



#AHOY2050

Exploring scenarios for the maritime industry's pathway to a greener future.

MAN Energy Solutions
Future in the making

It's time for a broader perspective.

Contents

Introduction	3
Four scenarios in a nutshell	4
Key insights	6
Methodology	8
Matisse Ship Model	9
Scenario A	10
Scenario H	16
Scenario O	22
Scenario Y	28
STEEPL factors in detail	34
Glossary	36
Contacts and resources	38



Dear Clients, Colleagues, and Friends:

As this study is going to press, we are facing a new and unprecedented challenge. The world will be a different place as we recover from the COVID-19 pandemic and, at this point, it is hard to tell what it will look like. One thing, however, is certain: efforts to prevent climate change must continue.

For our industry, the course has been set: The regulations of the International Maritime Organization (IMO) require the shipping industry's carbon footprint to be reduced by at least 50% by 2050 compared to 2008. At the same time, the projected increase in shipping emissions is driven by the growth of international trade. The IMO predicts that shipping emissions could grow by between 50 and 250 % by 2050, based on industry growth scenarios.

So, the international shipping industry needs to solve this dilemma: reduce our industry's carbon footprint while growing our business.

MAN Energy Solutions has championed the Maritime Energy Transition since 2016. We not only develop technological solutions but also support an appropriate global regulatory framework – and we want to provide a platform for in-depth discussion.

To date, there are only a few medium/long-term studies that provide an outlook on major reductions in greenhouse gas (GHG) emissions and most scenarios focus on technology only.

Therefore, we commissioned the Fraunhofer Institute for Systems and Innovations Research (ISI) to develop holistic scenarios that incorporate a long-term view to 2050. These holistic scenarios take into account all relevant factors affecting the transition process, including changes in lifestyle and thinking, economic growth, regulation, and digitization.

With this brochure we would like to present to you four different future scenarios for shipping in 2050, as identified by the study. As is the nature of scenarios, they are not future predictions. However, they do provide valuable insights for the whole industry and thus may contribute to better understanding and decision-making.

Here are my three key takeaways. First, we need society's advocacy to make the maritime energy transition a success. The underlying change process required is much bigger than our industry. Second, global growth can be an important driver for decarbonization – and vice versa. And finally, at some point down the road we may have to discuss a ban of fossil fuels, which takes us right back to the first insight.

What are your conclusions? Let's discuss them!

We would like to remain in close contact with you and all stakeholders to shape a vision for our industry's successful future together – and act upon it.

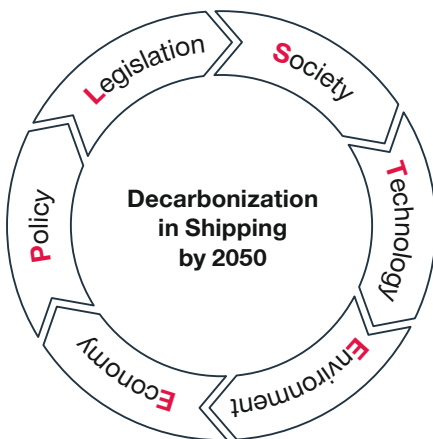
A handwritten signature in blue ink that reads "U. Lauber". The signature is fluid and stylized, with a checkmark-like flourish at the end.

Dr. Uwe Lauber

Chairman of the Executive Board of MAN Energy Solutions SE

Introducing the four scenarios.

Shipping is a major contributor to global GHG emissions and the IMO has laid out a strategy and policies to change that. However, there are multiple critical factors that will determine the development of low-carbon technologies and the possible future of shipping. #AHOY2050 introduces four different scenarios, each with a very different outcome in regard to the industry's future, technological development and GHG mitigation efforts.



For the first time, this scenario study takes into account all relevant factors affecting the shipping industry's transition process toward decarbonization, including changes in lifestyle and thinking, economic growth, regulation, and digitization.



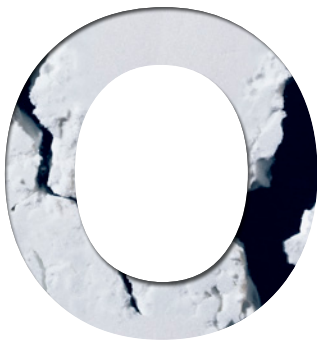
All aboard!

In Scenario A, the IMO objectives are achieved within the target time frame. A big step toward a carbon-neutral future has been taken. In addition, the strong climate policy targets from the United Nations Framework Convention on Climate Change (UNFCCC) are reached to achieve 2°C climate stabilization. Technological change has created a clear competitive advantage for the shipping industry and is acting as a driver for growth.



Hanging on to old ways.

In Scenario H, climate change policy continues to be supported by a limited number of countries only. The shipping industry fails to reach IMO climate targets. The division within society increases conflicts between groups in favor and against the targets. Left to their own devices, markets fail to drive true technological change; they carry on with business as usual. For shipping, this means that liquefied natural gas (LNG) becomes the main alternative to heavy fuel oil (HFO) and diesel fuels, since it does not require great changes in operations or behavior.



Out of control.

In Scenario O, the IMO objectives fail. The decarbonization of shipping and the reduction of GHGs cannot be systematically implemented. Only a few stakeholders are driven by climate change impacts. In fact, the development of low-carbon fuels (LCF) is stagnating. The shipping industry is focused on increasing the efficiency of fossil fuel technologies and also benefits from low oil prices and economic growth. Society turns away from a sustainable lifestyle. With a lack of support from most governments, climate policy to achieve GHG mitigation fails.



Yes we can?

In Scenario Y, the strong climate policy targets from the UNFCCC and the IMO objectives have been more than achieved by 2050. Low-carbon technologies for shipping become state of the art. Changes in global culture result in a sluggish or even shrinking economy. Climate change and a sustainable lifestyle are priorities. Alternative goals to conventional economic growth are developed. There is no “catch-up” by developing countries.

Five key insights.

Learning 1: Decarbonization needs global regulation

Learning 2: Rapid action is required

Insights from the scenarios will be different for everyone. However, there are five important insights that we believe are relevant for our industry's ongoing discussion on how to make decarbonization happen.

If there is no international agreement that adopts a stringent climate change mitigation policy in the short to medium term, current emissions legislation for NO_x/SO_x will lead to the growth of LNG as an alternative fuel. A comprehensive shift toward carbon-free fuels will not take place. Climate targets will be missed.

LNG and other low flashpoint fuels can be a bridging technology for power-to-liquid/power-to-gas (PtL/PtG) fuels like ammonia replacing fossil fuels. A global agreement to mitigate climate change and strong political support for the development and use of LCF could pave the way for such a transitory pathway.

Large-scale decarbonization can be achieved in shipping by 2050. However, it requires rapid action to make low-carbon alternatives the technologies of choice for most ships by at least 2035. Next to new propulsion systems for newbuildings, this will include a major retrofit market as well as the development of new bunker infrastructures.

Conclusion

Global regulation to mitigate climate change is the engine for a rapid shift toward and a growing demand for green shipping. Public opinion is the driving force behind global regulation and – as a consequence – fast action.

Learning 3: Decarbonization can be a driver for growth

In an increasingly globalized world, only green shipping can cover the growing demand for international logistics – if decarbonization is a global priority. Shipping will be of fundamental importance for global economic growth.

In terms of emission reduction, shipping has clear advantages over other transport vehicles. Ships are large and heavy enough to permit the use of alternative low-carbon energy technologies even if the energy density of the propulsion plant and fuel is reduced. Hence, shipping can become more competitive with air cargo and air passenger transportation.

Learning 4: Public opinion matters

Regulation is the motor for rapid change. Its driving force, however, is public opinion. Successful decarbonization depends on the majority of the world population buying into a sustainable lifestyle. The global community must support regulation and also be prepared to invest in low-carbon technologies.

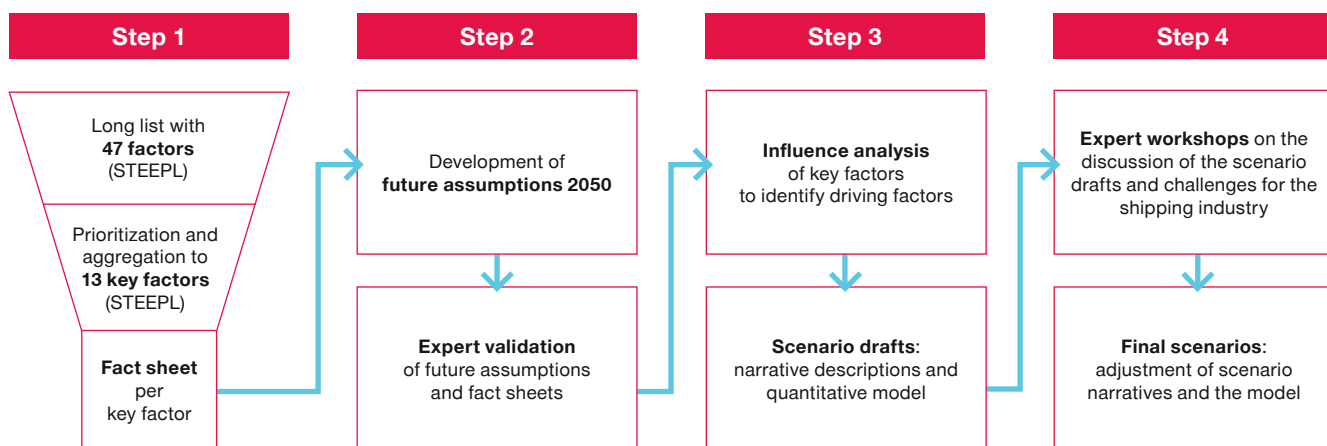
Learning 5: Decarbonization and digitization are autonomous trends

The shipping industry will undergo a process of digital transformation with many benefits, including significant progress in autonomous shipping. While the digitization trajectory is not linked to the progress of decarbonization, it can facilitate the latter, notably through new possibilities for control and optimization.

Methodology at a glance.

The research project, which is the basis of the present study, estimates the extent to which the shipping industry can contribute to reducing GHGs worldwide. This potential is estimated by using different scenarios of the development and diffusion of technologies to reduce GHG emissions from shipping.

The project delivers insights through a four-step approach:



Identify STEEPL factors

General factors that determine the context for the scenarios have been structured using the STEEPL approach. STEEPL stands for society, technology, economy, environment, and legislation/policy. (See page 34 for a detailed overview of these factors.)

Define future assumptions until 2050

Possible future developments for each factor have been identified and validated through interviews with experts from the industry and the surrounding environment.

Build future scenarios

Assumptions have been combined into four different scenarios of the decarbonization process with a time frame until 2050. These scenarios combine qualitative narratives up to 2050 with quantitative model results.

Interpret scenarios and identify challenges

The scenarios have been discussed in a workshop with 30 international experts, verified with stakeholders and updated. In a further round, the experts' feedback for the final results has been incorporated.

STEEPL graph

The four-step approach combines the external framework conditions in alternative scenarios with corresponding challenges for the future shipping industry.

The scenarios cover a range of possible futures, determined by different developments of the STEEPL factors and changes in the maritime industry.

The MATISSE-SHIP simulation model.

For the numerical representation of empirical facts, the MATISSE-SHIP model was adapted for the shipping industry. Primarily, the MATISSE-SHIP simulation model is used as a research tool to test whether the assumptions are feasible. In our case, the model offers a multilevel perspective on transitions and the share of different drivetrain technologies in the specified period. Parameters used to define the properties of the technologies include GHG emissions, operating speeds and NO_x/SO_x/particles (PM₁₀, 2.5). New technology adoption in the fleets is calculated directly from the model and provided in a graph for each scenario.



All aboard!

Can regulation drive technological change?

Scenario A shows that a willingness to cooperate internationally drives technological innovation and consequently changes our way of thinking – even in the shipping industry. In this scenario, we are all in the same boat to build a world the next generation wants to live and literally sail in.

- **Regulation-driven technological innovation**
- **Strong climate policy**
- **Global economic growth and new markets**
- **Low-carbon future is achieved**

What will the shipping industry look like in 2050?

In Scenario A, the IMO objectives are surpassed within the target time frame. A big step toward a carbon-neutral future is taken. In addition, the strong climate policy targets from the United Nations Framework Convention on Climate Change (UNFCCC) are achieved with 2°C stabilization. Technological change has created a clear competitive advantage for the shipping industry and is acting as a driver for growth.



IMO goals

As industries, logistics, and cruise passengers make clean shipping a clear priority, the transport sector comes under very strong pressure. Stakeholders of the shipping sector intensify measures to achieve the IMO targets. Fossil fuels in newbuilding are prohibited from 2035. The IMO objective is surpassed: 80% GHG reduction by 2050.

State of technology

Research and development (R&D) of green technologies becomes the main focus of the shipping industry. LCF are the predominant alternative for shipping.

Retrofits

A major market for retrofit conversions evolves. LCF technologies for shipping are mainly PtL/PtG, H2 fuel cells, biofuels, and wind technologies. In fact, due to learning effects and development support, PtL/PtG become the cheapest option for high-speed shipping as they enable a cost-effective conversion of vessels and further usage of Otto/Diesel cycle motors. Biofuels do not take off, because of very strong demand from the aviation sector.

Newbuildings

Newbuildings concentrate initially on LNG dual fuels – in response to the global sulfur cap – and wind assistance, as there are rapid financial returns from the savings in fuel costs from wind technologies. The strong regulatory, price and customer demand incentives also cause a boom for PtL/PtG fuels. This takes a little longer as fuel supply chains have to be developed.

Opportunities for growth

Complex global supply chains provide economic growth and require intercontinental production and efficient supply chains. Multilinked transport chains are increasingly intertwined, both in passenger and cargo traffic. At the same time, transport volumes increase. This is an opportunity for green shipping. It becomes more competitive with air cargo and air passenger transportation due to strong support for low-carbon technologies.

Impact of digitization

Increasing digital information flow has a beneficial impact on safety, economical, and environmental performance within the shipping industry. Real-time monitoring of ship systems or cargoes helps reduce costs. Sensors on board enable condition monitoring and navigation, autonomous collision avoidance, and a course control given the wind and sea state. As a result, autonomous shipping is state of the art in 2050.

Conclusion

Regulation and climate policy drive technological innovation in shipping and improve our sustainable way of living.

How did we get there?

Mindset change

Increased environmental awareness helps to prepare and implement measures to reduce the likely impacts of climate change and to create pressure in political systems worldwide. At the same time, social disturbances such as mass migration waves – due to extreme weather conditions – lead to social acceptance of climate protection. Societies are using technological solutions to avoid emissions and maintain their sustainable lifestyles.

Regulation

Mindset change results in political pressure and a greater willingness to adopt stringent mitigation measures. The consequence of these developments is a strong global response to climate change on both international (e.g. UNFCCC) and national levels with mandatory implementation and achievement of the Paris Agreement and the 2°C target. Global legal frameworks, in cooperation with industry, are set to build an international LCF infrastructure. This is reflected by extensive international support for the global development and deployment of PtL/PtG and accelerated growth of the renewable energy electricity supply.

Technology and innovation

There are almost no further investments in unsustainable technologies. R&D on green technologies becomes the major focus of the sector. R&D is also supported by financial incentives from national governments and is pushed by a significant increase of oil prices due to tax systems.

Economic development

The global economy is growing. Strong population growth including a new middle class in developing regions such as South America, Asia, and Africa opens new markets. There are moderate economic growth rates in the Europe, OECD Asia, and North America triangle.

Global collaborations are facilitated by open borders, a reduction of trade barriers and harmonized legal frameworks. This leads to a continuing increase in the overall volume of global trade and more complex logistics networks.

Progress in digitization

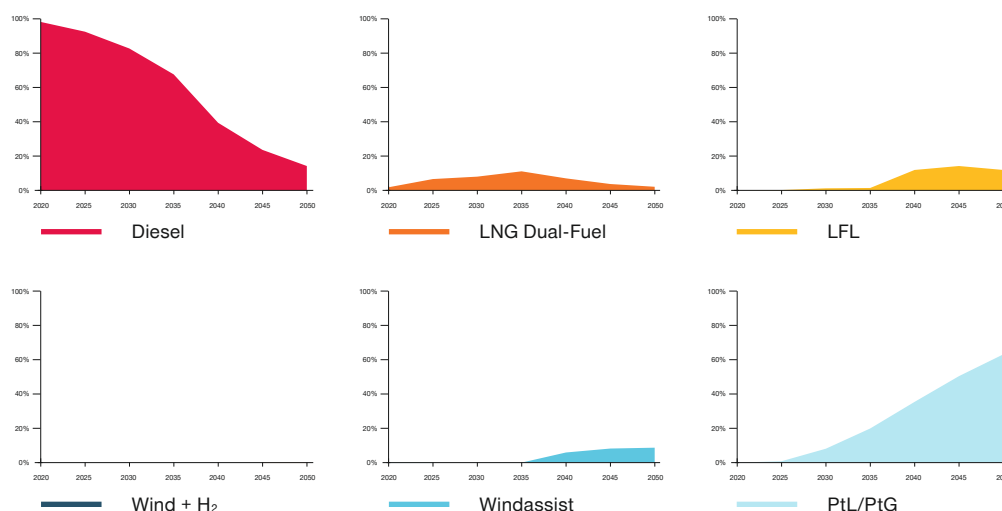
Digitization is established across all private, public, and social sectors. Digital technologies facilitate the daily routine in our professional and private lives.

What can we learn?



- 1 **Regulation is key for reaching climate policy goals.** Climate protection and growth go hand in hand if regulation provides the framework.
- 2 **Decarbonization cannot stop with LNG** or any other fossil resource. Bigger CO₂ reductions via synthetic carbon-free fuels are required to reach carbon neutrality. LNG is not a blind alley investment – it is an investment in the future since all such engines can be retrofitted to run on carbon-free fuels without further technical adaptations.
- 3 The industry's clear commitment to climate protection and green fuels provides **growth opportunities for the shipping industry** – making it a green alternative to air freight since it has more cost-effective options to reduce its CO₂ footprint (slow steaming, wind). If intercontinental trade increases, global climate targets can be achieved with CO₂-free transport using LCF technologies.
- 4 **Sustainable and climate policy-based financing** becomes a **key driver** for the decarbonization of shipping.
- 5 MATISSE-SHIP scenario: **the transition** from LNG to PtL and Synthetic Natural Gas (SNG) has to happen **within the next ten years** if we want to make this scenario happen. LNG lays the foundation for the switch to PtL/PtG while being accompanied by strong GHG regulation.

For the shipping industry this means:
All on board and a straight course through the water.



MATISSE-SHIP Scenario A

Scenario A is dominated by a constant decrease in diesel oil propulsion over time. At the same time LNG peaks in 2035 and lays the foundation for the switch to PtL/PtG as fossil fuels will be banned by 2035. At the same time, LFL fuels like ammonia and methanol are picking up and growing. The major fuels in 2050 with over 60 % share will be PtL/PtG.



Hanging on to old ways.

Is a world divided over climate policy capable of GHG mitigation?

Scenario H illustrates the consequences of ongoing global disagreement on how to deal with climate change. Everything is a compromise – even in the shipping industry.

- Basic mindset change toward sustainability, but only in some parts of society
- Global growth without new markets
- Weak climate change policy
- LNG as the predominant alternative for shipping

What will the shipping industry look like in 2050?

In Scenario H, climate change policy continues to be supported by a limited number of countries only. The shipping industry fails to reach IMO climate targets. The division within society increases conflicts between groups for and against the targets. Left to their own devices, markets fail to drive true technological change: They carry on with business as usual. For shipping, this means that LNG becomes the main alternative to HFO and diesel fuels, since it does not require great changes in operations or behavior.



IMO goals

The IMO goal of 50 % GHG reduction fails. Climate change mitigation measures at the IMO are stalled by some influential nations supporting fossil fuel technologies. As there is no global agreement to reduce emissions, decisions are mostly made at a local level. The objective of zero emissions fails as LNG is carbon-based and a new global supply chain for PtG has not been developed.

State of technology

Stagnating oil prices, which are in accordance with economic growth rates, strengthen the industry's focus on fossil fuel-based technologies. Therefore, improving the efficiency of fossil fuel-based vessels remains a key driver. Instead of LCF technologies, LNG becomes the main alternative fuel to HFO and diesel fuels. Despite the additional costs of LNG cryogenic storage and systems, there is a limited market in retrofitting for LNG systems. Bunker markets expand, infrastructure develops, and LNG prices continue to fall. Capital expenditures for LNG retrofits also decrease because designing and installing LNG systems becomes simpler with experience.

Opportunities for growth

Limited global collaboration implies companies are the main drivers of the development of energy infrastructure. Bilateral agreements and international collaborations lead to an increase of complexity – also affecting logistics networks. Consequently, intercontinental production requires highly efficient supply chains of parts and raw materials. The resulting increase of transport volumes is an opportunity for the shipping industry, albeit at the expense of rising emissions.

Impact of digitization

Digital technologies are an important factor for shipping, helping to manage complexity. For example, sensors on board allow for condition monitoring and navigation, autonomous collision avoidance, course control, and technical support for crews on board. In addition, there are remotely operated ships where no on-board crew is required. Moreover, ship management centers reduce the requirement for manned operation. Digitization also implies, however, that ship systems must be secured against digital threats.

Conclusion

Business as usual, in which current climate change policy continues, is not the way forward.

How did we get there?

Mindset change

In this scenario, sustainable consumption and environmental awareness are important only for some social groups. A split between groups for and against sustainability measures implies an increased risk for social conflicts and some uncertainty about whether CO₂ emissions will decrease or not.

Regulation

The split in society regarding sustainability can also be observed in politics. Global and national climate policies are not sufficient to achieve the Paris Agreement (2°C target). Political developments in some countries make the climate change issue even more contested. As a result, the willingness to implement climate protection measures is low. Societies tolerate the effects of climate change – such as climate refugees due to an increased number of extreme weather events.

Technology and innovation

Advances in naval architecture are mainly driven by new materials, such as nonsteel ships, designs for reuse and lighter-weight vessels based on carbon fiber materials. Although electric short-sea shipping exists, electrification of large-range vessels is not possible due to battery capacity restrictions. Instead, the development of PtL as an alternative is planned in the long run, supported by continuous development of renewable energies in other sectors.

Economic development

In this scenario we have global growth without new markets. Despite strong population growth in South America, Asia, and Africa, there is limited economic development. There is no significant change regarding the income and expansion of a middle class in these developing countries. Economic growth is still focused mainly on the Europe, OECD Asia, and North America triangle.

Progress in digitization

Digital technologies have mainly been established in the private and social sectors. This leads to decreasing social interactions. At the same time there is a fear of control through other countries, restriction of self-determination, and increasing power of global companies. Digital technologies are limited in the public sector because of data security reasons and fears of implicit threats such as large-scale hacker attacks.

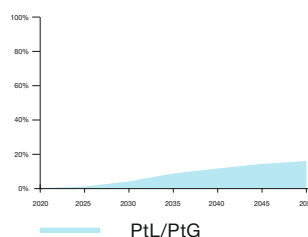
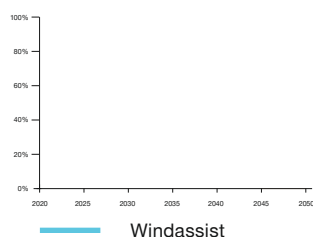
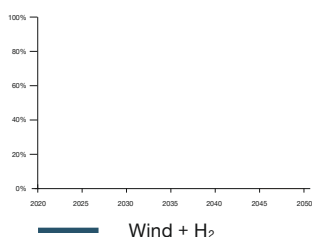
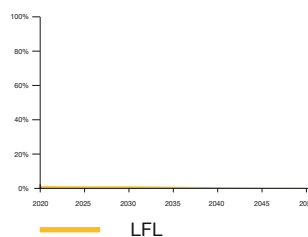
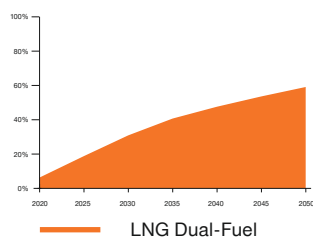
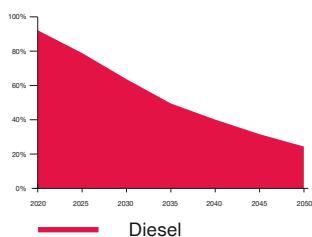
What can we learn?



- 1 **A switch to LNG is not enough to reach IMO goals.** Focusing on the improvement of efficiency of fossil fuel-based vessels will lead to missing the targets.
- 2 **The markets alone will not fix the problem.** While a switch from HFO to LNG will happen eventually, if left to the markets, this will be too little, too late.
- 3 **Without a global regulatory framework, climate change mitigation goals will be missed.** Also, the innovation and growth potential of a global economy will be inhibited.
- 4 **Digitization will act as a firefighter** as complexity on all levels will increase.
- 5 **MATISSE-SHIP scenario: air quality measures alone are not enough** for the “big switch” that leads to LCF technologies.

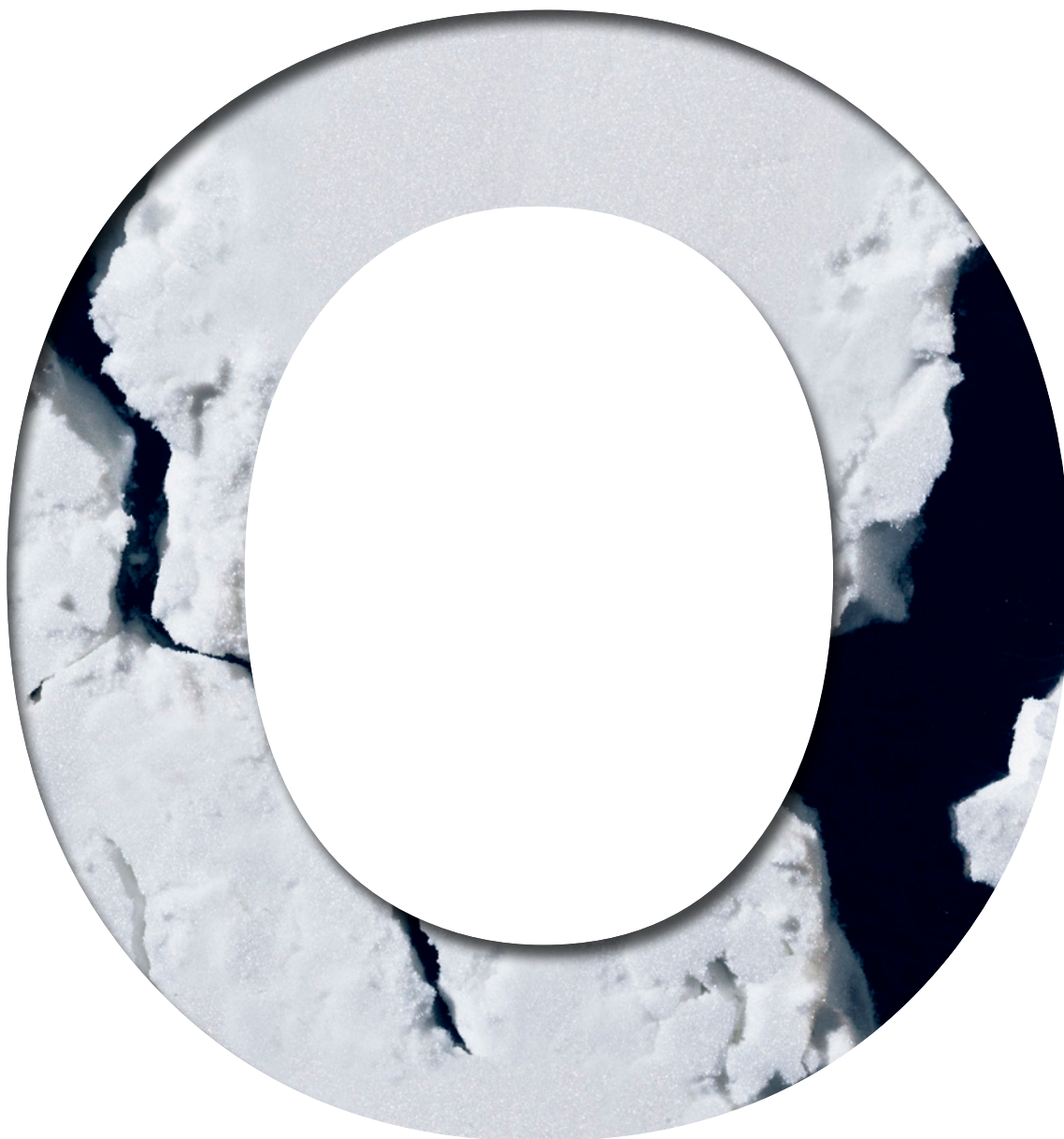
For the shipping industry this means:

We are either all in this together or continue to muddle through.



MATISSE-SHIP Scenario H

Scenario H is a clear LNG dominated scenario. It addresses the need to cope with air quality measures and does not require great changes in operations or behavior. Diesel oil is decreasing but will still be around in 2050 with around 25% market share. The usage of PtL/PtG will pick up from 2040 onwards but too late to achieve climate goals.



Out of control.

What if environmental awareness in society was just a hype?

In Scenario O we see what happens if change in favor of sustainable lifestyles is just a temporary phenomenon. In shipping, with no global regulatory framework, the focus is on increasing the efficiency of existing technologies.

- Low environmental awareness
- No global climate policy framework
- Low oil prices beat maritime energy transitions
- LCF technologies make only slow progress

What will the shipping industry look like in 2050?

In Scenario O, the IMO objectives have failed. The decarbonization of shipping and the reduction of GHGs cannot be systematically implemented. Only a few stakeholders are aware of climate change impacts. In fact, the development of LCF is stagnating. The shipping industry is focused on increasing the efficiency of fossil fuel technologies and also benefits from low oil prices and economic growth. Society turns away from a sustainable lifestyle. With lack of support from most governments, climate policy aimed at GHG mitigation fails.



IMO goals

The IMO target to reduce GHGs emissions by 50% by 2050 has not been reached. The lack of low-carbon technologies leads to an increase of emissions on an absolute scale.

State of technology

The development of LCF stagnates. PtL/PtG technologies develop very slowly because of a lack of support from most governments for the technologies and bunker supply chains. The focus of innovations is more on efficiency increase of fossil fuel technologies. Also, there is rapid expansion of raw materials extraction in the Arctic and the Antarctic.

Opportunities for growth

Trade demand rather than climate change is the key driver for the shipping market's development for most of the period until 2050. Since investments in ships are determined by financial considerations, there is a limited uptake of wind technologies as they demonstrate operational cost savings without requiring new bunker supply chains or infrastructure. In addition, there is a limited market for retrofits for dual-fuel systems to meet the requirements of Nitrogen Oxide and Sulfur Oxide Emission Control Areas (NECAs, SECAs). EU policy measures enable a limited retrofit-market for wind assistance and dual-fuels for ships operating in European waters.

Impact of digitization

Shipping benefits from digital technologies in terms of reduced costs. Remote monitoring and control reduce crew costs. Other benefits include optimization of hull forms and drives for very low operational speeds with real-time route optimization and arrival prediction, 3D printing and product-service systems in shipbuilding.

Autonomous shipping is a widely used technology in 2050. Sensors on board enable condition monitoring and navigation, autonomous collision avoidance, and course control given the wind and sea state.

Conclusion

Ignoring the impact of climate change will backfire on business eventually as climate change impacts increase.

How did we get there?

Mindset change

Increasing environmental awareness in society and the initial change of models in favor of sustainable lifestyles were just a temporary phenomenon. There are limited opportunities and a lack of willingness in society and governments to spend additional money on environmental protection or for the consumption of sustainable products. Only toward 2050 will the effects of climate change have caused a change in attitude. This is, however, mainly because the damage to national economies becomes visible.

Regulation

There is no functioning global collaboration to reduce climate change impacts. As the Paris Agreement is not mandatory, temperatures increase by far more than 2°C. The number of extreme weather events increases. However, the environment is not the primary scope of political agendas. Finally, the EU decides to take the lead – through bilateral agreements for joint technology developments, for instance.

Technology and innovation

A stagnating oil price causes oversupply. Therefore, liquid fuel consumption remains profitable. This development discourages energy conservation and fuel switching. In shipping, initially, the construction of fossil fuel-based instead of renewable energy-based vessels continues. By 2050, LCF technologies do not prevail and the electrification of the shipping sector fails due to capacity restrictions and high costs. Extreme weather due to changes in ocean currents and temperatures causes more losses of ships at sea.

Economic development

An expanded middle class in developing countries of South America, Asia, and Africa evolves. This opens new markets. However, growth stagnates in Europe, OECD Asia, and North America as the global impacts of climate change become more severe. Moreover, there is a renaissance of nationalism and economic protectionism. This leads to increasing trade tensions and a higher risk of conflicts. Domestic markets are sealed off with trade barriers. As the international division of labor decreases, logistics networks become less global and more national or continental.

Progress in digitization

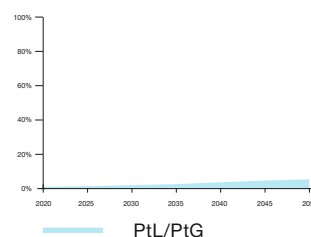
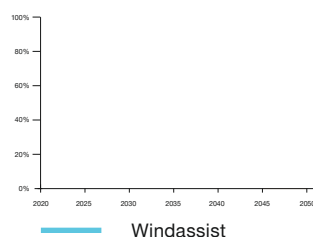
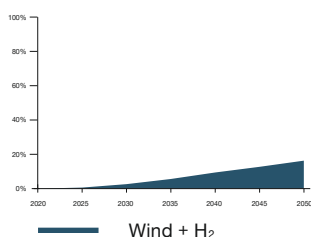
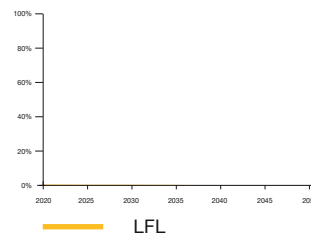
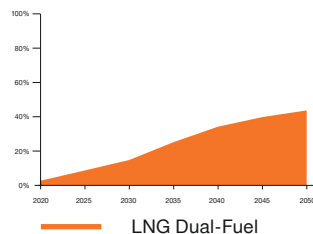
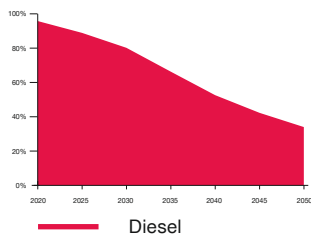
Digital technologies are established across private, public, and social sectors. They operate as an accessory to make everyday life easier.

What can we learn?



- 1 **Protectionism is dangerous in many ways.** While growing trading volumes are an opportunity for growth, protectionism and unilateralism hinder the maritime energy transition.
- 2 **Low oil prices always win.** Maritime energy transition does not stand a chance against low oil prices if there is no global regulatory framework.
- 3 **The EU cannot solve the problem alone.** A local regulatory framework cannot make everyone else join in. LCF technologies will only make slow progress.
- 4 **MATISSE-SHIP scenario: LCF technologies can develop to a certain point driven by the idea of cost reduction. But markets alone will not lead to the domination of LCF technologies.**

For the shipping industry this means:
Making existing technology more efficient is not a business model for the future.



MATISSE-SHIP Scenario O

Scenario O is dominated by ship owners trying to reduce costs and a missing comprehensive global IMO GHG strategy. This will lead to an ongoing market share of 80 % for fossil fuels like diesel oil and LNG in 2050. In addition, local or regional GHG regulation will lead to an increase in LCF technologies like wind propulsion. But this will not grow beyond a niche market.



Yes we can?

Can a change in mindset transform the world?

Scenario Y shows how climate change leads to a massive shift of social paradigms. The resulting strict climate mitigation policies drive a rapid substitution of fossil fuels. It becomes clear, however, that a radical change to society in favor of sustainability comes at a price.

- **End of global growth as we know it**
- **Strong climate policy**
- **PtL/PtG and wind technologies develop rapidly**
- **Fundamental social change**

What will the shipping industry look like in 2050?

In Scenario Y, the strong climate policy targets from the UNFCCC and the IMO targets have been exceeded by 2050. LCF technologies for shipping become state of the art. Change in global culture results in slower growth or even a shrinking economy. Climate change and a sustainable lifestyle become a priority. Alternative goals to conventional economic growth are developed. Developing countries do not catch up.





IMO goals

IMO objectives are clearly achieved. In fact, due to global pressure, the IMO decides a binding target to reduce GHG emissions by 90% by 2050. This requires a pathway of 50% by 2035. A global legal framework prohibits the use of fossil fuels in the transport sector globally from 2030.

State of technology

LCF technologies for shipping, such as PtL/PtG, H₂ fuel cells, and wind technologies, become state of the art. As a result, there is a rapid transition away from fossil fuels within the transport sector. Biofuels do not take off because of the very strong demand from the aviation sector and social concerns about land use for the production of biofuels. Decarbonization of shipping is also supported by partial electrification of short-sea shipping. Long-range vessels, however, cannot be electrified because of limited battery capacity.

Opportunities for growth

The fossil fuel ban supports the adoption of lower-carbon, low-flashpoint fuels and wind assistance within a short period of time. As industries, logistics, and cruise passengers prioritize clean shipping, the transport sector is put under very strong pressure. To ensure energy supplies, policies determine the legal framework conditions to build an adequate LCF infrastructure on a national and continental level. By accelerating the growth of the electricity supply from renewable energies, rapid development of PtL/PtG in shipping is made possible. Retrofit markets for both PtL/PtG and wind technologies are an important part of rapid decarbonization.

Impact of digitization

Digital technologies become an important factor for shipping: sensors on board enable condition monitoring and navigation, autonomous collision avoidance, course control given wind and sea state, and technical support for crews on board. There are also remotely operated ships where no crew is required with ship management centers reducing the requirement for manned operation. Digitization also implies that ship systems must be hardened against digital threats and made highly redundant.

Conclusion

Public opinion is a powerful force to be reckoned with. From a global perspective, a “less is more” lifestyle can stabilize the climate but not level out inequalities.

How did we get there?

Mindset change

Society experiences fundamental mindset changes in favor of a sustainable lifestyle and higher environmental awareness. New social concepts and behaviors, such as a stronger focus on work-life balance, job sharing, and more sustainable consumption become the new normal. Waves of migration due to extreme weather events imply a social acceptance that climate protection is of crucial importance.

Regulation

Political pressure and a higher acceptance of mitigation measures enable strict climate policy goals. The consequence of this development is a strong global response to climate change, the achievement of the Paris Agreement, and a stabilization of the targeted level of 1.5°C. In order to secure the energy supply, a legal framework for the development of an adequate LCF infrastructure has been determined by policies. This will ensure the increasing supply of electricity from renewable energies, which will enable the rapid development of PtL/PtG in shipping.

Technology and innovation

PtL/PtG and wind technologies develop rapidly. Governments fund the development of green technologies. The marine industry is driven by new materials, such as nonsteel ships and ship constructions that are recyclable or made of light carbon fiber materials. The requirement for rapid decarbonization is met through large-scale retrofitting for low-carbon technologies. The demand to stop the construction of ships with fossil propulsion systems prevails.

Economic development

It's the end of global growth as we know it. Although the populations of South America, Asia, and Africa increase significantly by 2050, developing countries do not catch up. The radical and sustainable transformation of society indicates low or even declining economic growth in Europe, OECD Asia, and North America. Spurred by this development, there is a paradigm shift towards qualitative growth of sustainable goods and services instead of conventional economic expansion.

Progress in digitization

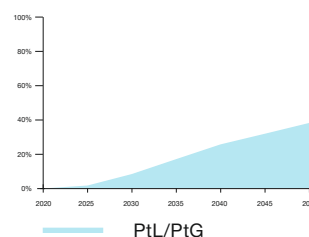
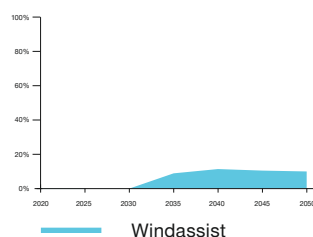
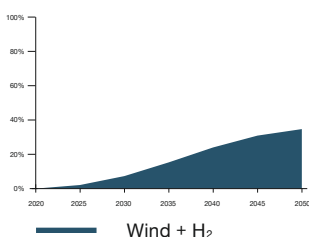
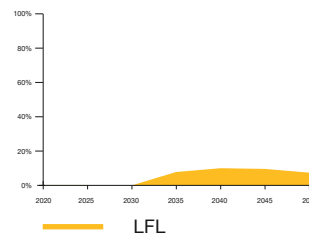
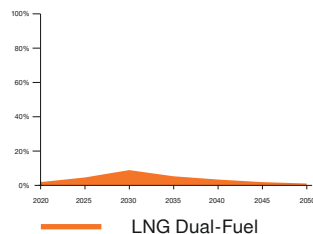
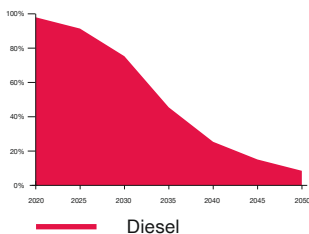
Digital technologies are established mainly in the private and social sectors. This leads to a change of social behavior, such as the reduction in face-to-face social interaction. This goes along with an increasing power of global companies and the threat of foreign control instead of self-determined behavior of people. The diffusion of digital technologies in the public sector is limited due to digital threats such as large-scale hacker attacks or concerns regarding data protection.

What can we learn?



- 1 **Fast action pays off.** IMO targets are reached via a fossil fuel ban by 2030. The Paris Agreement is enforced around the globe.
- 2 **Technology follows regulation.** If the political world sets the legal framework to build an adequate LCF infrastructure on a national and global level, technology follows. This enables the rapid development of PtL/PtG in shipping.
The demand for rapid decarbonization is met by the widespread introduction of low-carbon technologies in both newbuildings and retrofits.
- 3 **Mindset matters.** Global regulation and successful decarbonization can be driven forward by a change of awareness in society.
- 4 **Abstinence can be an alternative to innovation and technological progress.** However, it requires a conscious decision to renounce economic growth and prosperity. At the same time, this development is typically supported by a continuing wealth gap.
- 5 MATISSE-SHIP scenario: the acceptance of lower operational speeds allows LCF technologies to grow and to foster a relevant market share.

For the shipping industry this means:
If customers prioritize clean shipping, the industry must be prepared to act very quickly.



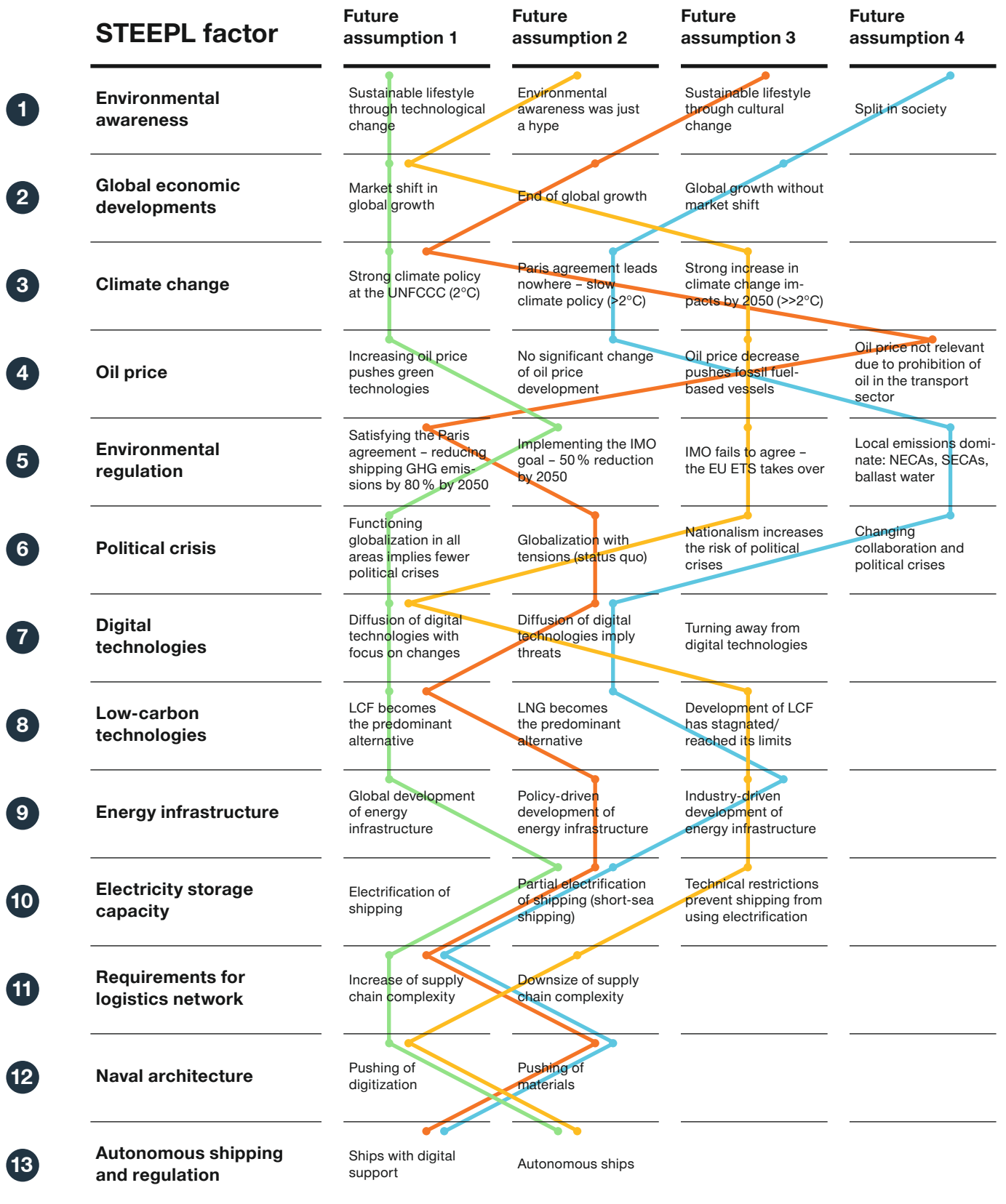
MATISSE-SHIP Scenario Y

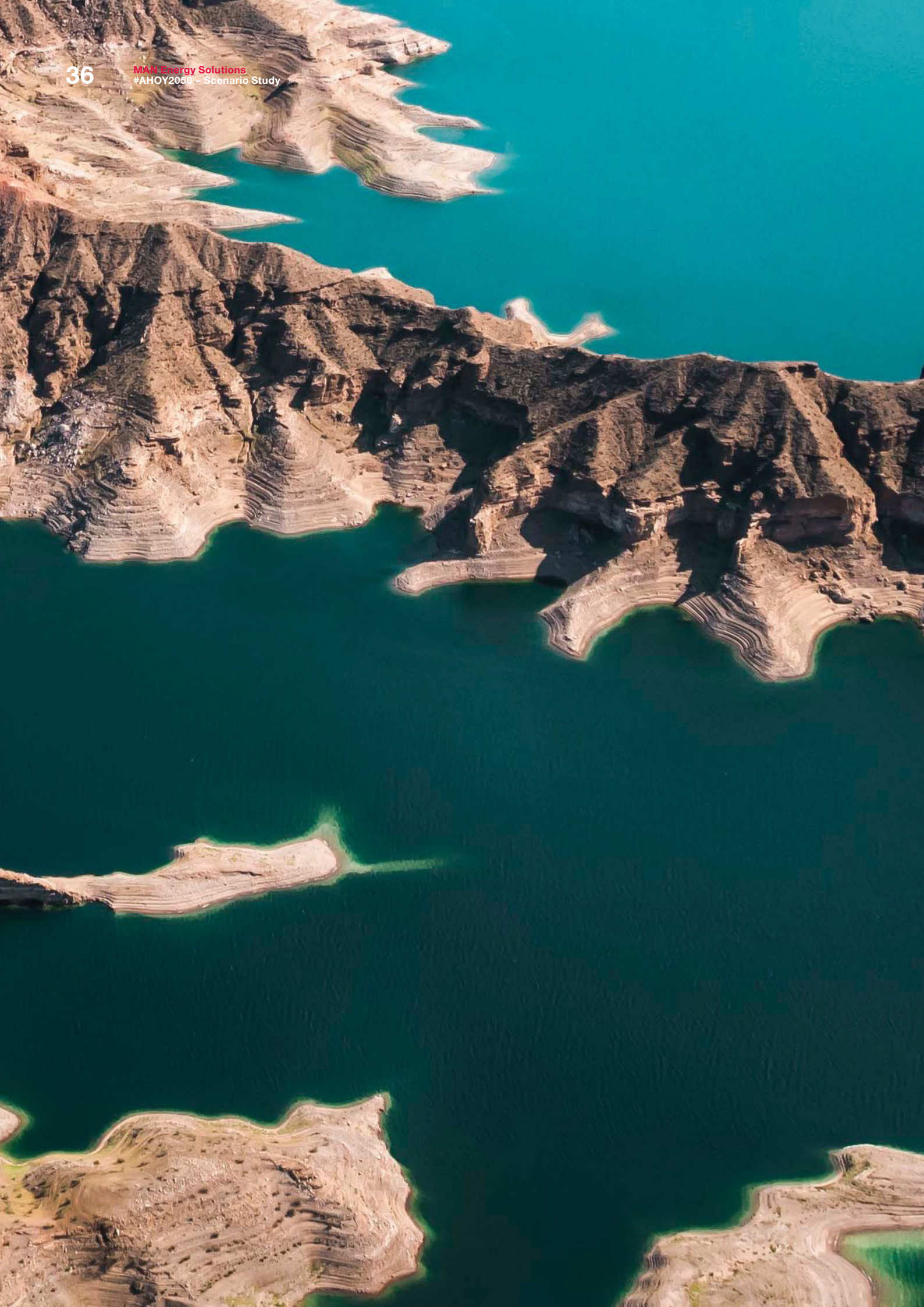
The Y scenario is dominated by the strongest decline in fossil fuels of all scenarios. LNG already peaks in 2030 at a low level due to the fossil fuel ban in 2030. Depending on ship types, in 2050, PtL/PtG fuels will almost have the same market share as wind and H₂. LCF technologies will dominate the market with 90%.

STEEPL factors in detail.

To deliver a broader perspective, general factors that determine the contexts for the scenarios have been structured using the STEEPL approach. STEEPL stands for society, technology, economy, environment, and legislation/policy. Initially, a long list of 47 factors was compiled. In the course of this study, 13 key factors (see graphic) with high relevance for the shipping industry were identified. See our chapter on Methodology (pages 8–9) to learn more about the study’s scientific approach.







Glossary.

CCS	Carbon capture and storage (no emission of CO ₂ into the atmosphere)
CO₂	Carbon dioxide
GHG	Greenhouse gas
HFO	Heavy fuel oil
Hydrogen	Fuel cell/hydrogen combustion engine
IMO	International Maritime Organization
LCF	Low-carbon fuels
LFL	Low flammability limit fuels: ammonia, methane, methanol
LNG	Liquefied natural gas
LNGDF	LNG dual fuel
NECAS	Nitrogen Oxide Emission Control Areas Regions, where the emission of nitrogen oxide by ships is being limited
PtG	Power-to-gas
PtL	Power-to-liquid
PtX	Power-to-X
R&D	Research and development
SECAS	Sulfur Oxide Emission Control Areas Regions, where the emission of sulfur oxide by ships is being limited
SNG	Synthetic natural gas
UNFCCC	United Nations Framework Convention on Climate Change
Wind + H₂	Wind combined with small fuel cell
Wind assist	Flattner rotor combined with fossil fuel engine

Thank you.

In course of the preparation of this study we did not only rely on the expertise of Fraunhofer ISI but have also asked various stakeholders to critically review and discuss the underlying assumptions and scenarios of this study.

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Science and Technology Policy Institute

Shell International Trading and Shipping
Company Limited

Transport & Environment

TU Hamburg Harburg (TUHH)

UCL Energy Institute

Umweltbundesamt

University of Siegen

VDMA

Contacts and resources.

If you would like to take a deep dive into our research, you can download the complete original study here:



www.man-es.com/ahoy2050

On this page you can also find further resources including press releases.

We look forward to discussing the study's insights with you. Please share your thoughts with us.

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