas, Diesel, HFO Systems
(<1000 rpm)

MTU Energy Pack

MTU 400 GS
MTU 4000 GS

B35:40 (Gas)
B36:45 (Gas)
### GAS PORTFOLIO

<table>
<thead>
<tr>
<th>Power System</th>
<th>Power Range (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S 400</strong></td>
<td>200 – 420</td>
</tr>
<tr>
<td><strong>S 4000</strong></td>
<td>762</td>
</tr>
<tr>
<td><strong>Bergen Engines</strong></td>
<td>6,800 – 11,340</td>
</tr>
</tbody>
</table>

#### Power Sources
- Medium Speed: Natural Gas
- High Speed: Natural Gas, Biogas, Sewage Gas, Landfill Gas

**Pride in Service**
## MTU Series 4000
natural gas / biogas

<table>
<thead>
<tr>
<th>Actual technical features (L32/33/L64FNER)</th>
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<tbody>
<tr>
<td>Cylinder Arrangement</td>
</tr>
<tr>
<td>Bore/Stroke</td>
</tr>
<tr>
<td>Power Range</td>
</tr>
<tr>
<td>Speed</td>
</tr>
<tr>
<td>Combustion</td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Electrical Efficiency</td>
</tr>
<tr>
<td>NOx Emission</td>
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MTU SERIES 4000 L64 FNER SPECIFICATIONS

<table>
<thead>
<tr>
<th></th>
<th>8V4000 L64 FNER</th>
<th>12V4000 L64 FNER</th>
<th>16V4000 L64 FNER</th>
<th>20V4000 L64 FNER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 g/bhp-hr NOx</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LT Temperature</td>
<td>136°F</td>
<td>136°F</td>
<td>136°F</td>
<td>136°F</td>
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<tr>
<td>Compression Ratio</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
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<tr>
<td>Electrical Output (ekW)</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
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<tr>
<td>Electrical Efficiency (%)</td>
<td>42.9</td>
<td>43.7</td>
<td>43.3</td>
<td>43.3</td>
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<tr>
<td>Total Efficiency (%)</td>
<td>89.7</td>
<td>89.8</td>
<td>90.0</td>
<td>90.1</td>
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<tr>
<td>MN</td>
<td>80</td>
<td>80</td>
<td>80</td>
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</tr>
</tbody>
</table>
Microgrid Systems
MICROGRID ADVANTAGES

• Improved generation efficiency
  – T & D losses (8 to 15%)
• Reduced carbon emissions
• Distributed generation
  – Energy resiliency
  – Sustainability
• Renewable energy integration
  – Wind (25 to 45% capacity factor)
  – Solar (13 to 19% capacity factor)
  – Biogas (95% + capacity factor)
• Local generation assets
• District heating and cooling systems
• Electric vehicle charging stations
MTU MICROGRID SOLUTIONS

1. Genset
2. Circuit Breaker
3. Main Breaker
4. Uninterrupted Power Supply
5. Switch Gear
6. Load
7. Energy Storage
8. Renewables
9. Main Supply
10. Master/Microgrid Controller
11. Intelligent System
12. Wireless Communication

ADDITION: flexibility, speed, grid support and reliability by our diesel and gas gensets to the renewable energy and storage.

RESULTS INTO: full energy integration providing a low-carbon, autonomous and distributed energy system.

PRIDE IN SERVICE
### MTU ENERGYPACK

#### Nominal capacity range (dependent of C-rate)
- 700 – 1260 kWh

#### Current range
- 1,360 – 2,808 A

#### Battery cell chemistry
- NMC (lithium-nickel-manganese-cobalt)

#### Battery efficiency (round-trip)
- 92.5% (2C at 85°C)

#### C-rate
- 2C

#### DC-voltage range
- 750 – 992 V (DC)

#### Specified cycles (at 2C at 85% DoD @ 25°C)
- 3,600

#### Dimensions (L x W x H)
- 12.2 x 2.4 x 5.2 (incl. HVAC, excl. safety ladder, excl. 10ft transformer container)

#### Weight
- 27,700 kg (excl. transformer container)

#### Transformer
- Rated voltage / voltage range: Customer specific

#### Inverter
- Peak power: 2,515 kW (DC) / 2,475 kVA (AC)
- Rated frequency: 50 / 60Hz

#### Battery Racks
- Supported communication interfaces:
  - Profibus DP / Profinet
  - Modbus / Modbus TCP
  - Ethernet UDP

#### Air conditioning
- Ambient temperature: -20°C up to +40°C
- Installation altitude: 1,000 m above sea level

#### Control Cabinet
- Control and monitoring (via external interface)
  - Yes (Touchscreen, SoC LED on container wall)

#### Fire suppression system

#### Double floor

#### PRIDE IN SERVICE
MTU MICROGRID VALIDATION CENTER

MTU microgrid validation center:

- Full flexibility regarding integration of renewables (solar, wind etc.)
- Highly flexible testing capability
- Real load simulation
- Capable of going fully off-grid
- Self sustaining
- Advanced integrated MTU automation system
MTU ENERGYPACK CONTROLS

- **Energy Shifting**
  - Managing / shifting energy
  - Optimize energy system, physical and economical

- **Power Quality & Frequency Stabilization**
  - Maintaining power quality and frequency deviations
  - Increase reliability of grid operation

- **Integration of Renewables**
  - Increasing & optimizing renewable energy utilization

- **Backup Power**
  - Covering time until backup generation is synchronized

**PRIDE IN SERVICE**
MTU Control Systems

PRIDE IN SERVICE
MTU FACTORY CONTROL SYSTEMS

**MMC + MIP**

- **MMC**: MTU Module Control
- **MIP**: MTU Interface Panel
  - CHP System controller
  - Genset controller (includes Synchronization)

**PRIDE IN SERVICE**
MASTER CONTROL SYSTEM (MCS)

MCS Characteristics:

• Add-on as complete plant control system
• Start/Stop selection of the generator sets to meet facility needs for heat and power
• Complete functionality for island operation
• Series 400 engines can be operated together with Series 4000 engines
• MCS is equipped for control up to 30 generator sets
• Large touchscreen with custom screens for facility control functions
• Data logging
INTEGRATED PLANT CONTROL SYSTEM

Remote system
Master Control System
Building
Switchgear
Transformer
Grid

Remote System (Ethernet)  Plant communication  Power-Low voltage  Power-High voltage

PRIDE IN SERVICE
MTU REMOTE MONITORING SYSTEMS

**Improved Maintenance Schedule**
- 1 common maintenance schedule for L64 FNER
- Improved serviceability: MS50202/05
- Harmonized service intervals i.e.:
  - TBO cylinder heads 63k → USP
  - 3k Operating hours as basis interval
  - Very low lube oil consumption
  - Reduced LCC costs

**MTU Go! Manage**
Dashboard with fleet, system & engine view to monitor asset information and live systems data for owners and plant managers.

**MTU Go! Act**
The mobile app is designed to support on-site operators.
LifeCycle Costs

PRIDE IN SERVICE
LIFECYCLE MAINTENANCE PERIODS

NATURAL GAS

- Manufacturer Recommended 8 year Cycle
- Based on 16V4000 L64 FNER
- Based on Natural Gas Fuel Source
- Based on 8000 hrs Annual Operation
- 3,000 hrs – Engine Oil Change with External Tank
- 3,000 hrs – Spark Plug Change
- 3,000 hrs – Air Filter Change
- 6,000 hrs – Gearbox Oil Change
- 9,000 hrs – Replace Fuel Gas Filter
- 21,000 hrs – Turbocharger Overhaul
- 21,000 hrs – Replace Cylinder Pack
- 21,000 hrs – Replace Drive Coupling Element
- 24,000 hrs – Coolant Change
- 24,000 hrs – Replace NSCR Catalyst Elements
- 31,500 hrs – Replace Alternator Bearings
- 32,000 hrs – Replace SCR Catalyst Elements
- 63,000 hrs – Cylinder Head Overhaul
- 63,000 hrs – Replace Camshaft System
- 63,000 hrs – Alternator Overhaul
- 63,000 hrs – Gearbox Overhaul

(55 mph x 8760 hrs/yr = 481,800 miles/yr)

How many cars would you own for just one year of 24/7/365 continuous operation???
LIFECYCLE MAINTENANCE CONCEPT

QL1
Basic Maintenance
- Spark plugs
- Filter changes

QL3
Component Maintenance
- Turbocharger
- Top end overhaul

QL4
Extended Component Maintenance
- Major overhaul
- Engine rebuild

QL2
Unscheduled Repair or Maintenance

Preventive Maintenance
Corrective Maintenance
Fluids

Lubricating oil and Coolant

PRIDE IN SERVICE
LIFECYCLE CALCULATION OUTPUTS

Total cost of ownership per engine - Overview by year

- Project Support Cost
  - not included in this overview
- Oil change cost
- Coolant change cost
- Transp., travel and accommodation
  - not included in this overview
- Total labour cost
- Total material cost

PRIDE IN SERVICE
ANY FURTHER QUESTIONS?

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“Pride in Service”