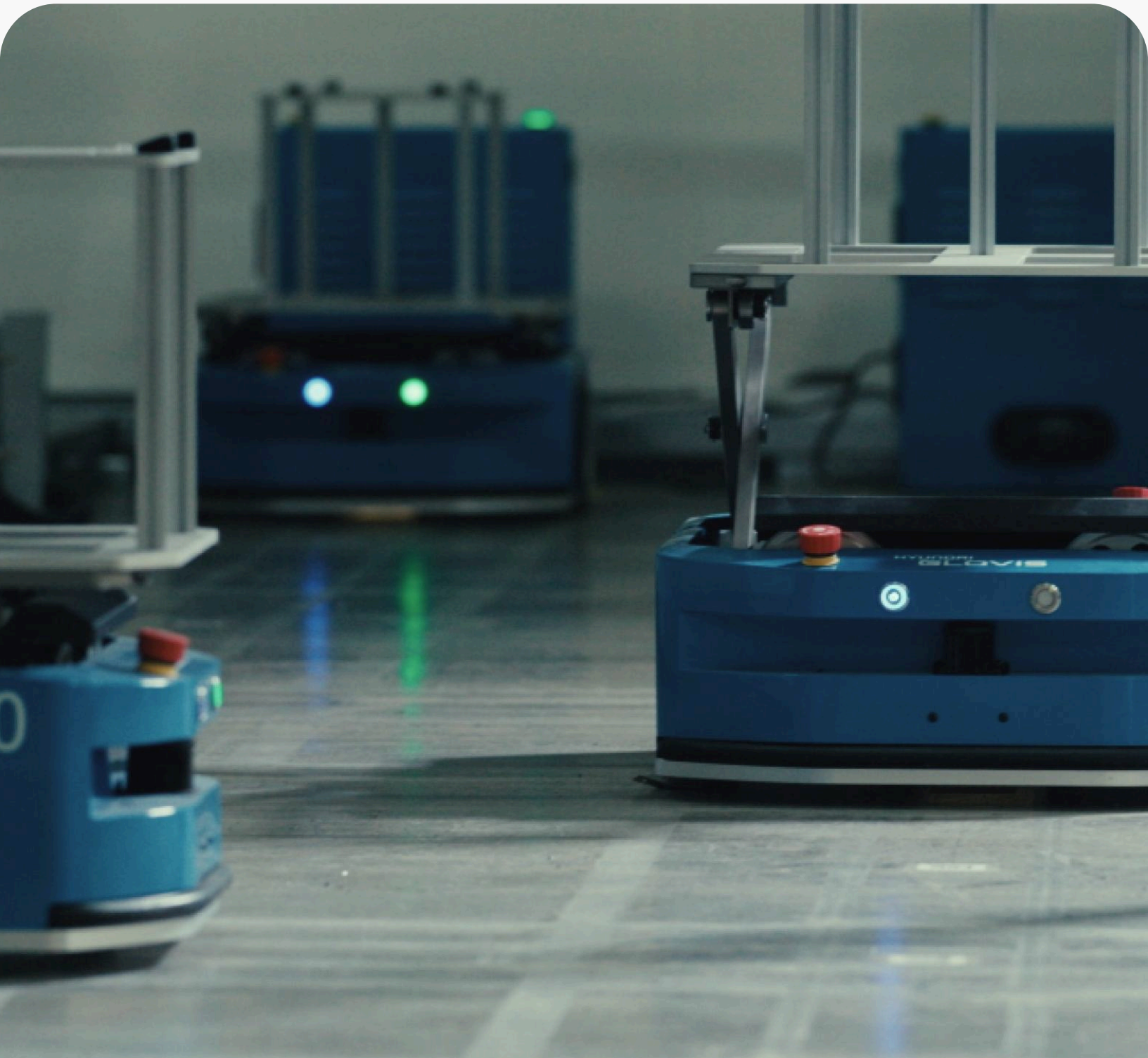
CaPow
Power in Motion

HYUNDAI CRADLE

Case Study

Hyundai Glovis



CaPow
Power in Motion

Agenda

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2. Objectives and KPIs
3. The Solution: CaPow's Genesis
4. Setup and Integration
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1 Problem Statement

Hyundai Glovis Co., Ltd. is a logistics company headquartered in Seoul, South Korea. It is part of the Hyundai Motor Group. Hyundai Glovis supplies ocean transportation logistics advice, cargo space, loading/unloading, and packaging services.

Like many other automation fleet operators, Hyundai Glovis is facing a key challenge with the use of Automated Guided Vehicles (AGVs) – including significant downtime due to the need for routine battery charging.

This **downtime impacts operational efficiency,** creates **inflated operational and capital expenditures,** and leads to **inefficient space utilization** in warehouses due to charger placement requirements.

Inflated fleets: Inefficient capital use

Charging zones: Inefficient space use

The results are: **longer ROI duration,** the **purchasing of additional (overhead) robots and chargers** to maintain the required throughput, and **the loss of potential yield** due to insufficient floor space lost to chargers.

2 Objectives and KPIs

The key objective was to experience 100% AGV uptime - with no use of additional robots or chargers - while maintaining the required throughput.

Another objective was to validate easy integration with both existing infrastructure in the testing facility and with the existing AGV platform

By defining a strict KPI of achieving no battery percentage losses over a defined period of time, Hyundai Glovis could prove significant operational efficiency gains and confirm robustness and scalability of the solution.

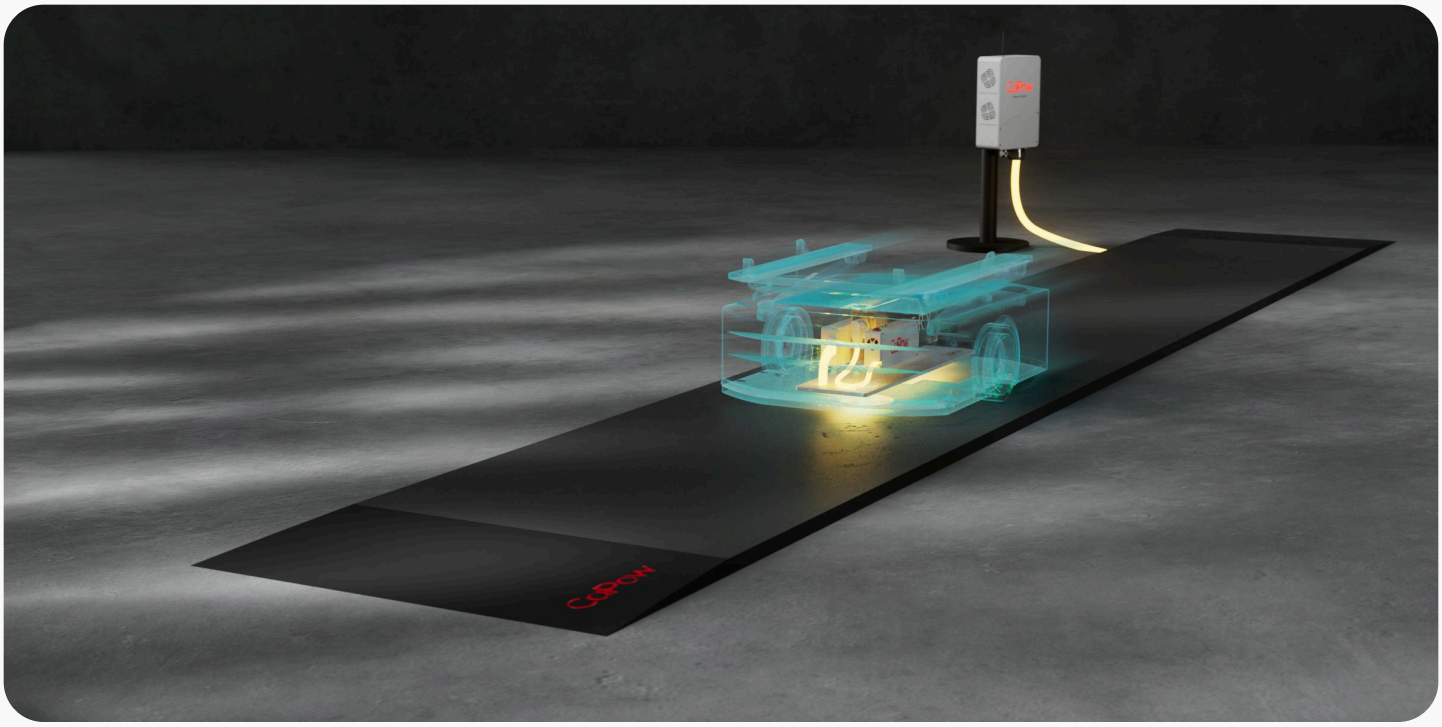
0%
Battery Loss

Zero Modifications
to Existing Operations

Headache-Free
Integration

3 *The Solution:* CaPow's Genesis

CaPow's Genesis System enables AGVs to charge while in-motion and dock-free, and completely eliminates charging downtime.
Harnessing capacitive power transfer along with CaPow's patented Adaptive Lock-In mechanism, AGVs can now be charged while performing their operational routes, without deviating from the primary "money trail", and without dependence on operational idle time.
CaPow's Genesis also allows charging in vast misalignment scenarios in which the AGV misses the designated charging spot. The supported misalignment is up to 50 percent of the size of the robot.



Power-in-motion key benefits include:

- Zero operational efficiency losses
- Zero real-estate lost to charging equipment
- Zero additional robots - the industry standard is 20% extra fleet
- Zero interference with fleet management:
  - No designated routes
  - No charging thresholds or routines
  - No designated charging spot configuration

4 Setup & Integration

Setup

The facility was divided into two identical setups:

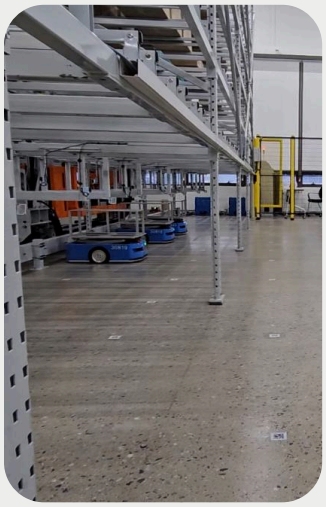
- Section A was equipped with three Hyundai Glovis RT-30 robots and two stationary chargers

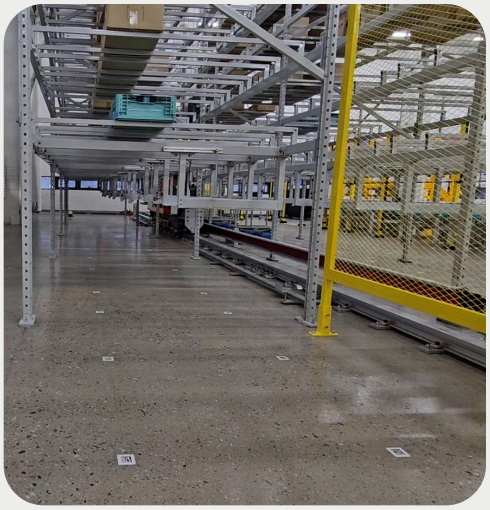
in designated locations. This cluster performed according to traditional operational mode, in which robots operate until hitting 40% battery remaining, and then head to a stationary charger until they reach 95% battery charged.

- Section B was equipped with three Hyundai Glovis **CaPowered** RT-30 robots, as the picking station

stopping point along the robot's operational route was defined as CaPow's charging location.

Section A: Traditional - two chargers





Section B: *CaPowered* - no chargers

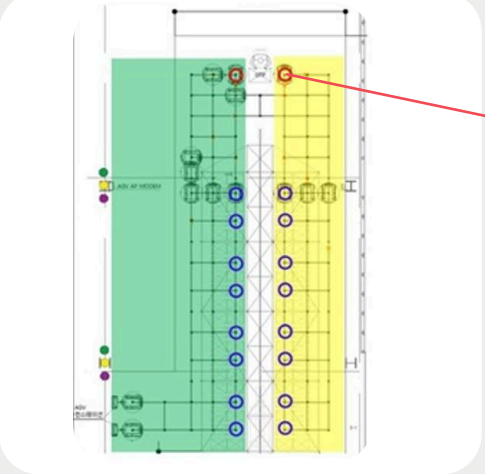
Measurements were taken from the robots to estimate their average power consumption.
In addition, duty cycle time was measured to establish the nominal stopping time in a picking station, and the average route distance and time from the picking station to the bin pickup stations.

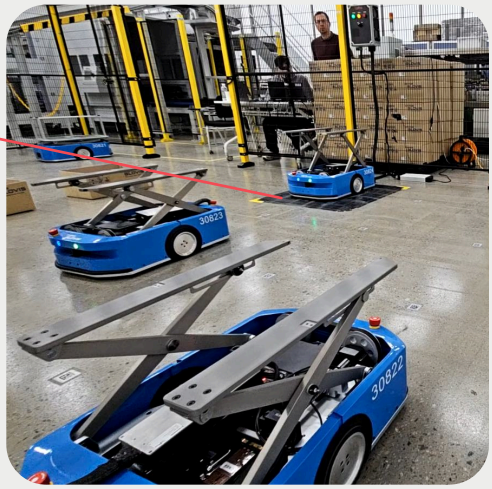
Integration

The designated scenario was a Bin-to-Person application in which robots picked up bins placed by a Mini-load system at designated stations, and brought them to a picking station, where station #1 was closest to the picking station.

The CaPow charging pad was placed in the picking station to provide a dock-free, instant power boost - while the operator picked from the bin. The charging pad was placed without excavation or mounting:

Facility layout





Charging mat at picking station

Designated CaPowered robots were retrofitted on-site, with no required hardware or software modifications:

Robot antenna placement

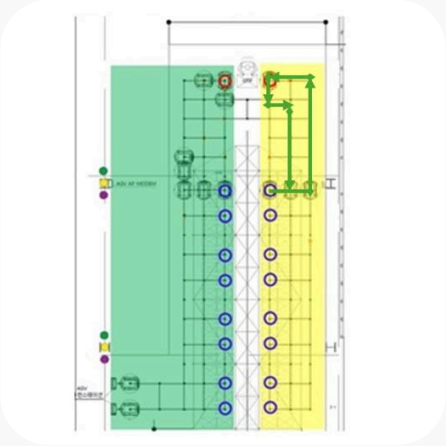
Genesis Receiver integration

5 Operational Scenarios

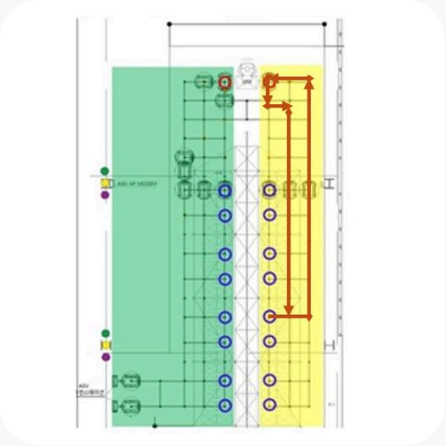
Typical routes included a robot driving from the picking station to pick up a bin from a designated station and return to the picking station.

Both sections operated in parallel and ran designated robots in three defined scenarios:

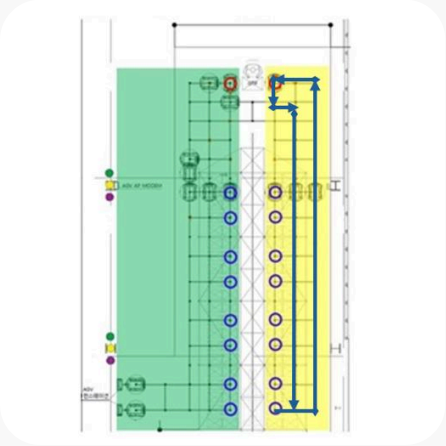
- **Short Route** – Round-trip from picking station to Station 1 (closest to picking station).
- **Mid Route** – Round-trip from picking station to Station 5 (mid-distance to picking station).
- **Long Route** – Round-trip from picking station to Station 8 (farthest to picking station).



Short Route



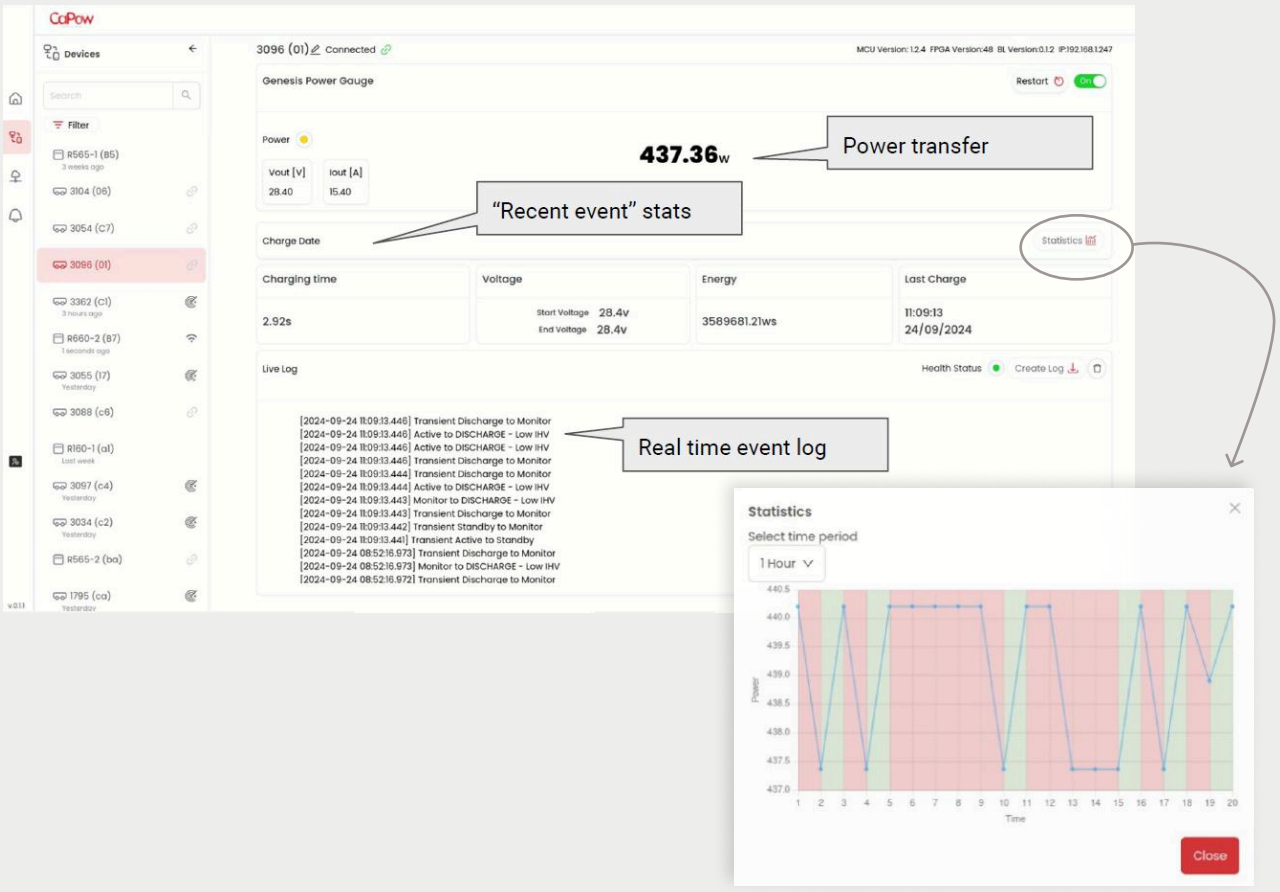
Mid Route



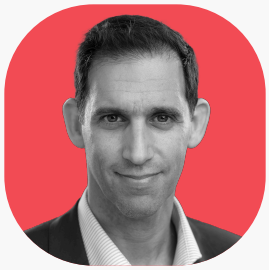
Long Route

The battery status was measured by both Hyundai Glovis Fleet Manager software and CaPow's Genesis Energy Management System (GEMS).

In addition, CaPow's GEMS also measured vital energy data like actual and average voltage, current and power delivery:



The long route example can be viewed here.



Noam Geffen CBO CaPow highlights,

"The success of this PoC demonstrates how CaPow's solution breaks operational efficiency barriers and allows operators to tap into unlocked potential."

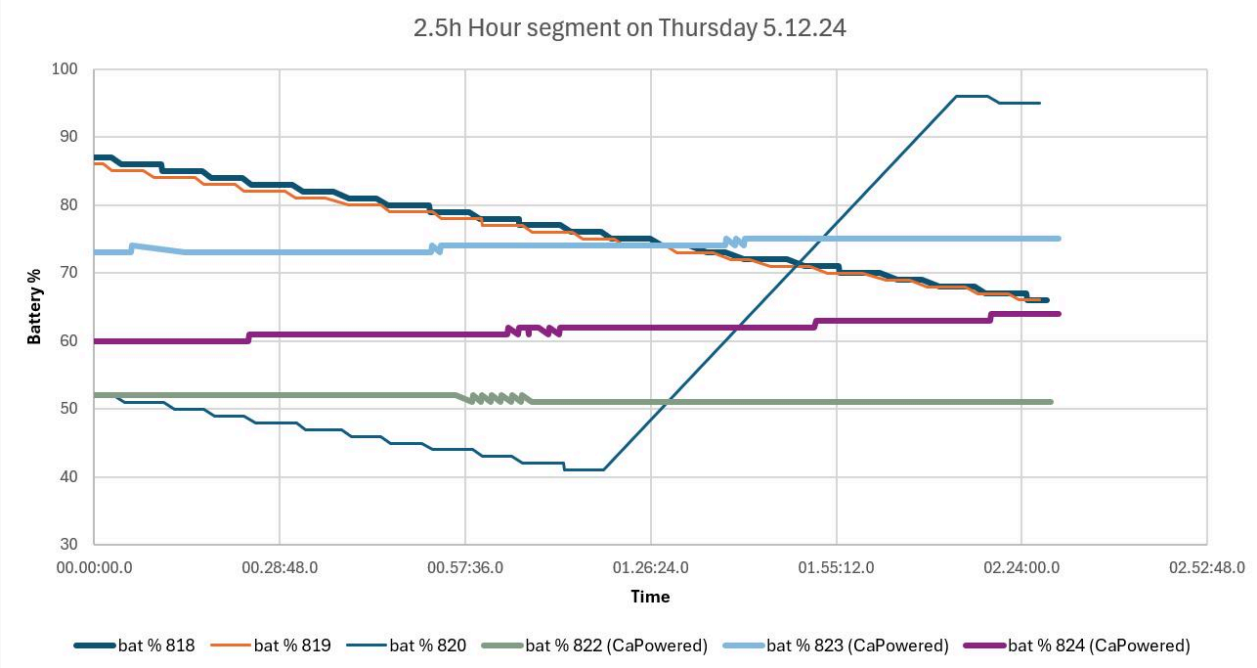
6 Results

Short Shift (150 Minutes)

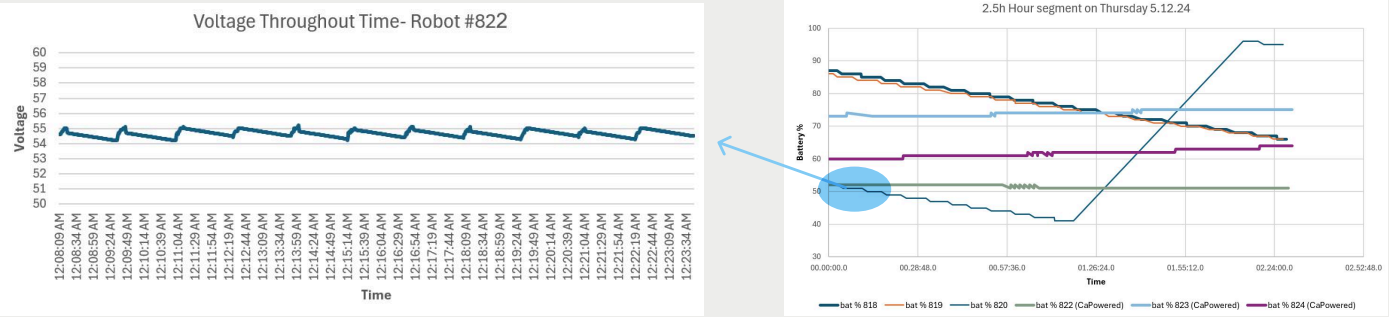
The robots ran continuous cycles for 150 minutes (2.5 hours) in two separate zones. Robots 818, 819, and 820 were utilized in traditional mode, while robots 822, 823, and 824 were utilized along with the CaPow system.

Test results:

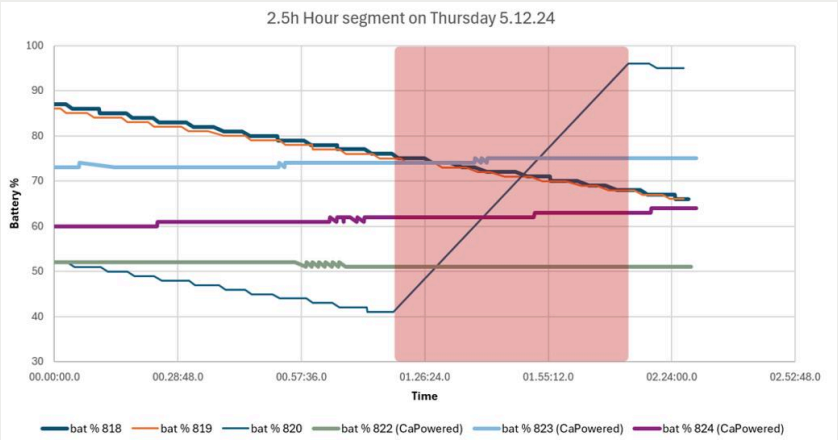
Robot #	Zone	Task	% at start	% at end	Runtime	Diff/hour
818	A (traditional)	Long route	87%	66%	148 min	-8.5%
819	A (traditional)	Mid route	86%	66%	148 min	-8%
820	A (traditional)	Short route	52%	41%	79 min	-8.3%
822	B (CaPowered)	Short route	52%	51%	148 min	-0.4%
823	B (CaPowered)	Long route	73%	75%	148 min	+0.8%
824	B (CaPowered)	Mid route	60%	65%	162 min	+1.85%



A more in-depth analysis zooms into a graph segment to show the change in battery voltage.
The duty cycle of 14 seconds in the picking station vs. ~74 seconds is clearly shown in the graph.
The short bursts of charging vs. the long gradual voltage decline shows that the duty cycle is sustainable for long durations of time:



The red area highlights the operational downtime a robot sustained due to charging.
During this time period the robot was out of circulation and provided no production:



Result analysis:

Non-CaPowered robots suffered an average **battery percentage loss of 8.3% per hour**

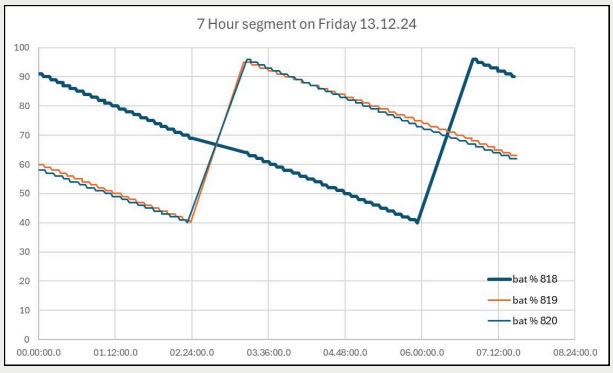
CaPowered robots **gained 1% per hour on average**

While all CaPowered robots remained fully operational during the test, non-CaPowered clusters suffered operational inefficiency for 50 out of 147 minutes (33%)

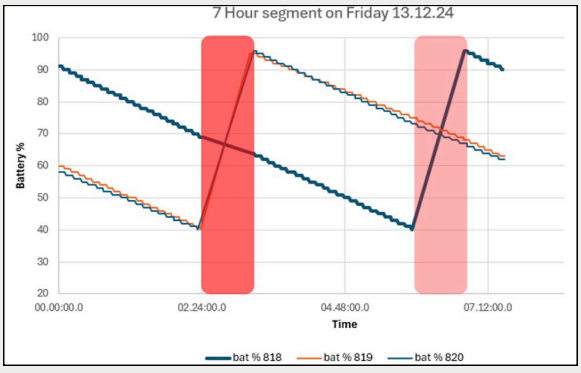
Long Shift (420-490 Minutes)

The robots separately ran continuous cycles for 7-8 hours. Traditional section (Non-CaPowered cluster) Results:

Robot #	Zone	Task	% at start	% at end	Runtime	Diff/hour
818	A (traditional)	Long route	91%	40%	355 min	-8.6%
			96%	90%	39 min	-9.23%
819	A (traditional)	Mid route	60%	40%	143 min	-8.39%
			95%	63%	257min	-7.5%
820	A (traditional)	Short route	58%	40%	142 min	-7.6%
			95%	63%	257 min	-7.5%



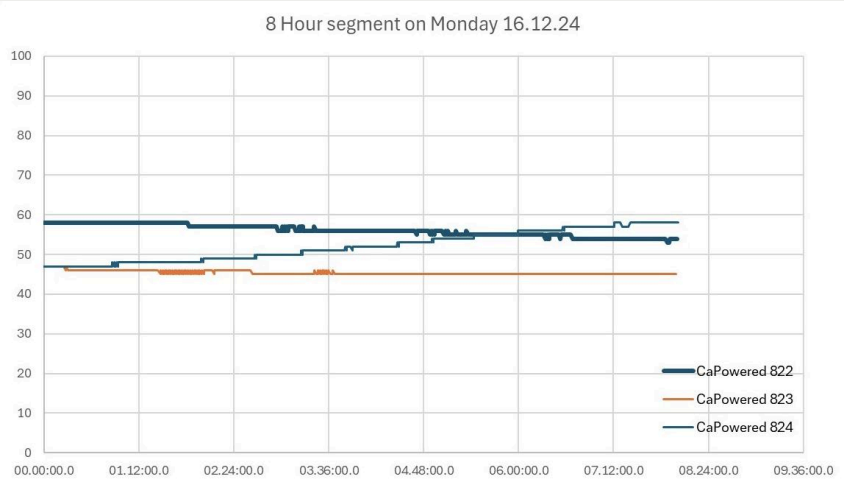
Battery % Graph



Operational Inefficiency Zones

CaPowered section results:

Robot #	Zone	Task	% at start	% at end	Runtime	Diff/hour
822	B (CaPowered)	Short route	58%	54%	480 min	-0.5%
823	B (CaPowered)	Long route	47%	45%	480 min	-0.25%
824	B (CaPowered)	Mid route	47%	58%	480 min	+1.3%



Result analysis:

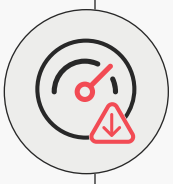
All CaPowered robots worked the entire shift without charging downtime, and their operation was 100% efficient

The traditional section robot cluster suffered a 33% operational inefficiency period - 150 minutes downtime out of 447 minutes

The slight battery percentage decline in two robots is due to duty cycles which were defined according to the maximal route distance and the minimal picking time

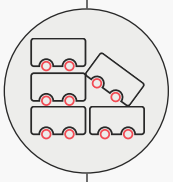
7 Conclusions

The deployment met all predefined KPIs and successfully achieved all targets:



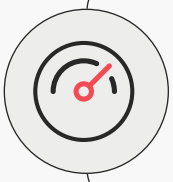
Zero downtime

Traditionally powered robots experienced charging downtime, without full utilization of the fleet. The average work:charge ratio was 6.75:1 (6.75 hours work per 1 hour charge).
CaPowered robots achieved 100% uptime for 100% of the fleet in some cases, and extended the work: charge ratio to 220:1 in other cases.



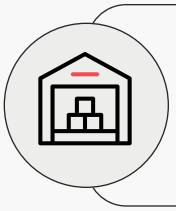
Fleet inflation

Averaging a 6.75:1 work: charge ratio mandates that for every seven working robots, an eighth one has to be purchased to secure full operational efficiency.
Moreover, for every shift lasting more than 6.75 hours, a replacement robot has to be purchased.
CaPow's solution lowers the entry barrier by allowing the operator to purchase the minimal number of robots needed.



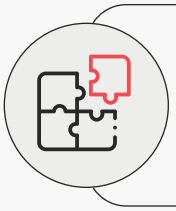
Operational efficiency

The CaPowered fleet enjoyed full operational efficiency without the need for compensation for charging downtime with additional robots, while traditional cluster robots experienced a 33% operational efficiency loss.



Facility "real-estate"

By powering robots while enroute, Genesis requires no extra space in the facility and allows operators to reclaim wasted, precious facility space occupied by chargers.



Setup and integration

Integrating Genesis into an operation was headache-free, and did not require any robot internal modification or fleet/facility changes.

8 Savings Calculation

An exemplary analysis of a full 8-hour shift deploying a 100-robot operation, and utilizing 55% Depth-of-Discharge regime (working till battery percentage hits 40%, charging to 95%) reveals the following:

According to the measured traditional cluster's work:charge ratio (6.75:1), every 7th robot is charging at any given moment, on average.

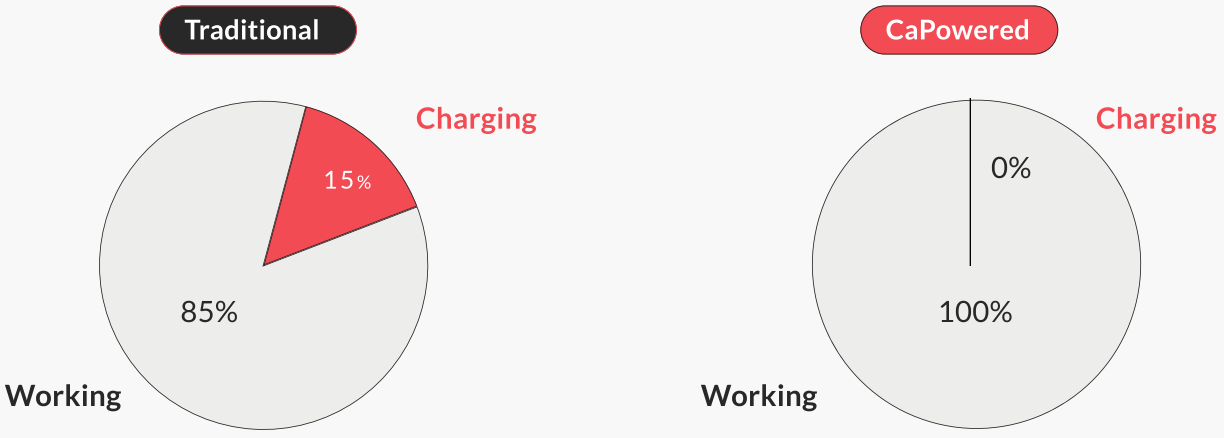
Therefore, the utilized fleet **will include only 85 working robots**, which will result in **15% operational efficiency loss.**

Alternatively, to maintain full operational efficiency, the operator is mandated to purchase **15 additional robots.** Those additional robots also burden fleet management.

In addition, **15 new chargers must be purchased.** Those chargers will be placed in the warehouse, and might result in:

- Taking up valuable warehouse space
- Add additional operational downtime due to driving distance the robots need to go in order to charge and come back

Traditional Charging Vs. CaPowered fleets



9 Key Takeaways

Genesis:

100% provides constant 100% operational efficiency for mobile robot fleets

Reduces entry barriers by eliminating the need for additional robots and chargers

Increases productivity by freeing up occupied space taken by traditional chargers

About Hyundai CRADLE

Hyundai CRADLE is Hyundai Motor's corporate venturing and open innovation business, which partners and invests extensively in prominent global startups to accelerate the development of advanced future automotive technologies.
CRADLE identifies newly established startups that focus, amongst others, on 'Disruptive Innovations', including mobility services, artificial intelligence, robotics, smart energy solutions, smart cities, and cybersecurity.
For more information, please visit cradleinc.com.

About CaPow

CaPow is a pioneer in the field of efficient power delivery for robotic fleets. Its novel Power-In-Motion technology transfers energy to robotic fleets while in motion, eliminating downtime and ensuring constant throughput. The Genesis system seamlessly integrates into existing warehouse infrastructure, enabling operators, automation experts, and OEMs to achieve maximal efficiency while dramatically reducing overall expenses.
For more information, please visit capow.energy.