DTU Compute
IT-Elektronik

Innovation Pilot report - Loop 2 - Group 58

Company Proposal for Egholm A/S

Innovation Pilot, Fall 2025 - 62999

Mads Richardt
Student no. s224948
November 27, 2025

Ferhat Erman
Student no. s224729
November 27, 2025

Allan Jeng Hersborg
Student no. s230620
November 27, 2025

Asbjørn Rath Nielsen
Student no. S235508
November 27, 2025

Lucas Eiruff
Student no. s215822
November 27, 2025

Casper Kielstrup
Student no. s235068
November 27, 2025

Contents

1 Executive Summary **1**

2 Introduction **1**

3 Problem Analysis: The “Hard Nut” **2**
3.1 Contextual Analysis . . . 2
3.2 Defining the Core Problem . . . 2
3.3 Behavioral Insights . . . 2

4 Proposal Rationale **3**
4.1 Problem and Vision . . . 3
4.2 Problem Validation . . . 3
4.3 Proposed Solution: The Energy-Aware Assistance System (EAAS) . . . 4
4.4 Innovation and Value Proposition . . . 4
4.5 Supporting Insights and Research . . . 5
4.6 Solution Validation . . . 5

5 Prototype Implementation **5**
5.1 User Interface Architecture . . . 5
5.2 Core Logic: Task Auto-Detection . . . 5
5.3 Feedback Algorithm: The Traffic Light . . . 6
5.4 Behavioral Features . . . 7
5.5 Simulation & Validation . . . 7

6 Business and Economic Impact **7**
6.1 Cost Drivers and Development . . . 7
6.2 Operational Optimization via Data . . . 7
6.3 Strategic Competitive Advantage . . . 8

7 Further Perspectives **8**
7.1 Long-term AI Development . . . 8
7.2 Data-Driven Product Evolution . . . 8
7.3 Multi-Task Optimization . . . 9
7.4 Gamification and Behavioral Scaling . . . 9
7.5 Integration with Broader Sustainability Initiatives . . . 9
7.6 Technical and Market Expansion . . . 9

8 Conclusion **9**

Appendices **10**

Appendices **10**

A Mail from Eggholm A/S 10

B Egholm Case Brief 11

C Production Facility Visit Notes 12

C.1 Optimization Potential . . . 12

C.2 Product Design & Interface . . . 12

C.3 User Behavior & Operation . . . 12

C.4 Technical Insights & Questions . . . 12

C.5 Testing & Validation . . . 13

Bibliography 14

1 Executive Summary

Egholm A/S stands at a pivotal transition point as it electrifies its portfolio of utility machines. While the shift to electric drivetrains offers significant environmental and noise-reduction benefits, it introduces a critical challenge: battery runtime. Current electric models operate for approximately 2–3 hours per charge, significantly less than the 8-hour workday expected by municipal customers. Our analysis reveals that this limitation is not solely technical but largely behavioral; operators often default to maximum power settings regardless of the task's actual requirements, leading to unnecessary energy waste.

This report proposes the **Energy-Aware Assistance System (EAAS)**, a behavioral design solution integrated into the tractor's interface. Instead of forcing restrictions or requiring complex manual adjustments, EAAS uses real-time sensor data to provide intuitive, non-intrusive feedback—such as a simple color-coded display—that nudges operators toward more efficient behavior.

Key findings and value proposition:

- **The "Hard Nut":** The core problem is the disconnect between operator habits (formed on diesel machines) and the energy-sensitivity of electric systems.
- **The Solution:** EAAS acts as a digital co-pilot, translating complex load data into simple actionable cues (e.g., "Green" for optimal, "Red" for wasteful).
- **Business Impact:** For Egholm, this system reduces the pressure to install larger, cost-prohibitive batteries (which account for 25% of production costs). For customers, it extends daily runtime and lowers the total cost of ownership.
- **Strategic Scalability:** The system lays the foundation for future telematics and AI-driven optimization, transforming energy efficiency from a static hardware feature into a dynamic, data-driven competitive advantage.

By bridging the gap between machine capability and human behavior, EAAS ensures that Egholm's electric tractors can deliver both the performance operators expect and the sustainability municipalities demand.

2 Introduction

Egholm A/S is a recognized leader in the development and manufacture of utility machines for municipalities and the outdoor maintenance sector. As the industry moves decisively toward sustainability [1], Egholm has begun electrifying its product line. This transition presents a complex challenge: electric machines must meet the rigorous 8-hour workday demands of municipal operators while managing the inherent limitations of battery capacity.

Currently, Egholm's electric models face a runtime barrier, typically operating for 2–3 hours per charge under standard conditions. While technical solutions such as larger batteries exist, they drive up costs and weight, potentially pricing the machines out of the competitive market.

Through collaboration with Egholm's management and technical team, we have identified that this challenge is not purely hardware-related. A significant portion of energy consumption is dictated by operator behavior. Interviews and initial data (see Appendix A) suggest that operators, accustomed to diesel engines, often default to maximum power settings regardless of the task at hand—vacuuming dry leaves with the same force used for wet debris, for example.

This report explores the potential of the **Energy-Aware Assistance System (EAAS)**, a solution designed to bridge the gap between technical capability and human usage. By leveraging behavioral design and real-time feedback, we aim to demonstrate how Egholm can extend machine runtime and reduce costs without expensive hardware upgrades.

The following sections will detail our analysis of this “Hard Nut” problem, the development of our EAAS prototype, and the business case for implementing such a system in the next generation of Egholm tractors.

3 Problem Analysis: The “Hard Nut”

The company’s original challenge focused on improving the everyday energy efficiency of their E-Traktor and lowering operational costs for professional users, without negatively affecting workflow or user experience. The company operates in a market where electric machinery is increasingly attractive due to regulatory pressure, sustainability goals, and long-term cost considerations. However, high up-front investment, range limitations, and uncertainty about real-world performance still influence customer expectations. This makes efficient use of the electric drivetrain a central competitive parameter.

3.1 Contextual Analysis

Through early desk research and conversations with company representatives, we gained a clearer picture of the tractor’s use context. The E-Traktor is typically operated by municipal workers, landscape contractors, and facility maintenance personnel. These operators often work under time pressure, perform repetitive tasks, and do not always have strong incentives to adjust machine settings for optimal energy usage. We believe that many users tend to run the tractor at maximum power, regardless of weather, task type, or terrain conditions, even in situations where lower power would be sufficient.

From our company visit and dialogue with Egholm’s engineers, we learned that approximately 25% of the tractor’s total cost comes from the battery pack. Consequently, inefficient operation—such as running at maximum power when unneeded—drains energy unnecessarily and inflates the Total Cost of Ownership (TCO). Tasks such as mowing wet grass or vacuuming dust in high humidity have vastly different power requirements, yet operators often use a static, high-power setting. It became evident that improving efficiency is not simply about installing bigger batteries or redesigning motors—it is about helping users operate smarter.

3.2 Defining the Core Problem

We utilized the **Double Diamond** framework [2] to structure our innovation process. In the *Discover* phase, we analyzed Egholm’s technical setup and operational context. In the *Define* phase, we pinpointed user behavior as the primary variable in energy consumption. This led us to define our “Hard Nut” challenge statement:

> ***How can we influence and support user behavior so that the E-Tractor is used more energy-efficiently in daily operation—without it being perceived as a limitation—and thus contribute to lower operating costs and increased market value?***

3.3 Behavioral Insights

During the first diamond phase, detailed operator interviews highlighted several recurring behavioral themes that informed our strategy:

- **Low Prioritization:** Energy optimization is rarely a conscious priority for daily users.

- **Preference for Simplicity:** Operators value reliability and predictability over the ability to fine-tune complex settings.
- **Risk Aversion:** Power reductions are often perceived as a performance risk (e.g., "will the machine be strong enough?"), leading to a safety-first, max-power habit.
- **Lack of Feedback:** Users lack real-time data on how their driving style affects battery drain.
- **Diffuse Responsibility:** The municipality pays the energy bill, while the operator controls the machine, creating a disconnect between usage and cost.

The human side of this "Hard Nut" is critical. Many operators rely on habits formed with diesel engines [3], where idling or high RPMs had different consequences. Electric drivetrains deliver instant torque, meaning small adjustments can yield significant savings. To succeed, any solution must provide transparent, non-intrusive feedback that feels like a helpful assist rather than a restriction.

4 Proposal Rationale

Our proposal is centred on developing an Energy-Aware Assistance System (EAAS) for Egholm's E-Traktor: an interaction-driven support system that guides operators toward more energy-efficient behaviour through simple, real-time feedback and light-touch behavioural nudges [4]. The system is designed to respect operators' needs for efficiency and control, while simultaneously helping Egholm and their customers reduce energy consumption, extend battery runtime, and document usage patterns.

4.1 Problem and Vision

Throughout the project, we identified a core behavioural issue: operators consistently default to maximum power, regardless of the task, surface conditions, or the actual energy required. As our research and interviews showed, this behaviour is rooted not in laziness but in uncertainty and risk aversion—operators prefer predictability over optimisation. Combined with the absence of telematics and feedback systems, this leads to unnecessary energy consumption and reduced runtime.

The vision behind our proposal is therefore twofold:

- Enable operators to make smarter decisions without increasing cognitive load.
- Provide Egholm with data and tools that turn energy efficiency into a strategic advantage, both commercially and sustainably.

The EAAS concept embodies this vision by creating a direct bridge between machine data, user behaviour, and energy-aware operation.

4.2 Problem Validation

We validated the problem through multiple methods:

- Interviews with Egholm's COO and engineers, who highlighted the lack of data, the behaviourally driven inefficiencies, and the desire for non-intrusive ways to influence user behaviour.
- Desk research on the operational context of municipal electric machinery, which showed similar behavioural patterns in other segments.
- Technical insights from Egholm's internal testing, which confirmed that energy needs vary significantly depending on the task (e.g., wet vs. dry grass).

These combined findings validate that the main “hard nut” is behavioural, not technical.

4.3 Proposed Solution: The Energy-Aware Assistance System (EAAS)

The Energy-Aware Assistance System (EAAS) is not merely a monitoring tool but a behavioral design solution. It bridges the gap between the machine’s technical capabilities and the operator’s daily usage patterns. The system is built upon five core design principles derived from our prototyping phase:

1. **Task-Aware Intelligence:** The system does not apply a ”one-size-fits-all” rule. Instead, it auto-detects the current operation (e.g., mowing, vacuuming, sweeping, or transport) and adjusts its recommendations accordingly. This addresses a critical insight: optimal power varies by task *and* conditions. For instance, mowing wet grass requires *more* power to prevent clogging, whereas vacuuming wet leaves requires *less* power to avoid wasting energy on heavy, grounded debris.
2. **Non-Intrusive Feedback:** To respect the operator’s workflow, the system employs a ”Traffic Light” metaphor (Green-Yellow-Red) for at-a-glance comprehension [3]. There are no pop-up windows or blocking alerts that interrupt operation.
3. **Positive Reinforcement:** Rather than punishing inefficiency, the system celebrates success. It tracks ”Energy Saved” and ”Green Zone Streaks” to provide psychological rewards for efficient operation, fostering a sense of achievement rather than surveillance.
4. **Actionable Guidance:** Suggestions are concrete and immediate. Instead of vague advice like ”Reduce Power,” the system offers a one-tap ”Apply Now” feature that adjusts settings to the optimal level, showing the direct runtime benefit (e.g., ”+12 min”).
5. **Operator Respect:** The system acts as a co-pilot, not an enforcer. Manual control is always available, and alerts can be dismissed, ensuring the operator remains the final authority.

4.4 Innovation and Value Proposition

The innovative aspect of EAAS lies in its integration of behavioral psychology with machine intelligence. Unlike standard telematics that report data *after* the fact, EAAS intervenes in real-time to alter the outcome.

Key Innovations:

- **Contextual Intelligence:** The ability to distinguish between scenarios where high power is wasteful (dry sweeping) versus necessary (wet mowing) prevents counterproductive advice that would erode user trust.
- **Hysteresis Logic:** The feedback algorithm includes a delay buffer to prevent ”flickering” signals, creating a calm, stable interface that operators can trust.
- **Quantified Impact:** By showing the immediate gain in battery runtime, the system translates abstract ”efficiency” into the operator’s most valuable currency: time to finish the job.

The value proposition extends beyond energy savings: it reduces range anxiety for operators, provides documented sustainability metrics for municipalities, and offers Egholm a software-defined competitive advantage that reduces the pressure to simply install larger, more expensive batteries.

4.5 Supporting Insights and Research

The proposal rests on several research findings and tests:

- Behavioural analysis confirming operators' preference for simplicity and predictability.
- Technical insights showing large variations in power needs depending on conditions.
- Validation from Egholm that telematics is desired but not yet implemented, meaning a lightweight behavioural system is an ideal first step.
- Industry literature showing that gentle nudges, colour-based feedback, and simplified dashboards significantly change operational habits in professional electric equipment.

4.6 Solution Validation

We validated the EAAS concept through:

- Feedback sessions with operators, who preferred the simplicity of the coloured display over complex menus.
- Discussions with Egholm's COO and engineers, who confirmed the technical feasibility and strategic relevance.
- Iterative design sessions, where different feedback mechanisms were tested for clarity, intrusiveness, and perceived usefulness.

This combination of qualitative validation and technical grounding ensures that the solution is realistic, adoptable, and aligned with Egholm's future direction.

5 Prototype Implementation

To validate the feasibility and user experience of the Energy-Aware Assistance System (EAAS), we developed a fully functional web-based prototype (`` `eaas_ui_prototype.html` ``) that simulates the tractor's operating environment. This high-fidelity prototype demonstrates how the system processes sensor data, detects tasks, and provides real-time feedback to the operator.

5.1 User Interface Architecture

The user interface is designed for high readability in outdoor conditions, utilizing a dark, high-contrast color palette to reduce glare and eye strain. The layout is divided into three logical zones:

Primary Status Dashboard: The most prominent area, containing the "Traffic Light" indicator, current task display, and battery status. This ensures that critical efficiency data is always in the operator's peripheral vision.

Actionable Insight Card: A dynamic space that appears only when an improvement is possible. It displays specific suggestions (e.g., "Reduce suction power") and a one-tap "Apply Now" button to implement the change instantly.

Telemetry & Sensor Grid: A secondary layer offering detailed metrics (speed, torque, power draw) and environmental data (humidity, surface conditions) for operators who desire deeper insights.

5.2 Core Logic: Task Auto-Detection

A central feature of the prototype is its ability to infer the operator's intent without manual input. The `detectTask()` algorithm fuses data from three simulated sources:

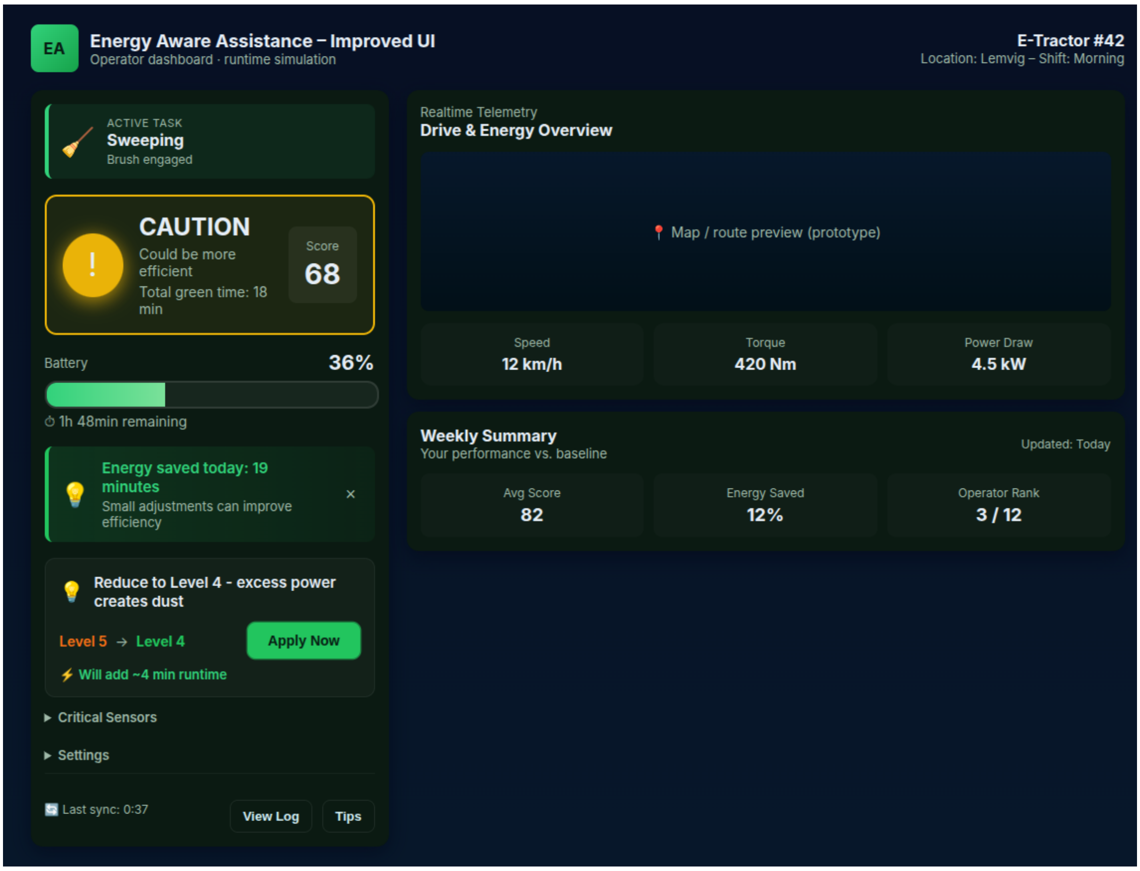

Figure 1: Conceptual UI Prototype of the Egholm Eco-Assistent Power Guidance System. The display shows current task, outside conditions, operator power setting, and an efficiency indicator with dynamic suggestions for energy saving.

- **Load Level (1-5):** Measures resistance on the motor/hydraulics.
- **Power Level (1-5):** The operator's current setting.
- **Attachment Status:** Whether the PTO (Power Take-Off) is engaged.

For example, high load combined with high power draw indicates **Mowing** (sustained cutting resistance). Conversely, medium load with variable power suggests **Vacuuming**. If no attachment is active, the system defaults to **Transport** mode. This distinction is crucial because, as noted in our rationale, a power level that is efficient for mowing may be wasteful for transport.

5.3 Feedback Algorithm: The Traffic Light

The "Traffic Light" indicator is driven by a context-aware calculation that compares the current power setting against a pre-defined "Optimal Range" for the detected task and environmental conditions.

- **Green (Optimal):** Power is within the specific range (e.g., Level 4-5 for wet mowing).
- **Yellow (Caution):** Power deviates by one level from the optimal range, or efficiency scores are moderate.
- **Red (Inefficient):** Significant deviation (e.g., running Level 5 for dry sweeping) or low battery status (<30%).

To prevent distraction, the system implements a **3-second hysteresis** (delay) on status changes. This ensures the indicator remains stable and does not flicker during momentary load spikes, building operator trust in the signal.

5.4 Behavioral Features

The prototype implements specific features to drive behavioral change:

Actionable Suggestions

When the system detects inefficiency (Yellow/Red state), it generates a "Suggestion Card." Crucially, this card quantifies the benefit (e.g., "Energy: Will add 12 min runtime") and offers a single "Apply Now" button. This reduces the friction of making an adjustment—the operator does not need to guess the correct setting, only to approve the system's recommendation.

Positive Reinforcement

Drawing on behavioral psychology, the UI emphasizes rewards over penalties. A "Green Zone Streak" counter tracks how long the operator has maintained optimal efficiency, and an "Energy Saved" metric accumulates throughout the shift. This gamification element encourages operators to maintain their streak, turning energy saving into a personal achievement.

5.5 Simulation & Validation

The prototype includes a dynamic simulation loop that runs every 3 seconds to mimic real-world variability. It simulates battery drain (which accelerates in Red status), fluctuating efficiency scores, and changing weather conditions (Wet/Dry). This allowed us to verify that the auto-detection logic correctly adapts recommendations—for instance, advising higher power for mowing when "rain" is simulated, but lower power for vacuuming under the same conditions.

6 Business and Economic Impact

During our visit to Egholm's offices and production facilities, we gained a clear understanding of the economic constraints and opportunities involved in developing the next generation of electric utility machines. A central insight was that the battery pack accounts for approximately **25% of the total production cost** [5]. Consequently, any innovation that extends runtime without increasing battery size has a direct, positive impact on the machine's unit economics and market competitiveness.

6.1 Cost Drivers and Development

Egholm currently invests heavily in physical testing to validate battery performance across diverse conditions. We learned that prototypes are driven to locations like Switzerland to test performance in extreme cold—a necessary but expensive and logistically complex process. While these tests ensure reliability, they represent a significant fixed cost in the development cycle.

We identified a strong business potential in shifting from purely physical testing to a data-driven approach [6]. By combining Egholm's initial baseline measurements with the proposed EAAS framework, the company can reduce its reliance on expensive field trips.

6.2 Operational Optimization via Data

Before full telematics can deliver precise automated recommendations, Egholm needs to establish a "reference map" of energy usage. The EAAS system facilitates this by gathering data on:

- **Task-Specific Power Needs:** Differentiating requirements for dry vs. wet grass.

- **Load Variations:** Measuring how surface conditions (e.g., gravel, asphalt) affect resistance.
- **Environmental Factors:** Quantifying the impact of moisture and temperature on consumption.

Integrating this data flow offers two major economic advantages:

1. **Scalability:** Once the sensor framework is deployed, Egholm collects data from the entire fleet at near-zero marginal cost, turning optimization into a continuous, scalable process.
2. **Reduced Testing Costs:** Real-world customer data can supplement or partially replace expensive international stress tests, providing faster feedback loops at a lower cost.

6.3 Strategic Competitive Advantage

For municipal customers, the value proposition is straightforward: intelligent power management translates to longer runtime per charge and a lower Total Cost of Ownership (TCO). Since the battery is a dominant cost factor, documenting that the machine utilizes its capacity with maximum efficiency becomes a powerful sales argument.

Overall, the EAAS approach supports a robust business case, enabling Egholm to:

- **Reduce Development Costs:** By streamlining the testing and validation phase.
- **Accelerate Innovation:** Shortening the feedback loop for product improvements.
- **Strengthen ESG Profile:** Providing documented energy savings for sustainability reporting.
- **Differentiate Market Position:** Moving beyond hardware specs to offer ”intelligent” machinery.

In conclusion, energy optimization is not merely a technical feature but a strategic business tool that addresses Egholm’s most significant cost driver while delivering tangible value to the customer.

7 Further Perspectives

The Energy-Aware Assistance System (EAAS) presents significant opportunities for expansion and refinement beyond its initial implementation. Several strategic directions emerge that could enhance both the system’s capabilities and Egholm’s market position.

7.1 Long-term AI Development

As the system accumulates operational data from diverse environments and user behaviors, machine learning algorithms could evolve from reactive feedback to predictive optimization. The EAAS could learn to anticipate energy demands based on historical patterns, weather forecasts, and task-specific requirements. This advancement would enable proactive suggestions, such as optimal charging schedules or route planning that minimizes energy consumption while maximizing productivity.

7.2 Data-Driven Product Evolution

The operational data collected through EAAS sensors represents a valuable asset for Egholm’s product development pipeline. Aggregated anonymized usage patterns could inform future tractor designs, battery configurations, and feature prioritization. This data-driven approach would create a feedback loop where user behavior insights continuously improve hardware and software solutions.

7.3 Multi-Task Optimization

While initially focused on general operational efficiency, the EAAS framework could be specialized for different municipal tasks. Separate optimization profiles for mowing wet grass, vacuuming in high humidity, snow removal, or leaf collection would account for the unique energy demands of each activity. This specialization would maximize efficiency gains across Egholm's diverse product applications.

7.4 Gamification and Behavioral Scaling

Building on the positive reinforcement principles, expanded gamification features could include fleet-wide leaderboards, efficiency challenges between operators, and recognition programs. Such elements would foster a culture of sustainable operation across municipal organizations, potentially leading to broader adoption of electric equipment and reduced carbon footprints.

7.5 Integration with Broader Sustainability Initiatives

The EAAS could serve as a foundation for comprehensive sustainability management systems. Integration with municipal energy monitoring platforms, carbon accounting tools, or smart city infrastructure would position Egholm's tractors as key components in larger environmental initiatives. This ecosystem approach would enhance the perceived value of Egholm's products beyond mere equipment sales.

7.6 Technical and Market Expansion

From a technical perspective, the sensor and feedback framework could be adapted for other electric utility vehicles in Egholm's portfolio. Market expansion opportunities include partnerships with software providers for advanced analytics or collaborations with municipalities for pilot programs that demonstrate measurable environmental impact. These perspectives illustrate how the EAAS transcends its initial scope as a behavioral optimization tool, evolving into a comprehensive platform for sustainable equipment management. The system's success would not only extend operational efficiency but also establish Egholm as a leader in human-centered, data-driven sustainability solutions. [7]

8 Conclusion

The transition to electric utility machines represents both a technical challenge and a significant market opportunity for Egholm A/S. Our investigation confirmed that while battery capacity is a limiting factor, operator behavior plays a decisive role in real-world energy consumption. The current lack of feedback leads to a default "max-power" driving style that unnecessarily drains batteries and shortens runtime.

To address this, we proposed the **Energy-Aware Assistance System (EAAS)**. This concept moves beyond purely mechanical optimization to include the human element of the system. By providing operators with simple, real-time feedback on their energy efficiency, Egholm can achieve:

1. **Extended Runtime:** Reducing unnecessary power usage directly translates to longer operating hours, addressing the primary concern of municipal customers.
2. **Cost Efficiency:** Optimizing usage reduces the immediate need for larger, more expensive battery packs, preserving Egholm's competitive pricing structure.
3. **Future-Proofing:** The implementation of EAAS serves as a stepping stone toward full telematics and AI-driven predictive maintenance, positioning Egholm as a leader in smart, sustainable municipal maintenance.

We recommend that Egholm prioritizes the development of this behavioral interface alongside their hardware electrification. The “Hard Nut” of energy efficiency is not just about storing more power; it is about using the available power smarter. EAAS provides the tool to make that smart usage a daily habit for every operator.

Appendices

A Mail from Eggholm A/S

From: Eggholm A/S Representative
To: Martin
Subject: Response to Questions about Case Project
Date: October 2023

Hej Martin,

Jeg skriver på vegne af Gruppe 58, der har fået jeres case. Vi glæder os super meget til at arbejde med jeres firma. Vi har nogle praktiske spørgsmål som vi håber du kan hjælpe med at svare på så vi kan komme forberedt på onsdag 29/10.

1. Indsamler I allerede nogle former for data som vi kan få adgang til? Bruger I GPS så man ikke kører over det samme sted 2 gange? Har I noget data på hvornår jeres maskiner kører optimalt $\rightarrow$ ikke optimalt?

   I dag anvender Egholm ikke ’GPS’ overvågning på maskiner i drift. Dog har vi i forbindelse med det seneste projekt arbejdet med en leverandør omkring en fremtidig telematik løsning.

2. I spørger om det er muligt at indarbejde en form for motivation for brugeren af maskinerne til at bruge dem på en måde, hvor de bruger mindst mulig energi.

   Vi ved at brugere anvender maskinerne forskelligt, f.eks. max. sugekapacitet på opsamlingstanken, også når det ikke er nødvendigt.

   Er det fordi I allerede ved hvilke områder der kan forbedres?

3. Har I haft prøvet at løse disse problemer før, hvis ja, har i haft nogle succeser? Har I mødt nogle ”dead ends”?

   Vi har bl.a. indført en række forbedringer i produkterne (f.eks. SW) som er uafhængige af brugerens adfærd.

   Udgangspunktet for brugeren af maskinen er at opgaves løses bedst mulig og mindre fokus på energiforbrug. Det er her vi ønsker ideer der kan være med til at ændre brugerens adfærd.

4. Hvad er jeres motivation for at forbedre kundernes brug af maskinerne?

   Forbedret brug af maskiner skal komme både brugere (f.eks. mindre energiforbrug$\rightarrow$længere driftstid), kunder (f.eks. reduceret støj, støv mm.) og ikke mindst en lavere miljøbelastning.

B Egholm Case Brief

DTU

Description of innovation case

Egholm A/S is a family-owned company located in Lemvig, founded in 1992. Originally, Egholm developed agricultural machines and implements, but today we specialize in the design and production of robust utility machines that keep urban spaces, parks, and outdoor areas clean and attractive. Egholm has sold machines to schools, hospitals, cemeteries, and other institutions in more than 130 countries. We have a strong focus on innovation, quality, and sustainability, and we are currently finalizing our first ESG report.

We design our machines and attachments in our own prototype workshop. Easy tool change and operator comfort are central to the development of our equipment, which can be divided into three main groups: green for lawn and turf work, black for cleaning tasks, and white for snow-clearing tasks.

We maintain a good and close dialogue with our existing customers, and we want to continue developing products that meet future needs and requirements. Today, most of our attachments are hydraulic and partly electric. Our ambition is for energy optimization to become the next generation of utility machines.

Many users of our utility machines carry out several tool changes during a working day, and some tasks are more energy-intensive than others. We want our products in the future to help them minimize the total energy consumption across a wide range of tasks as much as possible.

Innovation question

How can we, through new technologies such as AI and machine learning, minimize the energy consumption of our utility machines?

Is it possible to incorporate some form of motivation for the user of the machines to use them in a way where they consumes the least amount of energy?

Name of company: Egholm
Contact person: Martin Wingaa
Email: mwi@egholm.dk
Mobile: 40308964
Company website: www.egholm.eu

CVR-nr. DK 30 06 09 46

Danmarks Tekniske Universitet
Engineering Technology
Lautrupvang 15
2750 Ballerup

C Production Facility Visit Notes

This appendix summarizes the key insights and observations recorded during our group's visit to the Egholm production facility. The notes have been translated from the original Danish and reorganized for clarity.

C.1 Optimization Potential

- **Efficiency Gains:** There is significant potential for optimization during normal use. Some attachments can be improved by 10–15%, while others show a potential improvement of 40–50%.
- **New E-Tractor Goals:** The new electric tractor currently in development has a target runtime of a full 8-hour workday.
- **Cost Drivers:** The battery accounts for approximately 25% of the total price of the E-Tractor. Reducing energy consumption would allow for a smaller, less expensive battery, directly improving the product's marketability.

C.2 Product Design & Interface

- **Complexity vs. Marketability:** The solution can be as complex as necessary, provided it remains profitable and marketable to the end-user.
- **User Interface Strategy:**
  - *Hard Functionality:* Critical controls like lifting/lowering tools or adjusting arms should remain on physical buttons and joysticks.
  - *Soft Functionality:* Parameters like cutting speed or suction power can be moved to touch screens or digital interfaces.

C.3 User Behavior & Operation

- **User Mindset:** End-users typically do not prioritize fuel economy (e.g., km/L) since refuelling is easy. However, operational efficiency (e.g., driving slower to maintain performance while saving energy) is a key optimization avenue.
- **Current Habits:** Users often default to maximum power ("full throttle") regardless of conditions. If the result is poor, they simply repeat the pass.
- **Lack of Guidance:** There is currently no training video or guide available to users on how to operate the equipment energy-efficiently.

C.4 Technical Insights & Questions

- **Context-Awareness:** Is the tool/motor needed right now? Could a "start/stop" function or an algorithm based on rain, speed, and grass length optimize the cutter blade speed?
- **Suction/Sweeping Optimization:**
  - Does the suction unit need to run continuously?
  - Alternative ideas included a "dustpan" mechanism or intermittent suction (collecting a pile and then shooting it into the hopper).
  - The "flow energy cost" of the suction unit is constant whether it is actively collecting debris or not.
- **Heating:** Heating is a major energy drain. Suggestions included distinguishing between summer/winter cabins or focusing heating on contact surfaces (steering wheel, seat) rather than the entire cabin air volume.

C.5 Testing & Validation

- **Current Testing:** Egholm performs tests, including cold-weather battery performance and snow tools in Switzerland.
- **Data Gaps:** There is currently insufficient data on optimal mowing speeds relative to grass length and moisture. More battery-based mowing tests are planned.
- **Focus:** The most important outcome for Egholm is a demonstrable solution that proves how energy is saved.

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