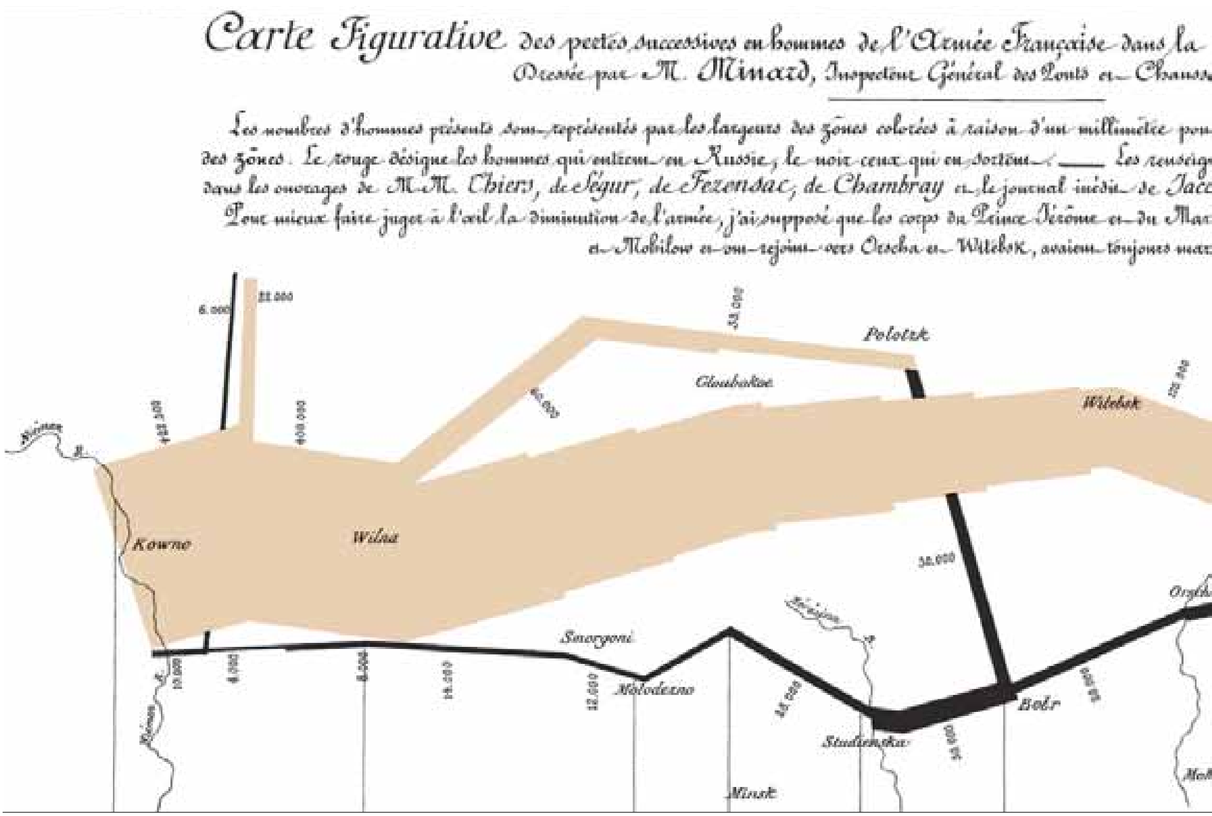
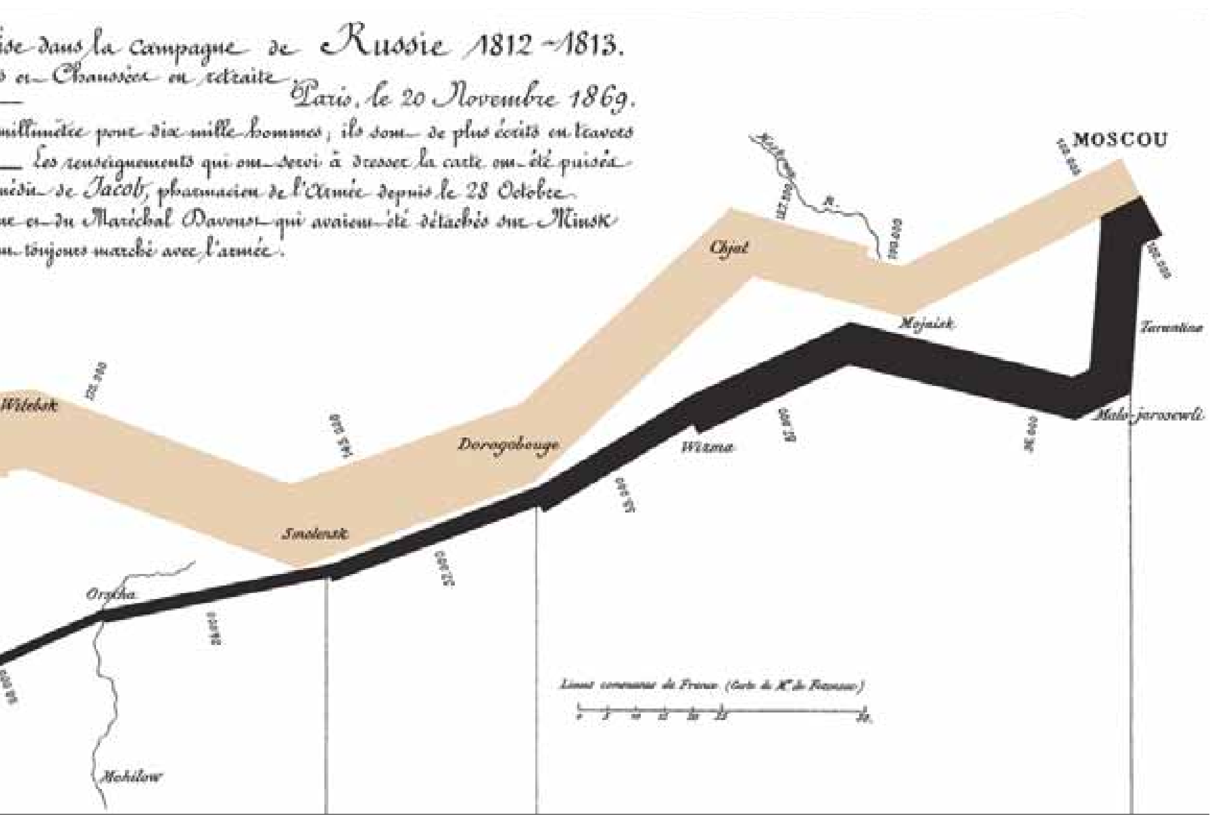
Managing the flow of energy



Tracking energy from fuel through its many transformations to useful work is not unlike what the French civil engineer Charles Minard did when he visualized Napoleon's invasion of Russia.



Unable to replace its losses, the Grande Armée returned from the campaign with only a few percent of its original troops. Charles Minard's remarkable diagram is one of the most famous Sankey diagrams, an increasingly popular type of infographic, where the arrow width is shown proportionally to the flow quantity.

By visualizing large amounts of information and complex relationships, diagrams like this quickly show the big picture and interpret quantitative data at the same time. Whether visualizing money, material or energy flows, the Sankey diagram is often the preferred tool. It is named after the Irish engineer Matthew H. Sankey, who first used it in a publication. In the annex to the minutes of a meeting of the Institution of Mechanical Engineers in 1898, he sketched the energy efficiency of a steam engine in comparison to an ideal steam engine without energy losses. Sankey used the same type of a diagram that Minard used to visualize Napoleon's losses three decades earlier.

Generations created a Sankey diagram that visualizes energy flow from fuel to utilization. It is important to note that the values will vary significantly according to the type of vessel, and that a diagram like this does not capture the dynamics of different operational modes. The diagram shows conversion of all mechanical power to elecricity for flexible distribution between various loads. In conventional or hybrid propulsion, a portion of the power would bypass the conversion to electricity and go straight to propulsion.

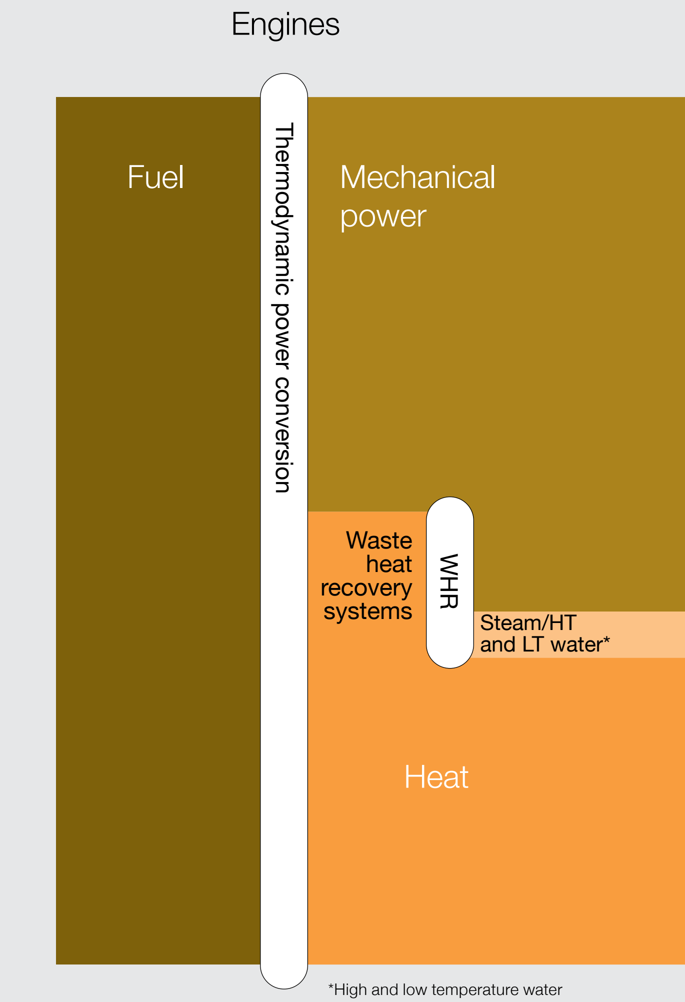
For cruise ships, a primary utilization factor would be the comfort of the guests (the hotel load). For a platform support vessel, it would be dynamic positioning, and for a tanker – the speed from A to B. Useful work would vary, and the width of the arrows, indicating the amount of energy would change from one minute to another. As a static picture, we can, in essence, think of the diagram as the energy accounted for during a year in operation or as the energy flow for an entire fleet.

The aim was to come up with a model that could be used to introduce various technologies and themes discussed in *Generations*.

By reading the diagram from left to right, one can see how a large portion of the fuel turns into waste heat due to the inefficiency of the combustion engine. However, reading the diagram from right to left could give an even more valuabe insight into how the cost driver to the left, the fuel consumption, could be tamed in a better way. Improvements of the processes on the right will affect the left side by a factor of two or three.

The most effective strategy for improved energy efficiency and reduced fuel costs is dead simple: close the gap between optimal and actual demand.

Text: Johs Ensby, Vibeke Larøi



*High and low temperature water

Energy flow

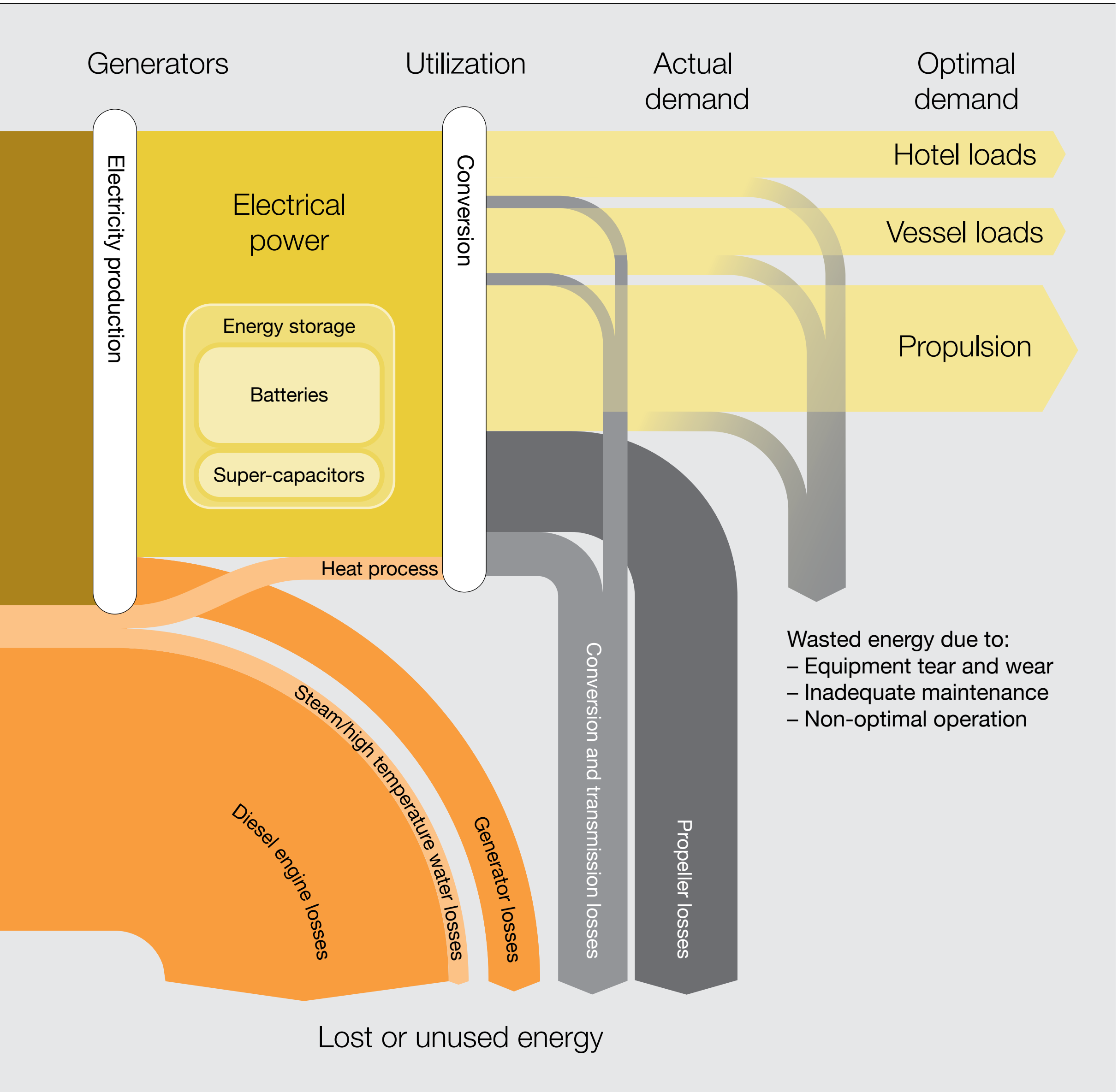
New regulations for SO_x, NO_x and particle emissions to air result from the combustion of marine fuels. Managing the cumulative impact of these regulations is one of this decade's key challenges. Get the full overview of the environmental regulations towards 2020 in the article on page 85.

The cruise industry has been working on fuel efficiency for 20 years, driven by the need to provide the highest possible value for money for their customers. Read more in the portrait of the "realistic visionary" Harri Kulovaara on page 12.

Read more about how liquefied natural gas (LNG) promises increased energy efficiency, lower emissions and a stable resource base on page 38.

On pages 30 and 104, Onboard DC Grid is presented as a bridge to new and environmentally friendly energy sources.

Learn more about what a waste heat recovery system is, how it works, as well as where and when it can be used in the "Achieving improved fuel efficiency with waste heat recovery" article on page 154.



On page 121, find out about how to use super-capacitators as energy buffers, reducing the load variations as seen by the system generators and thereby improving the system stability and fuel efficiency of available diesel gensets. Read more about battery technology on pages 110 and 114.

Total propulsion efficiency is a product of the efficiency in all parts of the propulsion train. See the article on page 136 for more information about propeller efficiency and hybrid propulsion systems.

Improved repair, replacements and maintenance to reduce tear and wear, as well as hull cleaning, propeller polishing, air removal from pipes and filter cleaning, all have a big impact on fuel costs. Small changes in operating conditions through trim optimization, route planning and optimal energy control present substantial fuel savings. Read more on operational efficiency versus new designs from shipowner's and operator's perspective on pages 60-65.

For more on the dilemmas and opportunities in an industry consuming 300 million metric tons annually, see page 80, and for more information on EMMA™ Ship Energy Manager, refer to page 96.