Deploying a full Charging Solution – a Case Study
Agenda

• The Case
• Scania Citywide BEV
• The Charging hardware
• The Charging software
• Key Learnings
The customers’ case

- 10-year contract
- City and suburban bus traffic in Strängnäs area
- 100% renewable energy
- Electric buses to be used at inner city routes
- Biogas buses to be used at suburban routes
- Operation from the bus depot in Strängnäs, Sweden
- 75% production and 25% incentive based payment
- Start of operation Dec 12, 2021

<table>
<thead>
<tr>
<th>Bus</th>
<th>Shift A start</th>
<th>Shift A end</th>
<th>Shift A duration</th>
<th>Shift A km</th>
<th>Shift A kWh</th>
<th>SoC after shift A</th>
<th>Time available</th>
<th>Target SoC</th>
<th>Energy (kWh)</th>
<th>Time set for charging</th>
<th>Power required (kW)</th>
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</thead>
<tbody>
<tr>
<td>101</td>
<td>05.02</td>
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<td>58.2</td>
<td>93</td>
<td>59%</td>
<td>1.37</td>
<td>76%</td>
<td>36.87</td>
<td>1.37</td>
<td>26.96</td>
</tr>
<tr>
<td>102</td>
<td>05.15</td>
<td>10.52</td>
<td>5.37</td>
<td>82.9</td>
<td>133</td>
<td>41%</td>
<td>2.87</td>
<td>96%</td>
<td>121.38</td>
<td>2.87</td>
<td>42.35</td>
</tr>
<tr>
<td>103</td>
<td>08.07</td>
<td>12.02</td>
<td>5.95</td>
<td>93.2</td>
<td>149</td>
<td>34%</td>
<td>1.75</td>
<td>90%</td>
<td>126.62</td>
<td>1.75</td>
<td>72.38</td>
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<tr>
<td>104</td>
<td>04.93</td>
<td>10.07</td>
<td>5.13</td>
<td>79.4</td>
<td>127</td>
<td>44%</td>
<td>1.82</td>
<td>82%</td>
<td>86.54</td>
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<td>47.64</td>
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<tr>
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<td>08.72</td>
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<td>56</td>
<td>75%</td>
<td>1.06</td>
<td>90%</td>
<td>33.18</td>
<td>1.06</td>
<td>31.60</td>
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## Analysis – Energy & Charging requirements

### Daytime depot charging
- **Duration**: 1 – 3 hours
- **Power per bus**: 27.99 kW (Winter)
- **Energy per session**: 35-126 kWh
- **Simultaneous charging need**: 2 buses
- **Charging sessions**: 1-3 per day
- **Charging solution**: Depot charger
  - Redundancy provided by 2 Power units (each with 3 outlets)

### Overnight depot charging
- **Duration**: 7-10 hours
- **Power per bus**: Max 30 kW (Summer)
- **Energy per session**: 120-217 kWh
- **Simultaneous charging need**: 6 buses
- **Charging sessions**: 1 per night
- **Charging solution**: Depot charger
  - Can add 2 user units in the future to expand to 8 charging outlets

### Charging Session 1

<table>
<thead>
<tr>
<th>Bus</th>
<th>Shift C start</th>
<th>Shift C end</th>
<th>Shift C duration</th>
<th>Shift C km</th>
<th>Shift C km, winter</th>
<th>SoC after shift C, winter</th>
<th>Time available</th>
<th>Target SoC</th>
<th>Energy (kWh)</th>
<th>Time set for charging</th>
<th>Power required (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>05.02</td>
<td>09.02</td>
<td>4.00</td>
<td>58.2</td>
<td>93</td>
<td>59%</td>
<td>1.37</td>
<td>75%</td>
<td>36.87</td>
<td>1.37</td>
<td>26.98</td>
</tr>
<tr>
<td>102</td>
<td>05.15</td>
<td>10.52</td>
<td>5.37</td>
<td>82.9</td>
<td>133</td>
<td>41%</td>
<td>2.87</td>
<td>95%</td>
<td>121.39</td>
<td>2.87</td>
<td>42.35</td>
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<tr>
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<td>06.07</td>
<td>12.02</td>
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<tr>
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<td>04.03</td>
<td>10.07</td>
<td>5.13</td>
<td>79.4</td>
<td>127</td>
<td>44%</td>
<td>1.82</td>
<td>82%</td>
<td>86.54</td>
<td>1.82</td>
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<td>75%</td>
<td>1.65</td>
<td>90%</td>
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<td>1.05</td>
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### Charging Session 2

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<th>Shift B duration</th>
<th>Shift B km</th>
<th>Shift B kWh</th>
<th>SoC after shift B</th>
<th>Time available</th>
<th>Target SoC</th>
<th>Energy (kWh)</th>
<th>Time set for charging</th>
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</thead>
<tbody>
<tr>
<td>10.38</td>
<td>13.52</td>
<td>3.13</td>
<td>55.4</td>
<td>88.64</td>
<td>36%</td>
<td>1.7</td>
<td>82%</td>
<td>104.39</td>
<td>1.75</td>
<td>61.41</td>
</tr>
<tr>
<td>13.38</td>
<td>20.17</td>
<td>6.78</td>
<td>112.4</td>
<td>179.84</td>
<td>15%</td>
<td>0.0</td>
<td>15%</td>
<td>2.09</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>13.77</td>
<td>20.07</td>
<td>6.30</td>
<td>101.9</td>
<td>163.04</td>
<td>18%</td>
<td>0.0</td>
<td>18%</td>
<td>2.00</td>
<td>-</td>
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<tr>
<td>11.88</td>
<td>17.78</td>
<td>5.90</td>
<td>88.1</td>
<td>140.96</td>
<td>19%</td>
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<td>70%</td>
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### Charging Session 3

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<th>Shift C duration</th>
<th>Shift C km</th>
<th>Shift C km, winter</th>
<th>SoC after shift C, winter</th>
<th>Time available</th>
<th>Target SoC</th>
<th>Energy (kWh)</th>
<th>Time set for charging</th>
<th>Power required (kW)</th>
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</thead>
<tbody>
<tr>
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<td>0.0</td>
<td>82%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.00</td>
<td>0</td>
<td>15%</td>
<td>0.00</td>
<td>0%</td>
<td>18%</td>
<td>0.0</td>
<td>82%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.00</td>
<td>0</td>
<td>18%</td>
<td>0.00</td>
<td>0%</td>
<td>18%</td>
<td>0.0</td>
<td>82%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>19.77</td>
<td>22.07</td>
<td>2.30</td>
<td>46.2</td>
<td>73.92</td>
<td>37%</td>
<td>0.0</td>
<td>82%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15.32</td>
<td>18.78</td>
<td>3.47</td>
<td>84.50</td>
<td>103.2</td>
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<td>50%</td>
<td>84.70</td>
<td>0.85</td>
<td>94.04</td>
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### Shift D

<table>
<thead>
<tr>
<th>Shift D start</th>
<th>Shift D end</th>
<th>Shift D duration</th>
<th>Shift D km</th>
<th>Shift D kWh</th>
<th>SoC after shift D</th>
<th>Start</th>
<th>End</th>
<th>Time available</th>
<th>Target SoC</th>
<th>Energy (kWh)</th>
<th>Time set for charging</th>
<th>Power required (kW)</th>
</tr>
</thead>
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<td>0.00</td>
<td>0</td>
<td>43%</td>
<td>0.00</td>
<td>0%</td>
<td>18%</td>
<td>20.07</td>
<td>5.2</td>
<td>9.0</td>
<td>100%</td>
<td>191.09</td>
<td>8.98</td>
<td>21.63</td>
</tr>
<tr>
<td>0.00</td>
<td>0</td>
<td>15%</td>
<td>0.00</td>
<td>0%</td>
<td>18%</td>
<td>20.07</td>
<td>6.1</td>
<td>10.0</td>
<td>100%</td>
<td>185.54</td>
<td>10.00</td>
<td>18.94</td>
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<td>19.77</td>
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<td>44.6</td>
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<td>7.8</td>
<td>100%</td>
<td>183.70</td>
<td>7.85</td>
<td>23.41</td>
</tr>
</tbody>
</table>

### Depot charger
- Max 30 kW (Winter)
- 6 charging outlets

### Depot charger
- Max 30 kW (Summer)
- 6 charging outlets

### Depot charger
- Max 30 kW (Winter)
- 6 charging outlets

### Depot charger
- Max 30 kW (Summer)
- 6 charging outlets
Scania e-mobility solution
- our offer to the customer for Strängnäs operation

**BEV buses**
- 6 Low-floor buses
- 330 KWh (10-Batt)
- Depot charging
- >150 km / shift
- ~200 km / day
- ~50,000 km/year
- Financial Lease fee

**Charging solution**
- Planning & Installation
- Optimization & Training
- 10y Repair & Maintenance
- Start-up + yearly fee

**R&M in depot**
- Scania in depot
- 10y R&M
- 10y Battery warranty (EPC)
- >99.7% uptime
- Price in SEK/km
- Damage repair available

**Software**
- FMS + Charger SW via VAS:
  - Charging status
  - Energy consumption
  - Available range
  - Pre-heating
  - Energy grid peak shave
  - Fleet optimization
  - Monthly fee

Start of operation Dec 12, 2021
Scania Citywide – Fully electric, Low floor

- Battery temperature control (BEV)
- Electrical system
- Electric doors
- Cut-to-length concept
- Charging connection
- Powertrain technology
- Front suspension technology
- Climate system
- Driver area
- Exterior design
- Interior design
- Safety features
- Passenger capacity

Scania Citywide
Electric powertrain

- 300 kW electric machine
- 2-speed gear box
- NMC (Nickel Manganese Cobalt) batteries
- Power electronic
- Battery Management System (BMS)
- Separate cooling circuit
  - Electric machine
  - Batteries
- SORT consumption
  - 0.94 kWh/km (SORT 1)
  - 0.82 kWh/km (SORT 2)
  - 0.77 kWh/km (SORT 3)

### Fully Electric

<table>
<thead>
<tr>
<th></th>
<th>Output</th>
<th>Torque</th>
<th>Energy Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric motor</td>
<td>300 kW peak</td>
<td>5400 Nm (peak)</td>
<td>0.75 – 1.25 kWh/km</td>
</tr>
<tr>
<td></td>
<td>250 kW continuous (R85)</td>
<td>3400 Nm (continuous)</td>
<td></td>
</tr>
</tbody>
</table>

Gearbox: 2-speed
Batteries

- NMC (Nickel Manganese Cobalt)
- Installed energy 8 or 10 batteries
- Usable energy options
- BMS (Battery Management System)
  - Automatic balancing
  - Strategic
  - Limp home
- Supply chain

<table>
<thead>
<tr>
<th>Fully Electric</th>
<th>Installed Energy</th>
<th>Usable energy BOL</th>
<th>Usable energy EOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Batteries</td>
<td>264 kWh</td>
<td>140 / 193 kWh</td>
<td>112 / 154 kWh</td>
</tr>
<tr>
<td>10 Batteries</td>
<td>330 kWh</td>
<td>165 / 241 kWh</td>
<td>132 / 193 kWh</td>
</tr>
</tbody>
</table>

100% installed battery capacity

Upper limit usable energy
Usable energy
Lower limit usable energy
Schematic view of the Charging Solution
System responsibility

SCANIA
“System responsibility for Buses, Chargers, Software and Service”

Customer

SSE

Partners

Wennstrom

KemPower
Charging hardware

All-in-one Chargers – Stations & Wallboxes

Stationary Chargers with Power Units & Satellites

Portable Chargers

Opportunity Chargers
Charging hardware solution

**SCANIA CHARGING SOLUTION**

- 2 x 120kW Power units
- 6 x 120kW Charge Posts

Bus 1  Bus 2  Bus 3  Bus 4  Bus 5  Bus 6
Charging software solution

Charging Management System
- Charging schedule configuration
- Pre-conditioning & departure activities
- Charging balancing
- Peak load shaving
- Battery life optimization
- Real time fault alerting (sms/email)
- Analytics

Scania Fleet Management Portal
- Vehicle positioning & tracking
- Charging events (start, finish, history)
- SOC status
- Warnings (Limp home mode)
- Driver Evaluation
- Service Planning
- Vehicle Performance
- Analytics
VAS – Value Added Services (VDV 261)

VEHICLE

ISO 15118

CHARGER

HTTPS "V2ICP" via VAS

OCPP

IPv6 tunnel

BACK-END

- Set departure time
- Set pre-conditioning
- Set SOC-level
- Let the charging pause

V2ICP: Vehicle to Infrastructure Communication Protocol
<table>
<thead>
<tr>
<th>Day</th>
<th>Weather</th>
<th>Buses</th>
<th>Charging point</th>
<th>Messages</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Low C</td>
<td>High C</td>
<td>Wind m/s</td>
<td>Skies</td>
</tr>
<tr>
<td>1 Tuesday</td>
<td>0</td>
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<td>1</td>
<td></td>
</tr>
<tr>
<td>2 Wednesday</td>
<td>-7</td>
<td>-3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3 Thursday</td>
<td>-8</td>
<td>0</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>4 Friday</td>
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</tr>
<tr>
<td>5 Saturday</td>
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<td>6 Sunday</td>
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<tr>
<td>7 Monday</td>
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<td>4</td>
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<tr>
<td>8 Tuesday</td>
<td>-3</td>
<td>4</td>
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<tr>
<td>9 Wednesday</td>
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<td>3</td>
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<td>-2</td>
<td>5</td>
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<tr>
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<td>6</td>
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<td>-2</td>
<td>3</td>
<td></td>
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<td>21 Monday</td>
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<td>snow/rain</td>
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<tr>
<td>27 Sunday</td>
<td>99</td>
<td>100</td>
<td>98</td>
<td></td>
</tr>
</tbody>
</table>
Key Learnings

• Important to understand the customers painpoints
• Put in some slack in the project plan
• Experienced Fulfillment partner is of great importance
• Experienced HW/SW-partner is the same
• Plan early for training, support and operation
• Start testing as early as possible
• The devil is in the details