

## A trailer-mounted renewable energy station can keep agricultural robots working in the field by swapping batteries automatically instead of waiting for conventional charging.

Field trials and modelling show near-continuous operation, lower diesel use, and a clearer commercialization pathway when the technical system is bundled with IP, documentation, and know-how.

**<4 min battery exchange**  
 designed cycle: 223 s

**38-42 kWh/day**  
 sunny summer tests

**2-3 robots supported**  
 light-duty tasks

**1.4 t CO2 avoided**  
 ~500 L diesel/season

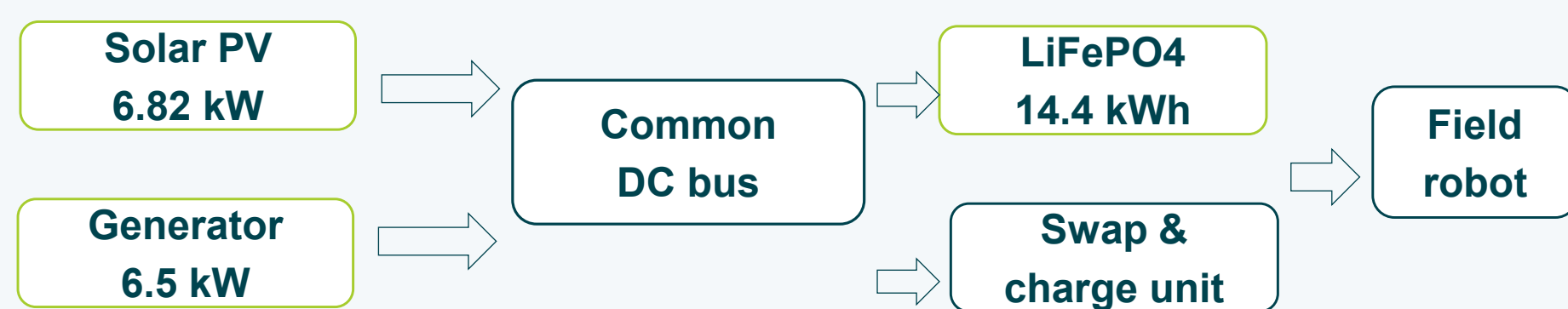


**Core value: mobile off-grid energy + rapid battery swapping + IP-backed technology transfer.**

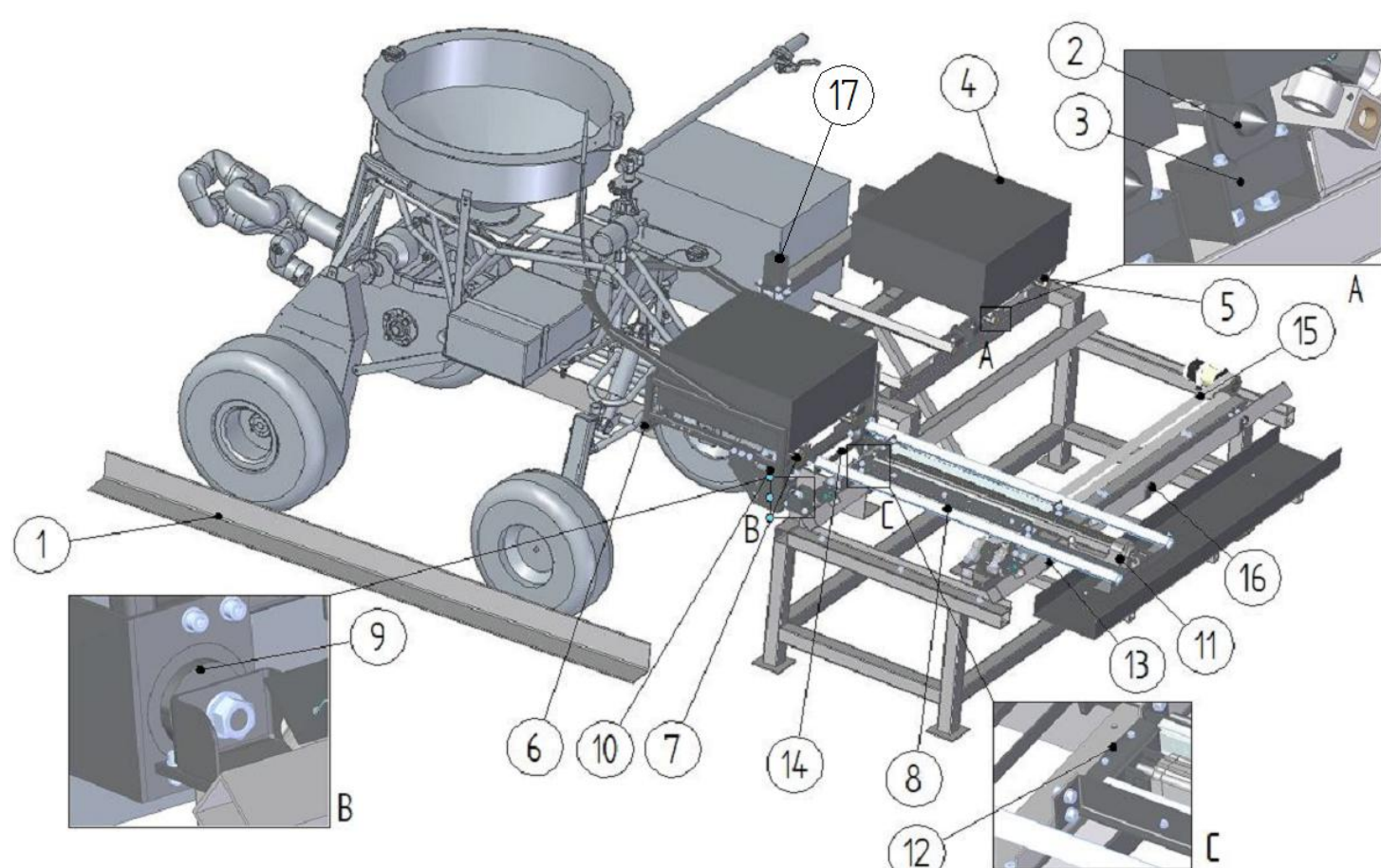
### Challenge & aim

- Robot batteries limit field time; long recharging reduces productivity.
- Mobile energy service avoids grid extension to every field and restores energy on-site.
- Study evaluates technical performance, IP management, and commercialization route.

### System design



SIMATIC PLC + embedded controllers coordinate tracking, charging, docking, safety



Battery swapping unit with robot docking and battery-transfer carriage

### Key specifications

<b>Photovoltaics</b>	22 panels, 6.82 kW peak
<b>Station storage</b>	48 V LiFePO4, 14.4 kWh
<b>Backup source</b>	6.5 kW controllable generator
<b>Robot battery</b>	51 V, 100 Ah, ~5 kWh cassette
<b>Swapping hardware</b>	alignment, trolley, locking & release
<b>Automation</b>	PLC control, BMS, sensors, Wi-Fi Direct

### Field performance

#### Robot uptime comparison for a planned 10-hour workday



**5.6 kW measured PV**  
 clear midday

**10 batteries/day**  
 ~5 kWh each

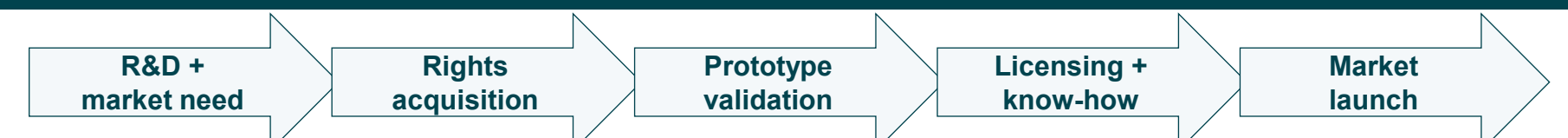
**100% docking success**  
 test cycles

**150 extra h/season**  
 per robot

Hybrid operation kept the work schedule during cloudy periods; the generator supplied only supplementary energy.

- 10-hour autonomous test: 3 swaps; each completed in under 4 minutes.
- Clear-sky production: 38-42 kWh/day; cloudy: ~18 kWh/day plus generator support when needed.
- Capacity: 2-3 light-duty robots or 1-2 energy-intensive robots per station.

### Commercialization & IP pathway



- Licensable portfolio: patent / utility model, technical documentation, prototype data, and operating know-how.
- Estimated production unit cost: ~EUR 30,000; value improves when one station serves 2-3 robots.
- Market route: equipment sales, leasing, or energy-as-a-service for farms and contractors.

**Current readiness: prototype demonstration stage (IRL 5-6). Next steps: multi-robot pilots, long-term reliability trials, standardized battery interfaces.**

### Visual conclusion



**Bring energy to the field, not the robot to the charger.**

- Less downtime and fewer unproductive trips
- Renewable, off-grid support for electric robots
- Clear value proposition for technology transfer