

DRY BULK TERMINAL

CAPACITY PLANNING

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INTRODUCTION

In 2012, the international seaborne trade for dry bulk cargo continued to grow: an overall growth of 5.7 percent, within which was a 7.2 percent increase rate for major bulks.ⁱ

Unlike other types of terminals (e.g. container terminals, general cargo terminals), for dry bulk terminals it is important to distinguish if they are export or import terminals. Because of the differences in objectives (i.e. export or import dry bulks), an export bulk terminal is designed rather differently from an import bulk terminal.

Export terminals are often located closer to the sources of bulk materials (e.g. mines); they focus on facilitating the outgoing flows of material, determined by the availability and characteristics of inland transportation. Sometimes export terminals have to keep a large (still unsold) stock, to support pricing in material trade. In many cases export terminals handle a limited number of material types, due to their location or ownership (terminals owned by traders/mining companies).

In general, import terminals need to match services both to the waterside and landside modalities; this is a challenge especially when such services must be offered simultaneously. In many cases import terminals face a stochastic arrival of vessels, and the landside services and inland modalities are selected by the consignee and thus are difficult for the terminal to plan. Unlike export terminals, import terminals usually handle multiple types and/or grades of bulk materials; hence the resulting complexity of waterside and landside services will be even larger. This article will focus on the analysis of export terminals.

EXPANSION OF EXPORT TERMINALS

As previously mentioned, export terminals usually handle less types/grades of bulk materials than import terminals. In general, the more types/grades of materials the terminal needs to handle, the larger the required storage area. This is because of concerns such as cross-contamination and/or certification requirement.

Van Vianen et al. also indicate that the storage factors, defined as annual throughput per material divided by storage area, of export terminals

are usually higher than import terminals. In addition, export terminals usually have a storage capacity around three to 10 percent of the annual throughput; while storage capacities of import terminals are commonly between 5 to 22 percent of the annual throughput.ⁱⁱ

Better area utilisation and process improvement of the existing facility is one of the two possibilities for the expansion of export terminals. This is the fastest way to increase a terminal's throughput and often the best way when it comes to the utilisation of available assets. The challenge is to maintain operations while upgrading the terminal's facilities; nevertheless in recent years a number of export terminals around the world have taken this approach successfully.

Another method of expansion is to create a new facility close to the existing one. However, this method often encounters problems such as lack of space, environmental constraints, difficulties to connect with existing facilities and/or services (eg. inland infrastructure, supporting services). Even when these issues are resolved it is still a very time consuming process to complete: 10 years or even more is not unusual.

POTENTIAL CAPACITY ANALYSIS OF EXISTING FACILITIES

The origins of bulk materials are often determined geologically therefore locations for many export terminals require a trade-off between inland transportation and deep-sea access, and when a location is selected, the bulk terminal must pursue expansions for many decades. In this context, it is important to understand the full capacity potential of the terminal.

An in-depth analysis of both waterside and landside arrival patterns and a survey of potential improvements are necessary to study terminal capacity potential. Such a survey may encompass continued 24 hours operation, modified arrival patterns, smaller or larger transportation units (eg. barge convoy, number of wagons in a train), upgraded terminal handling systems, and reduced equipment breakdown figures.

Because of the stochastic nature of arrival processes/patterns and terminal handling operations, more and more dry bulk terminals make use of dynamic simulations to investigate the potential of various improvement measures and to balance these measures according to their cost/benefit potential.

WATERSIDE INFRA AND SUPER STRUCTURE UTILISATION

Export terminals have a drive to maximise the throughput of their most expensive assets: the waterside infra and super structure: the quay/berth, the loading equipment, and the connecting transport system between the storage and the waterside loading equipment. Various methods can be applied in order to improve the utilisation of waterside infra and super structure:

IMPROVE BERTHING/UN-BERTHING PROCEDURES

Some export terminals have rather long berthing/un-berthing time (e.g. up to four hours). Minimising this time will bring apparent positive effects on the potential of vessel loading berth planning.

OPTIMISE VESSEL TRAFFIC RULES

Optimal traffic rules can result in shorter vessel journey times, resulting in higher utilisation rate of the berth.

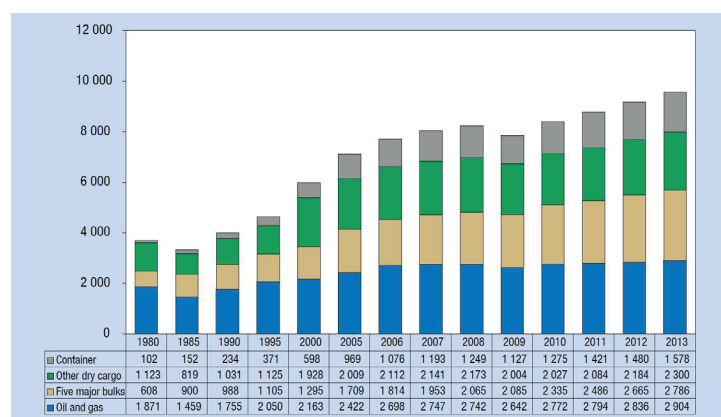
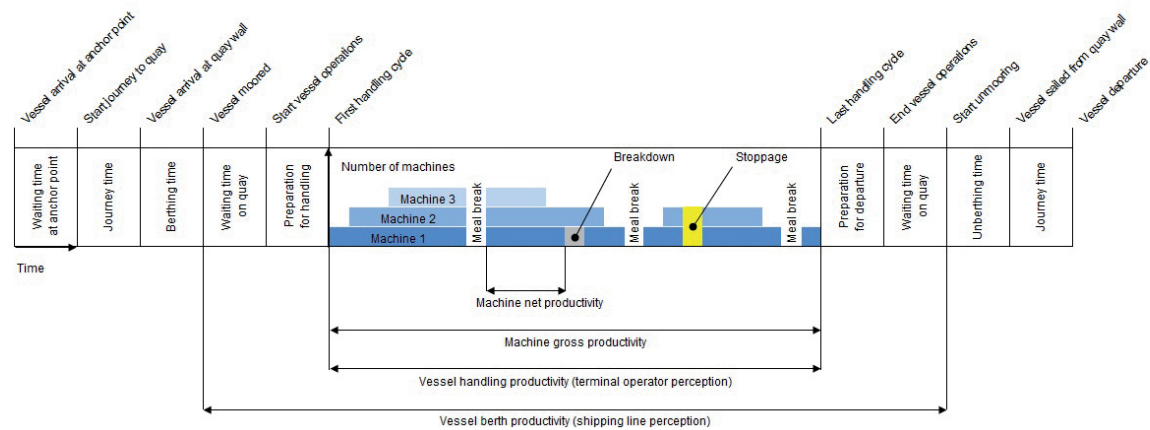


Figure 1: International seaborne trade in million tonnes loaded.ⁱ

Photo courtesy of the Prince Rupert Port Authority



Ridley Terminal, the Port of Prince Rupert, British Columbia, Canada.



Activity	Unit	Time	Explanation
Waiting time at Anchor Point	(hh:mm)	Result from simulation	Waiting for available berth
Journey time from Anchor Point to Quay	(hh:mm)	0:30	From anchor point to quay when berth becomes available
Berthing time	(hh:mm)	0:30	Approach to berth
Waiting time on Quay	(hh:mm)	Result from simulation	Waiting for available machines
Preparation for handling	(hh:mm)	0:30	Paperwork
Service time	(hh:mm)	Result from simulation	Handling of vessels by machines
Preparation for departure	(hh:mm)	0:15	Hatch closing / Machine travel / Ballasting
Waiting time on Quay	(hh:mm)	Result from simulation	Waiting for tide, channel or pilot
Unberthing time	(hh:mm)	0:15	Departure from berth till berth is given free for next vessel

Figure 2: Vessel duration.

REDUCE RELATED PROCESSES AND ADMINISTRATION

In some cases vessels have longer extended berth times because of process times holding up loading (e.g. sampling and weighing times), and/or administrative procedures (e.g. custom clearance, cargo surveyor, cargo documentation, inconsistent or lack of information). Higher berth throughput (average loading rate/hr) can be achieved by reducing these waiting times.

BETTER WATERSIDE HANDLING PROCEDURES

How do you evaluate the effect of delays/stoppages on the gross productivity? How much do these losses impact on the technical productivity of the equipment and the actual gross productivity achieved? It takes time to start and stop the material flows during the handling at the waterside; therefore during hatch changes, and when resuming

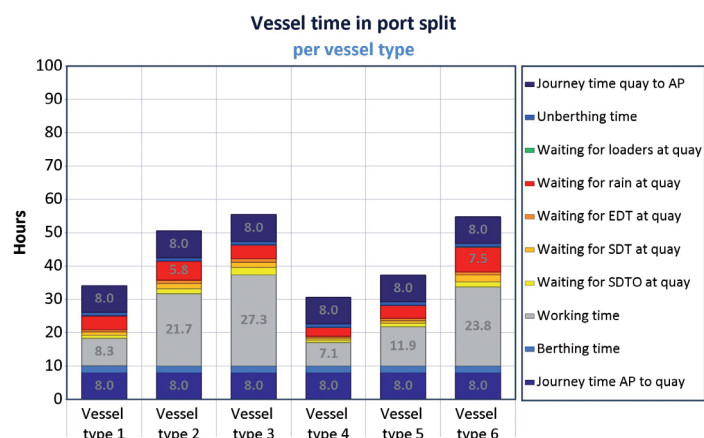


Figure 3: Vessel time in port with all stoppages.

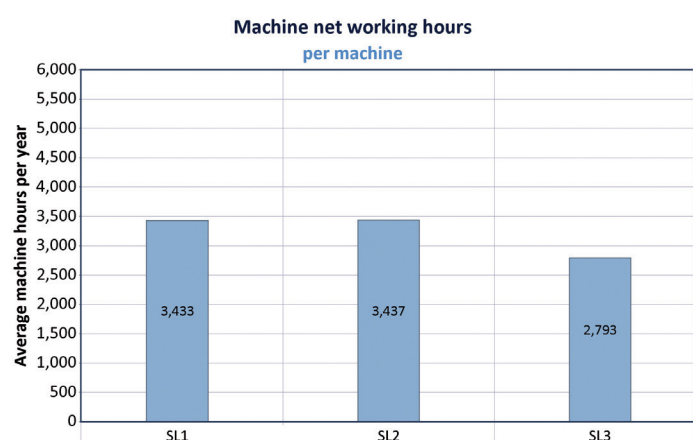


Figure 4: Working time per ship loader.

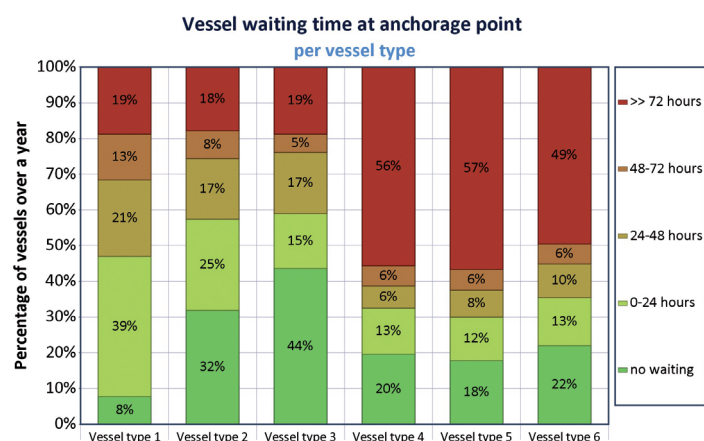


Figure 5: Vessel waiting time per vessel type.

from breakdowns or shift changes, effective loading time is lost. A better handling procedure can cut down the time lost due to start/stop.

DEPLOY SUITABLE EQUIPMENT

Do you know the impact of weather induced delays on planning/operations?

Extreme weather conditions such as strong wind, tidal ranges, heavy rain, or low temperatures can occur in certain parts of the world. The consequences of weather conditions can be minimised by installing provisions that allow all-weather operation.

MATERIAL FLOWS AND HANDLING SYSTEM CAPACITY

The storage areas of export terminals are used to accommodate the difference between incoming material flows and outgoing material flows, basically a buffer to connect the inland modalities and the waterside seagoing vessels. But in addition the storage area may serve as strategic market storage (trade or supply chain reliability).

Imbalanced material flows not only require higher storage capacity but also might cause longer material storage time. Despite the types of bulk materials an export terminal handles, it is recommended to realise shorter storage times; it is better for the bulk material quality and the terminal to achieve a larger throughput.

It is recommended to take a systematic approach for the whole logistics chain. Selections of charter contracts, vessel sizes, barge/train/truck arrivals, type and capacity of barges, train wagons, truck type and sizes, etc. will influence the potential capacity of existing facilities, as well as the possibility for future expansion. Improved planning in arrival patterns/processes together with more just-in-time connections are beneficial for export terminals.

Often the capacity of handling systems at the waterside is determined based on the required performance (i.e. vessel turnaround time). Landside handling capacity is driven by seasonal influences from bulk material sources (if any) and the services agreed between the bulk material suppliers and the barge/train/truck companies. As mentioned above, more uncontrollable variations in material flows result in higher demand for storage capacity. The handling capacity both at the waterside and the landside influence the hourly/daily/weekly/monthly incoming and outgoing material flows. Thus it is important to consider the performance (e.g. in terms of turnaround time) of waterside and landside together in order to balance the handling capacity.

CASE STUDY

Export terminals have various approaches to expansion due to the differences between material flows (both incoming and outgoing) and the functionality of the storage areas. A practical case of export terminal expansion studies is presented here to demonstrate the positive effect of using simulations to better determine the real potential terminal capacity when redesigning arrival patterns, charter contracts, inland transportation characteristics etc.

A grain and sugar export terminal is planning its expansion. The objectives of the study are to optimise the logistics processes (connecting rail and road networks) and determine the optimum capacity of the terminal. The terminal has identified the train handling operation and heavy rainfall as bottlenecks, and would like to know the optimal annual throughput with the planned storage expansion. Simulations with a dynamic approach have been applied to fulfil the objectives of the study.

In addition to the heavy rainfall, several other stoppages during vessel loading operations are also recorded by the terminal. The dynamic simulation-based analysis is a proven approach to analyse the potential berth capacity because of the stochastic characteristics of these stoppages. The results from the simulations quantify the impact from all stoppages and thus show the improvements attainable (see Figure 3). A sensitivity analysis, together with other berth analysis results such as berth occupancy, machine working hours (see Figure 4), vessel waiting time (see Figure 5) determine the optimal berth capacity. For cost reasons (the berth normally is the most expensive terminal asset) a high berth utilisation should be pursued but at the same time with a high effective hourly loading rate. At the end the latter parameter determines the yearly terminal throughput.

HANDLING CAPACITY AND MATERIAL FLOWS

Currently the train unloading operation is inefficient because of the physical conditions of the trains and the terminal (e.g. diverse wagon types, low unloading capacity). Simulations could show the impact of the unpredictable train arrivals and rail car unloading processes onto the train turnaround times for various statistical percentiles (see Figure 6).

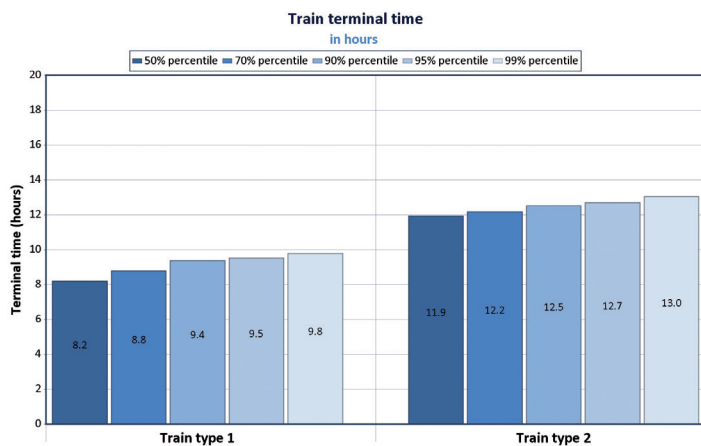


Figure 6: Train turnaround time statistics.

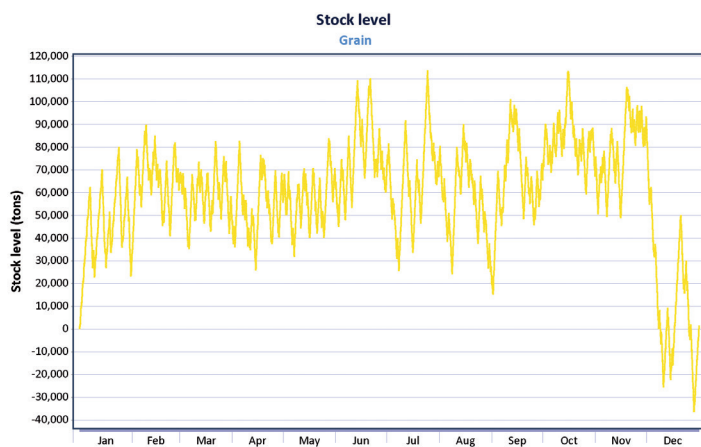


Figure 7: An example of simulated stock level change over a year.

Although the terminal already had plans to upgrade the handling capacity of the land-side, the simulations could still help to see the impact of the imbalance between water-side and landside handling capacity and characteristics onto the terminal throughput.

A good way to show the imbalance is to start the stock level at zero at the storage areas, and then project the incoming and outgoing flows on the terminal stock level, even allowing the stock level to go below zero (negative stock level). Indeed, a negative stock level in reality will never happen; however this is a very clear way to show the impact of imbalance between incoming and outgoing material flows.

Figure 7 shows how the stock level changes over a period of one year based on the simulation results. If the stock level stays for a prolonged period of time above the storage capacity, this means the landside incoming flows are larger than the outgoing flows at the waterside. On the other hand, a negative stock level shows that outgoing flows surpass the incoming flows. Such a graph can support the terminal to arrange arrival schedules for both the waterside and the landside in such a way that the available storage capacity is maximally used in the terminal's goal to fully utilise its assets.

The examples of the presented case learned that a capacity increase of 25-40 percent was possible with only minor investments. The study learned that better planning (including forward estimating of likely stochastics) could improve terminal economics.

IN CONCLUSION

With the continuous growth in dry cargo shipping, more and more dry bulk export terminals have expansion plans. In order to identify bottlenecks and maximise the potential of the terminal, it is important to include and quantify the impact from stochastic effects.

For a proper determination of the realisable capacity, it is recommended to consider the overall logistics process, the equipment handling capacity, and arrival characteristics of transportation modes connecting to the terminal. There are various methods to maximise the waterside infra and super structure utilisation, however various case studies showed that imbalanced incoming and outgoing material flows require an unnecessary high storage capacity. As many terminals face storage capacity as their throughput limiting factor, storage demand and material flow characteristics should be balanced. Simulation-based dynamic models proved to be useful tools for an intuitive approach. In this case study a simulation-based approach assisted in visualising and quantifying the influences from parameters such as varied arrival patterns (vessels, trains, trucks), and operational disruptions.

What would change with minor additional investments realise in improving throughput capability and terminal profitability? How much investment would be needed to realise a considerably enlarged terminal throughput potential? The simulation supported studies allowed terminal operators to help in their decision making to evaluate different investment options.

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ABOUT THE AUTHOR

Dr Mi-Rong Wu is a Project Manager for TBA, a leading terminal design and simulation company in The Netherlands. Her primary responsibility is managing projects for design and performance assessment in the bulk sector. She has five years' bulk sector research experience focused on subjects such as bulk terminal design, bulk material handling, and the development of a simulation model for bulk terminal design. Dr Mi-Rong Wu holds a PhD titled: 'A large-scale biomass bulk terminal' from Delft University of Technology. The research explores the possibility of a large-scale bulk terminal in West Europe dedicated to handle solid and liquid biomass materials.

ABOUT THE ORGANISATION

Netherlands-based TBA is a leading international provider of consultancy and software. Its product and service portfolio concentrates on marine terminals and intermodal container terminals. TBA's clients include all major terminal operators worldwide and many local port operators. TBA has completed over 200 terminal projects with varied scope; from design review to complete master planning. TBA supports a terminal operator during all stages from concept to realisation and thereafter in operations. TBA is specialised in ensuring that the planning is realised and targeted performance levels are achieved.

ENQUIRIES

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CAPACITY STUDY FOR AN EXPORT GRAIN TERMINAL



In 2014 the article titled “Dry bulk terminal capacity planning” elaborated on how a dynamic simulation approach, with the focus on quantifying the impact from stochastic effects, assists dry bulk terminals in their design and capacity planning. This approach proved to be beneficial and more and more dry bulk terminals have adapted such a method in their decision making process. This paper presents a case study to demonstrate how such an approach can be applied for assisting dry bulk terminals when it comes to investment decisions especially under current market situation.

CASE STUDY

A grain terminal plans to increase its handling capacity and has developed an investment plan. The terminal would like to use dynamic simulations to validate the planned investment and estimated/expected terminal capacity. In addition, the terminal would also like to identify the bottlenecks in the overall system and propose an investment path which is in line with the projected capacity increase.

The terminal faces the following challenges:

- The incoming material flows are brought to the terminal by trains. The terminal has no control on the train arrival patterns nor on the size of the trains (i.e. the length of the train with the number of wagons).
- The terminal already has an investment plan that covers various aspects, such as the upgrade of rail receiving infrastructure, the ship loading belt conveyor system, and a terminal process improvement project.

To capture the stochastic influences on the terminal, simulations have been performed in 2 steps:

1. At first, the inflow and outflow of the terminal were analysed (waterside/berth capacity and landside/rail capacity), along with the storage capacity.
2. The first overall analysis was then followed by simulations with a more detailed model, including the detailed belt conveyor network and storage bin configuration (see Figure 1 for the snap shot from the detailed model). This was done to capture the actual routing of the grain received from the railcars and to check the utilisation of the belts.

Various simulation scenarios relevant to the investment decisions were defined to assess the possible outcomes from different strategies. The simulation results were further translated into various KPIs to analytically and clearly demonstrate the impact. In addition to the KPIs outlined in the article “Dry bulk terminal capacity planning”, several other KPIs regarding the landside rail operations and the storage demand were also obtained from the simulations (see Figure 2).

The described simulation study not only helped the grain terminal to validate their investment plan but also identified operational bottlenecks. As a result, it was proposed to begin with an improvement program for the operational processes before starting the planned CAPEX for the further expansion of infrastructure. With a continuous improvement program the terminal could already increase its capacity with 40% and under while, the infrastructure upgrade project could be carried out. Simulation results also indicated that the handling capacity could be further increased with an additional 12% above the original objective after completion of both

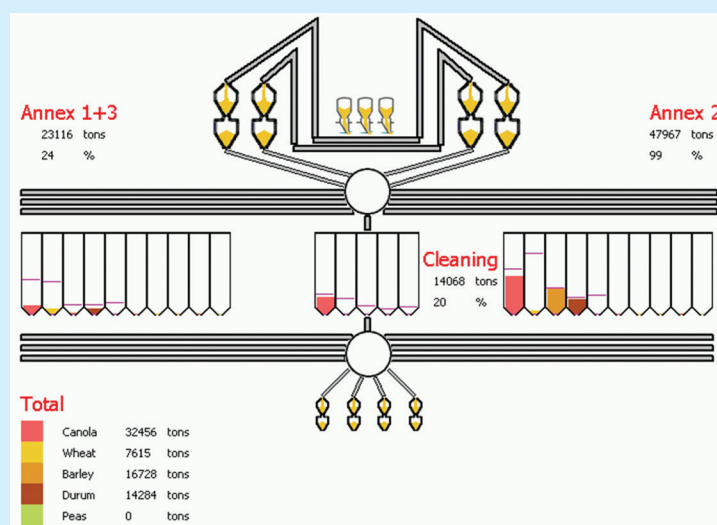


Figure 1: Snap shot from the simulation model for the belt conveyor network routing.

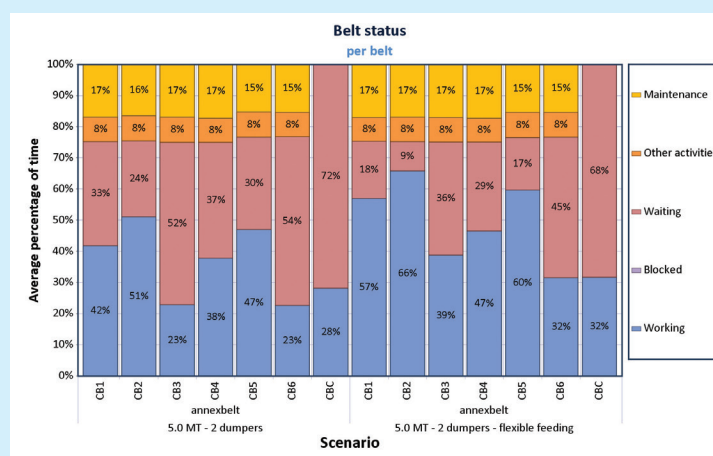


Figure 2: Belt conveyor network simulation results.

measures.

Since the publication of the article “Dry bulk terminal capacity planning” in 2014, bulk terminal operators are turning increasingly to simulation based tools, to support their decisions on process improvements and investment planning. The “what if” questions related to different investment choices and operational strategies can be systematically analysed with such tools. Furthermore, such an approach will assist operators in choosing where to invest and in determining the potential profitability from every step in their development plans and respective investment stages.