

CLIMEON

Business for a better world

2015 European Marine Waste Heat Recovery Solutions Technology Innovation Award



FROST & SULLIVAN



50 Years of Growth, Innovation & Leadership

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Background and Company Performance

Industry Challenges

Large ships are usually equipped with internal combustion engines of about 10 MW rating. About 50% of the energy content of the fuel (usually gasoline, diesel, or other marine fuels) is converted into heat, which somehow has to be dissipated. Most times, the heat from the engine or the main power train is cooled down through some form of heat exchange with surrounding water bodies. This energy may be used to form fresh water from the condensation of steam, or may be used to pre-heat combustion oils if they are in a very viscous state. During winter, the heat may be diverted to dwelling units to heat internal rooms in the entire ship. There are already some uses for waste heat in place. However, most of the heat that is produced through combustion is still wasted through the chimney or cooled away into the ocean.

Stockholm-based Climeon AB has developed an innovative technology named C3, which converts low temperature heat to sustainable electricity.

Technology Attributes and Future Business Value

Criterion 1: Industry Impact

Climeon AB has directed its efforts towards converting waste heat into electricity, as electricity can be employed to carry out multiple functions in a ship. Apart from this, Climeon chose the range of temperatures that are most difficult to handle (around 90 degrees Celsius). Though the basic technology has been known for years, Climeon customised and made it more efficient by avoiding losses that tend to consume energy, for example pump losses, friction, and resistance in the machine. This has been made possible with the inclusion of two heat exchangers (one for heating the gas and one for liquefying the gas). These heat exchangers are connected to an electricity generation and management system which produces electricity at specified industry standards (e.g. 380V AC at 50 Hz). The unit is capable of producing 690 volts or 220 volts output depending on the need.

Criterion 2: Product Impact

The technology is offered in the form of a product called 'Ocean™'. It was developed by gathering expertise from several Swedish universities. Its viability was proved in 2012 and 2013 when it recorded the highest efficiency at temperatures below 100 degree Celsius, which falls in the low heat range. The C3 technology typically operates in the 80 to 120 degrees Celsius range. The reason behind choosing this temperature range is that at 90 degrees Celsius, water acts as an energy carrier and above this temperature, pressurised systems are required. No commercially available technology can convert water at 90 degrees Celsius to electricity with a reasonable efficiency. For example, if there is 1 MW of energy in a 90 degrees Celsius water stream, then, with the aid of the C3 technology, it is possible to convert 10% of this energy to electricity. This is a significant achievement, as the theoretical maximum according to the laws of physics is around 18%.

Thus, the Climeon system exceeds 50% of this theoretical maximum. This efficiency is due to the optimisation of a number of components.

The Climeon system is a machine with a turbine, heat exchangers, a generator, pipes and pumps. The technology operates at a low pressure, not more than 2-3 bar, and does not require complex and expensive equipment. Some competing machines that work with high-pressure technology require more expensive and heavier equipment. Therefore, Climeon's technology not only provides high efficiency but also leaves a small carbon footprint using standard low-pressure components.

Criterion 3: Visionary Innovation

Climeon has been focusing on the marine industry because electricity onboard ships is expensive and the waste heat stream can be captured freely. Most times, this stream is directed straight into the ocean. This futuristic technology by Climeon has been successfully implemented onboard a ship called Viking Grace, which sails between Sweden and Finland. The technology has also been installed in the SSAB steel factory in Borlänge, Sweden.

Criterion 4: Application Diversity

Climeon estimates that presently there are 30,000 ships in use in the global marine market that can utilise the C3 technology, indicating a significant potential in the marine market. Other potential application areas are geothermal plants, steel plants, metal production, paper factories, solar heating, biomass combustion, and coal-fired power generation. The technology can also be coupled with district heating networks, especially to compensate the seasonal effect. Another prospective application is in steel mills, where the technology can be engaged during the production of flat steel when the metal is heated up many times while being rolled. This process results in a lot of water that is usually at around 90 degrees Celsius, which is subsequently released into a water body. This freely available heated water can easily combine with a Climeon Ocean unit to produce electricity.

Criterion 5: Financial Performance

The exceptional performance of the C3 technology, in the form of Ocean Marine equipment is due to the high performance turbine, which operates at more than 85% efficiency. If a ship owner invests in such a unit, the return on investment is expected to be as quick as a 2 to 5 year time period depending on various factors including the way the system is integrated, where is it placed, fuel price, and what kind of power is expended. If the unit has input feed at all times, i.e. the ship sails all the time, the best return on investment period can be realised. As this is not always the case, the return on investment varies from ship to ship.

Criterion 6: Scalability

Climeon showcases a 150 kW model at present but at the same time it has revealed its ambition to manufacture bigger models for steel factories. Climeon assembles these machines in a modular manner so that units capable of handling bigger power ratings such as 300 kW or 600 kW systems can be produced. This saves engineering costs of designing new systems from the ground level up, as larger systems could be difficult to retrofit into existing ships. The modular system increases the overall efficiency and versatility of the system. For example, the Viking Grace has been estimated to save 200 tonnes of fuel and >400 tons of CO2 emissions per year because of the amount of electricity it produces.

Conclusion

Climeon AB has developed its innovative C3 technology that provides customers with superior operating efficiency and can be applied in a number of sectors including marine, industrial manufacturing, power generation, etc. This technology delivers a high return on investment and Frost & Sullivan fully expects this system to take off within the marine industry. Because of its strong overall performance, Climeon AB is recognized with Frost & Sullivan's 2015 Technology Innovation Award.

Significance of Technology Innovation

Ultimately, growth in any organization depends upon finding new ways to excite the market, and upon maintaining a long-term commitment to innovation. At its core, technology innovation or any other type of innovation can only be sustained with leadership in three key areas: understanding demand, nurturing the brand, differentiating from the competition. This three-fold approach to nurturing innovation is explored further below.



Understanding Technology Innovation

Technology innovation begins with a spark of creativity that is systematically pursued, developed, and commercialized. That spark can result from a successful partnership, a productive in-house innovation group, or the mind of a singular individual. Regardless of the source, the success of any new technology is ultimately determined by its innovativeness and its impact on the business as a whole.

Key Benchmarking Criteria

For the Technology Innovation Award, we evaluated two key factors—Technology Attributes and Future Business Value—according to the criteria identified below.

Technology Attributes

- Criterion 1: Industry Impact
- Criterion 2: Product Impact
- Criterion 3: Scalability
- Criterion 4: Visionary Innovation
- Criterion 5: Application Diversity

Future Business Value

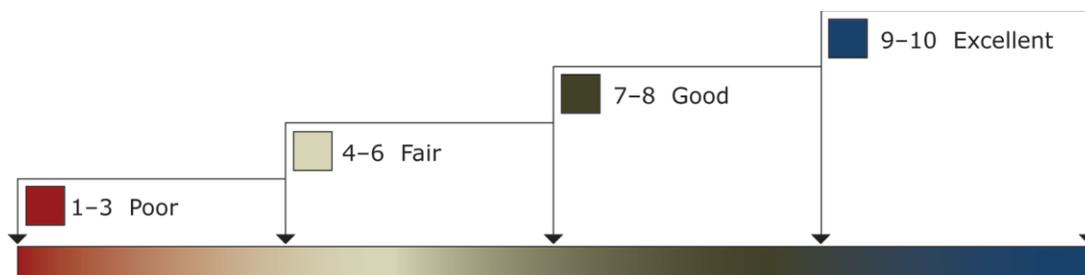
- Criterion 1: Financial Performance
- Criterion 2: Customer Acquisition
- Criterion 3: Technology Licensing
- Criterion 4: Brand Loyalty
- Criterion 5: Human Capital

Best Practice Award Analysis for Climeon AB

Decision Support Scorecard

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Scorecard. This tool allows our research and consulting teams to objectively analyze performance, according to the key benchmarking criteria listed in the previous section, and to assign ratings on that basis. The tool follows a 10-point scale that allows for nuances in performance evaluation; ratings guidelines are illustrated below.

RATINGS GUIDELINES



The Decision Support Scorecard is organized by Technology Attributes and Future Business Value (i.e., the overarching categories for all 10 benchmarking criteria; the definitions for each criteria are provided beneath the scorecard). The research team confirms the veracity of this weighted scorecard through sensitivity analysis, which confirms that small changes to the ratings for a specific criterion do not lead to a significant change in the overall relative rankings of the companies.

The results of this analysis are shown below. To remain unbiased and to protect the interests of all organizations reviewed, we have chosen to refer to the other key players in as Company 2 and Company 3.

<i>Measurement of 1-10 (1 = poor; 10 = excellent)</i>			
Technology Innovation	Technology Attributes	Future Business Value	Average Rating
Climeon AB	9.0	9.5	9.2
Competitor 2	8.0	8.5	8.2
Competitor 3	8.0	8.0	8.0

Technology Attributes

Criterion 1: Industry Impact

Requirement: Technology enables the pursuit of groundbreaking new ideas, contributing to the betterment of the entire industry

Criterion 2: Product Impact

Requirement: Specific technology helps enhance features and functionality of the entire product line for the company

Criterion 3: Scalability

Requirement: Technology is scalable, enabling new generations of products over time, with increasing levels of quality and functionality

Criterion 4: Visionary Innovation

Requirement: Specific new technology represents true innovation based on a deep understanding of future needs and applications

Criterion 5: Application Diversity

Requirement: New technology serves multiple products, multiple applications, and multiple user environments

Future Business Value

Criterion 1: Financial Performance

Requirement: High potential for strong financial performance in terms of revenues, operating margins and other relevant financial metrics

Criterion 2: Customer Acquisition

Requirement: Specific technology enables acquisition of new customers, even as it enhances value to current customers

Criterion 3: Technology Licensing

Requirement: New technology displays great potential to be licensed across many sectors and applications, thereby driving incremental revenue streams

Criterion 4: Brand Loyalty

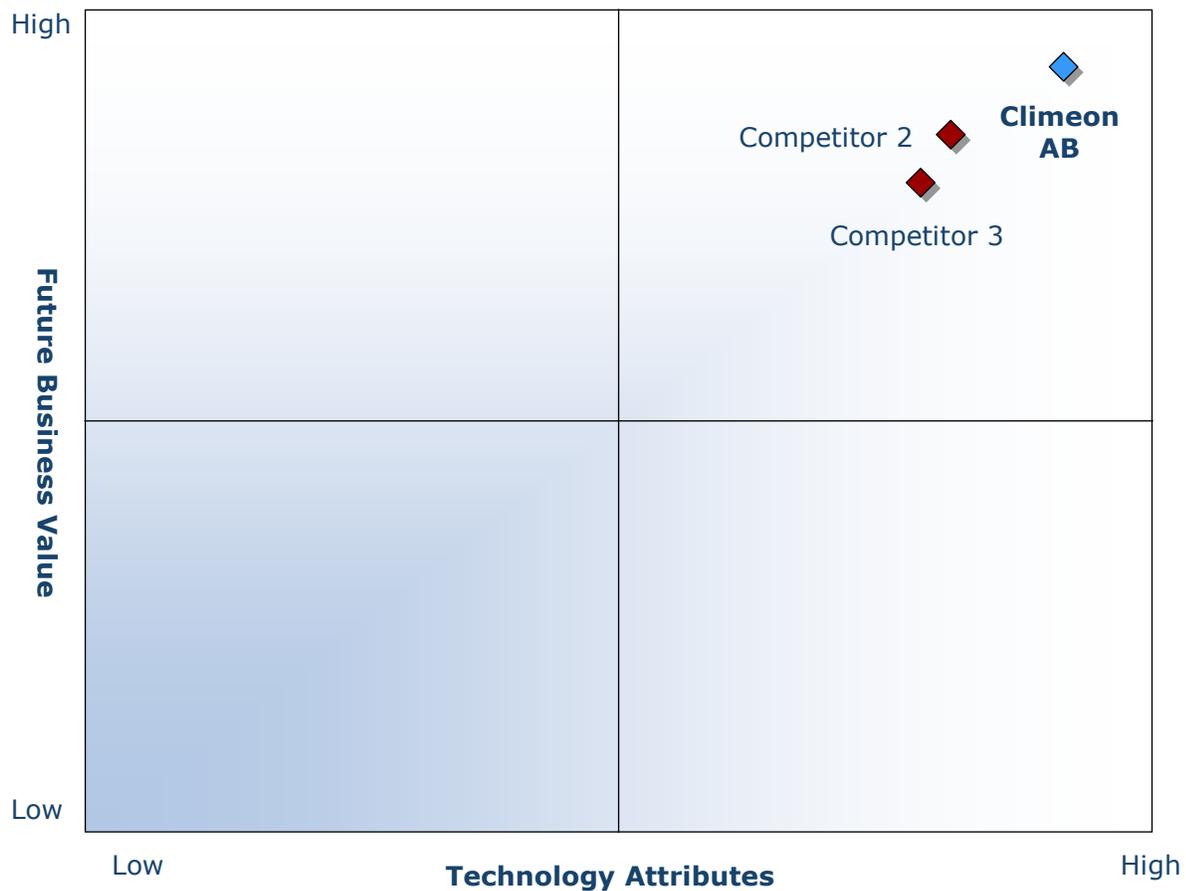
Requirement: New technology enhances the company’s brand, creating and/or nurturing brand loyalty

Criterion 5: Human Capital

Requirement: Customer impact is enhanced through the leverage of specific technology, translating into positive impact on employee morale and retention

Decision Support Matrix

Once all companies have been evaluated according to the Decision Support Scorecard, analysts can then position the candidates on the matrix shown below, enabling them to visualize which companies are truly breakthrough and which ones are not yet operating at best-in-class levels.



The Intersection between 360-Degree Research and Best Practices Awards

Research Methodology

Frost & Sullivan's 360-degree research methodology represents the analytical rigor of our research process. It offers a 360-degree-view of industry challenges, trends, and issues by integrating all 7 of Frost & Sullivan's research methodologies. Too often, companies make important growth decisions based on a narrow understanding of their environment, leading to errors of both omission and commission. Successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. The integration of these research disciplines into the 360-degree research methodology provides an evaluation platform for benchmarking industry players and for identifying those performing at best-in-class levels.

360-DEGREE RESEARCH: SEEING ORDER IN THE CHAOS



Best Practices Recognition: 10 Steps to Researching, Identifying, and Recognizing Best Practices

Frost & Sullivan Awards follow a 10-step process to evaluate Award candidates and assess their fit to best practice criteria. The reputation and integrity of the Awards are based on close adherence to this process.

STEP	OBJECTIVE	KEY ACTIVITIES	OUTPUT
1 Monitor, target, and screen	Identify award recipient candidates from around the globe	<ul style="list-style-type: none"> • Conduct in-depth industry research • Identify emerging sectors • Scan multiple geographies 	Pipeline of candidates who potentially meet all best-practice criteria
2 Perform 360-degree research	Perform comprehensive, 360-degree research on all candidates in the pipeline	<ul style="list-style-type: none"> • Interview thought leaders and industry practitioners • Assess candidates' fit with best-practice criteria • Rank all candidates 	Matrix positioning all candidates' performance relative to one another
3 Invite thought leadership in best practices	Perform in-depth examination of all candidates	<ul style="list-style-type: none"> • Confirm best-practice criteria • Examine eligibility of all candidates • Identify any information gaps 	Detailed profiles of all ranked candidates
4 Initiate research director review	Conduct an unbiased evaluation of all candidate profiles	<ul style="list-style-type: none"> • Brainstorm ranking options • Invite multiple perspectives on candidates' performance • Update candidate profiles 	Final prioritization of all eligible candidates and companion best-practice positioning paper
5 Assemble panel of industry experts	Present findings to an expert panel of industry thought leaders	<ul style="list-style-type: none"> • Share findings • Strengthen cases for candidate eligibility • Prioritize candidates 	Refined list of prioritized award candidates
6 Conduct global industry review	Build consensus on award candidates' eligibility	<ul style="list-style-type: none"> • Hold global team meeting to review all candidates • Pressure-test fit with criteria • Confirm inclusion of all eligible candidates 	Final list of eligible award candidates, representing success stories worldwide
7 Perform quality check	Develop official award consideration materials	<ul style="list-style-type: none"> • Perform final performance benchmarking activities • Write nominations • Perform quality review 	High-quality, accurate, and creative presentation of nominees' successes
8 Reconnect with panel of industry experts	Finalize the selection of the best-practice award recipient	<ul style="list-style-type: none"> • Review analysis with panel • Build consensus • Select winner 	Decision on which company performs best against all best-practice criteria
9 Communicate recognition	Inform award recipient of award recognition	<ul style="list-style-type: none"> • Present award to the CEO • Inspire the organization for continued success • Celebrate the recipient's performance 	Announcement of award and plan for how recipient can use the award to enhance the brand
10 Take strategic action	The award recipient may license the award for use in external communication and outreach to stakeholders and customers	<ul style="list-style-type: none"> • Coordinate media outreach • Design a marketing plan • Assess award's role in future strategic planning 	Widespread awareness of recipient's award status among investors, media personnel, and employees

About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, enables clients to accelerate growth and achieve best in class positions in growth, innovation and leadership. The company's Growth Partnership Service provides the CEO and the CEO's Growth Team with disciplined research and best practice models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages almost 50 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from 31 offices on six continents. To join our Growth Partnership, please visit <http://www.frost.com>.