SAVING ENERGY AT TERMINALS

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REDUCING OUR FOOTPRINT

Transportation is one of the world's largest contributors to global emissions, hence climate change. Since the introduction of the container, global trade has taken unprecedented growth, fostered by ever decreasing costs. At the tip of our fingers, the global shopping window is exposing itself to the global consumer. Digital forms of shopping facilitated by a growing global supply chain have created a market for buyers and sellers like we have never seen before. This newfound phenomenon has brought unparalleled prosperity to the world. Despite the many crises the world's politicians have at hand, the global economy keeps growing and will continue to do so. With another 6 billion people who have wealth levels well below the developed countries, there are enough prospects for the global sellers of more and less useful products.

While people in developed countries keep spending a lesser percentage of their disposable income on 'products' in favour of services, this is a long way out to the majority of the world's population. But as the world's wealth and levels of civilisation keep rising, an increasing number of products will be purchased, awaiting transportation.

Although transportation is getting more and more efficient, we still have a long way to go until our global supply chain is sustainable, or in more fashionable terms, 'carbon neutral'. As long as we have giant ocean steamers burning some of the dirtiest fuels in the world, there is work to do, which starts in ports. In 2030, European ports will have to be equipped with shore power so that these vessels in port stop polluting. The challenge just in realising that is already gigantic. The amount of power which needs to be supplied, combined with the infrastructure changes inside ports and terminals, will require enormous efforts from the port authorities and their concession holders.

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Along with these investments in new (electric) power provision, other investments inside the terminals can and should be made. Meanwhile, fully electrified terminal operations are available, although the cost of acquiring them and the long implementation times are substantial hurdles. Yet, electrification of the equipment fleet is seen as the key contributor for terminal operators to meet their emission reduction goals.

Not only does electrification come at a high cost, it has substantially impacts operations when it concerns mobile equipment. Certainly, battery technology is rapidly developing, but the high-duty pattern in terminals doesn't align well with the limited-capacity batteries offered these days. Recent research by Portwise shows that at least an additional 10-25 per cent of fleet needs to be acquired to keep operating at the same level when all equipment is battery-powered.

In addition, the charging itself brings its challenges. First, one doesn't (and can't) charge all vehicles at the same time, so to even out charging peaks, there should be a constant rotation of vehicles operating and being charged, which doesn't align very well with shift patterns. Secondly, the integration of large charging locations takes up space, and one central location may cause traffic issues.

So, if battery technology is not the non plus ultra, what technology brings a panacea? Is it hydrogen, biodiesel, compressed natural gas (CNG), or simply hybrid technology? The answer to this question is not so simple. Local availability of such fuels, pricing, and the operational fit, make it a question of tailoring to the situation.

Hydrogen may seem the solution, but it's not readily available (anywhere), very energy intensive to make, and overall (still) very expensive. Of course, it's conceptually feasible with green energy to produce it, but providing it at a large scale is still a long way out.

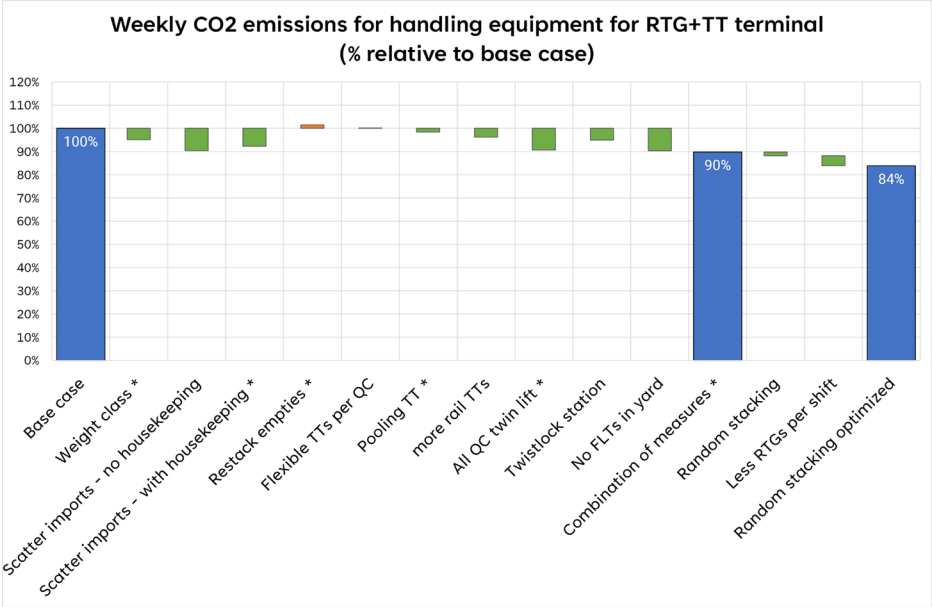


FIG 1.
Example case study: effect of productivity improvement measures on emissions

KEY POINT

What we - as Portwise - miss in the current (very valuable) discussion around reducing our emissions and environmental footprint is reducing the energy we use. Look at the electric cars we buy: they are all much bigger and heavier than the cars we drove before, offsetting any gains we have by electrification.

In any discussion around energy consumption, the first question should be how to reduce the amount we use to transport the cargo. Our operation is far from efficient as McKinsey quantified in 2018 (estimated waste of $70-80 billion, see reference). When we move containers through the terminal, we tend to move them on average five times, instead of the minimal two times! Three additional moves to get a container through a terminal. Why? Because we don't have our act together.

Therefore, the energy transition should start with operational efficiency, better information flow, better planning, and many more operational improvement measures. Evaluating improvement studies carried out by TBA in the period 2007-2020 shows that energy consumption can be reduced on average by 12 – 16 per cent: without investments in new technology.

Portwise has detailed models that allow us to measure energy consumption for all equipment, electric and conventional fuels. Portwise terminal models use kinematic equipment specifications with acceleration, deceleration, and conflict avoidance and consider load dependency and even the impact of wind. Suppliers of the equipment can provide information on energy consumption. Combined, it's a powerful way to get insights into the main drivers behind energy efficiency.

IMPACT OF OPERATIONAL IMPROVEMENT ON ENERGY CONSUMPTION

Portwise has extensive experience designing new ports and improving existing ports, always by means of quantitative analysis. Quantitative analysis repeatedly shows inefficiencies and, therefore, room for optimisation. While most of the focus was previously on productivity and cost, in hindsight, energy consumption can also be assessed by using our models.

Productivity measures that often get investigated are:

- Pooling of horizontal transport.
- Optimising driving behaviour and transfer point organisation at the apron.
- Yard strategy improvements: often more advanced strategies that minimise shuffles and maximise space, with limited human interference except setting the strategy parameters and boundaries.
- Increasing share of opportunity moves, such as dual cycling, double cycling and twin-lift;
- Relocation of certain areas which are frequently visited

Portwise compared the operational performance of scenarios with detailed simulation models. Especially simulating a longer period of time (a month or more) with peaks and slow hours proved useful. Detailed simulations are required to show the effects of yard strategy and equipment assignment rules. At the same time, it allows us to measure the active time and idle time per piece of equipment. For this initial estimate on past studies, we applied benchmark energy consumption

"ELECTRIFICATION OF THE EQUIPMENT FLEET IS SEEN AS THE KEY CONTRIBUTOR FOR TERMINAL OPERATORS TO MEET THEIR EMISSION REDUCTION GOALS."

figures per active hour and idle hour; and a benchmark of CO2 emissions per litre of diesel consumed. For new actual energy studies, we could include energy consumption in the model and get more refined insights.

Figure 1 shows the results from one example study of a marine terminal with Rubber Tyred Gantry cranes (RTGs) and terminal trucks. The base case represents a simulation of the current situation at the terminal. Each column shows the effect on CO2 emissions of one individual measure; green for reductions, orange for increases. The focus of the study was on productivity. The terminal selected feasible measures for productivity improvement, marked with *; and that combination resulted in 10 per cent emission savings. A more advanced scenario with random stacking would allow running with fewer RTGs and could reduce emissions 6 per cent further. Note: this reduction is using the existing diesel (not hybrid) equipment without electrification.

It turns out that productivity improvement and emissions go hand in hand (Figure 2). Usually, studies have solely focused on productivity and cost. However, this study focused on productivity and sought measures to improve it (vertical axis). Simultaneously, the study also discovered that the more moves a piece of equipment can make in an hour, the lower the consumption per move and the fewer emissions it produces (horizontal axis). This is especially the case for diesel engines, since

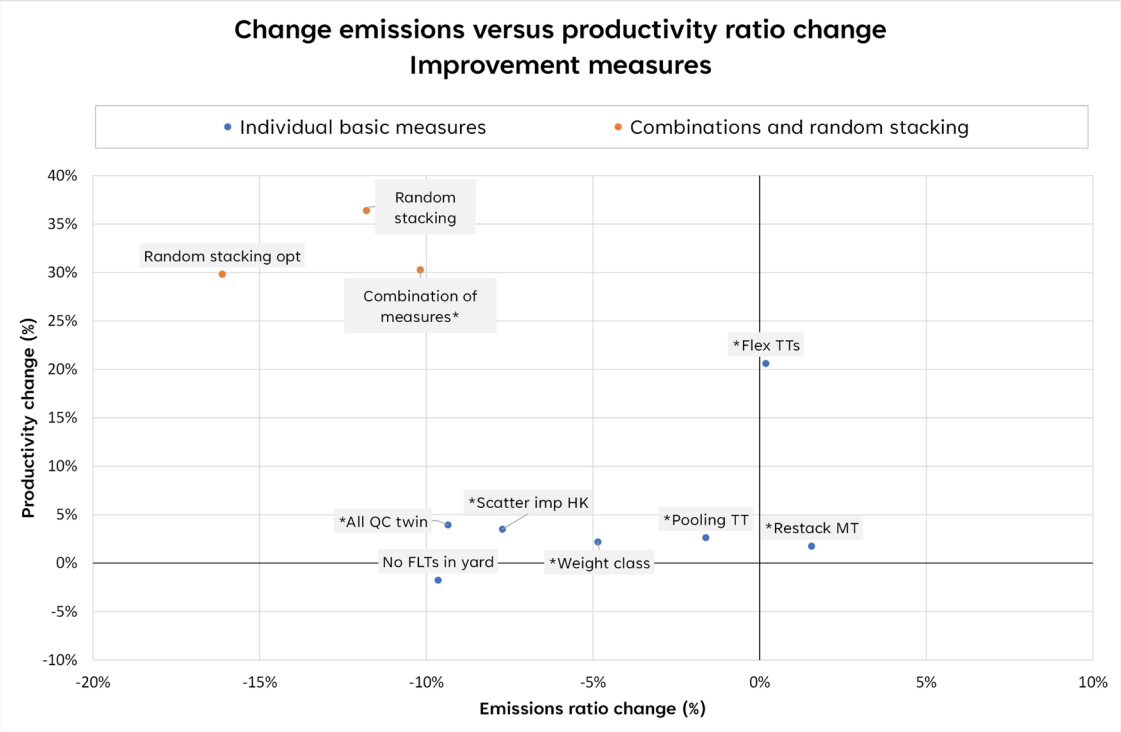
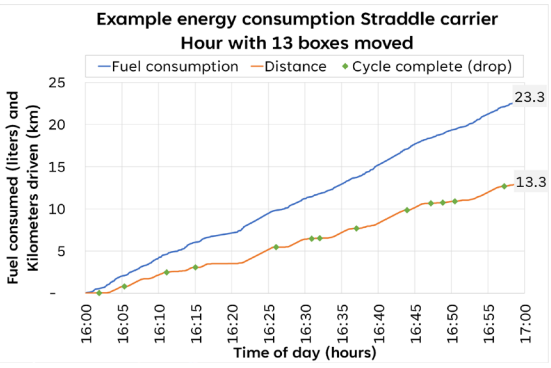


FIG 2.
Example case study: measures to improve productivity also reduce emissions



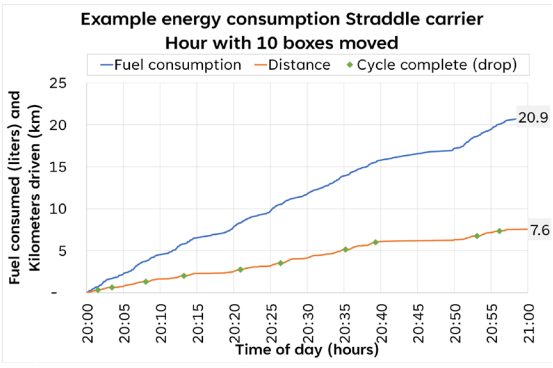
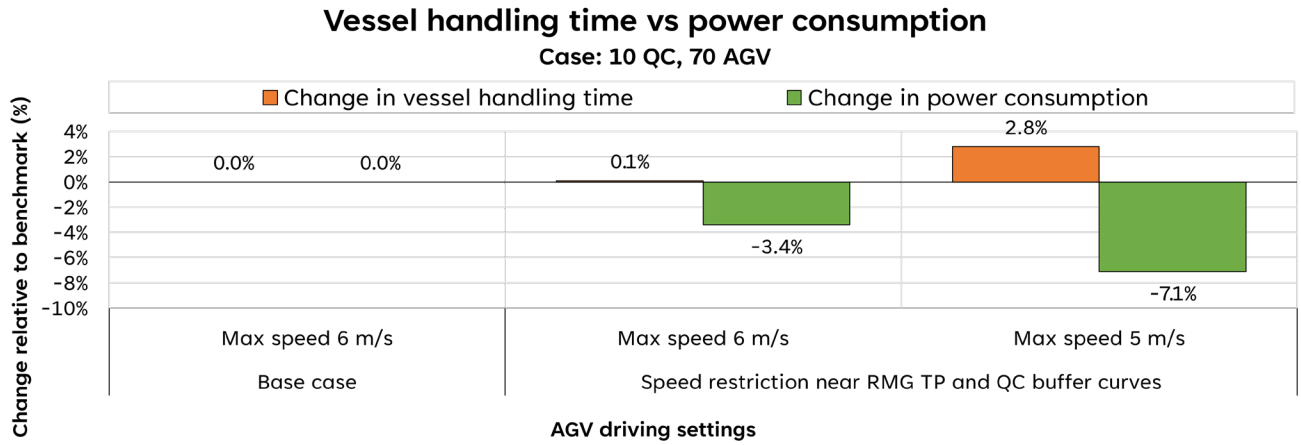


FIG 3.
Example energy consumption and distance patterns for one hour for a straddle carrier handling 13 moves/h versus 10 moves/h



they tend to still have high energy consumption while stationary (Figure 3).

Even less equipment and CAPEX savings sometimes appear possible with the most impactful measures. Figure 2 shows that combining individual measures improves productivity by 30 per cent and reduces emissions by 10 per cent. When an advanced yard strategy is implemented, productivity could be increased by 37 per cent with the existing equipment. The terminal could also opt for "only" 30 per cent productivity gain, such that RTGs can be deployed more economically and cost (and emissions) reduced by 16 per cent.

ENERGY EFFICIENCY IN AGV FLEETS

Portwise also has researched energy consumption on a terminal with electric automated transport equipment with the detailed model. Because the detailed model includes the kinematic specifications, the assignment and the traffic behaviour of the vehicles, it allows us to measure energy consumption and test scenarios with various driving strategies. How about yourself? Do you try to drive energy-efficiently in your own car? When cruise control is off, or it's too busy, it's a challenge to keep driving optimally.

Automated guided vehicles (AGVs), by definition automated centrally managed equipment, allow programmed strategies to coordinate the driving of all vehicles and keep energy use low. At the same time, simulation allows to test many strategies beforehand. Portwise carried out such studies, and afterwards, the resulting strategies were implemented in the AGV Management System. We compared a basic strategy where AGVs drive according to their maximum technical speed specifications to a scenario where AGVs drive slower when they are close to a curve by decreasing the maximum speed in certain areas. This minor change in driving behaviour resulted in 3.5 per cent energy savings at almost no performance cost, especially outside of peak speed (Figure 4). The simulation also showed that when all vehicles drive at a lower maximum speed, energy consumption is lower, but at the cost of some productivity.

We usually approach these kinds of studies by creating a prototype of the improvement into the simulation model, so it can also be built or configured in the software; this can either be a Terminal Operating System (TOS) or an Equipment Control System (ECS). The prototyped solution is then tested under varying circumstances to the original situation so that the impact of this change can be analysed in isolation.

FIG 4. Impact of improved AGV control to save energy without performance loss

CONCLUSION

The aforementioned examples show that there are opportunities to reduce the environmental footprint by focusing on operational efficiency. The results can be impactful without major investments, which are required if we go the route of electrifying entire operations. Nevertheless, the latter provides a large contribution to emission reduction, but should – in our view – not be seen as the sole panacea.

We should keep working on the energy transition inside terminals, applying the latest technology to reduce emissions, but foremost we should focus on operational energy consumption, and simply consuming less. Our long-lasting practice shows it can be done with focused and targeted change management and applying the world's best practices in efficient terminal operations.

ABOUT THE AUTHORS:
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ABOUT THE COMPANY:
Portwise, formerly part of TBA Group, is a world-leading consultancy and simulation firm that combines extensive automation and operational knowledge with proven simulation tools to create a future-proof plan for your port, terminal or warehouse operation.