Final Report:

Solar Powered E-Longtail Boat



Author Roland Schlegel, ZENNA AG

Date of the Report: 04.02.2023	Contract Number: 2019.02
Institution: ZENNA AG	Country: Thailand

Prepared by:

ZENNA AG Alte Spinnerei 16 CH-8877 Murg, Switzerland +41 44 586 11 22 mail@zenna.ch www.zenna.ch



With the Support of: **REPIC Platform** c/o NET Nowak Energy & Technology AG Waldweg 8, CH-1717 St. Ursen Tel: +41(0)26 494 00 30, Fax: +41(0)26 494 00 34, <u>info@repic.ch</u> / <u>www.repic.ch</u>

The REPIC Platform is a mandate issued by the: Swiss State Secretariat for Economic Affairs SECO Swiss Agency for Development and Cooperation SDC Federal Office for the Environment FOEN Swiss Federal Office of Energy SFOE

The author(s) are solely responsible for the content and conclusions of this report.

Contents

1.	Summary		
2.	Starting Point		
3.	. Results		
4. Project Review			6
	4.1	Project Implementation	6
	4.2	Achievement of Objectives and Results	13
	4.3	Multiplication / Replication Preparation	15
	4.4	Impact / Sustainability	15
5.	Outl	ook / Further Actions	16
	5.1	Multiplication / Replication	16
	5.2	Impact / Sustainability	16
6.	Less	son Learned/ Conclusions	18
7.	References		
8.	Annex		

1. Summary

Maximum of 1 page, containing the most relevant information; particularly: Why was this project implemented (Needs in the partner country)? What was implemented (project's content)? How was the project carried out and what objectives have been achieved? What do you foresee as further actions to be undertaken?

One of the most common transportation means in southern Thailand are the so called longtail boats. They are mainly used for transportation of goods and people to and from the islands, as well as to some mainland regions hardly accessible by road. Longtail boats are usually relatively simple wooden structures powered by old car or even truck engines. The use of such old engines is highly contaminating: oil, solid substances and lubricants contaminate the water and nature reserves, whereas the exhaust gases are a heavy source of CO_2 and cause air pollution. On top of that, these engines are very loud. All this has not only an enormous environmental impact, directly affecting the natural habitat of thousands of species and vegetation, but also negatively affects the living standards of locals and tourism, one of the main income sources in this region of the country. The rapid growth of the Thai economy in the past years has shoot up the goods and passenger transportation demand and therefore the use of longtail boats, the cheapest solution that most locals can afford.

This project aims the construction and proof of concept of a fully functioning prototype of an electric longtail boat powered by solar energy. The E-longtail boat will offer an affordable and competitive alternative solution to locals which while eliminating the damaging emissions (exhaust gases, oil, lubricant and noise) associated with the existing longtail boats.

In June 2021 the prototype was successfully set to water east of Bangkok on the Nakhon Nueang Khet Cacal for first tests. All basic features have been tested successfully including some performance tests. For the long-term testing the boat has been moved to Ayutthaya the former capital of Thailand and handed over to an operator for daily use. As further actions we see to main points, the cost reduction of the components and a prototype in the open see.

2. Starting Point

Short description of the initial situation at the project's start.

Due to the Thailands's geography, water transport plays a very important role in Thai people's daily lives, especially on the islands and other coastal regions where the access by road is very limited or even impossible. Rua hang yao (literally translated as long-tailed boats) are Thailand's most distinctive form of waterborne transport. The reason of their success: their simplicity and cost competitiveness. Longtail boats consist of a long and thin wooden vessel powered by big engine, typically removed from an old car or truck. A long propeller, also known as the "tail" of the boat, is attached to the engine and steers the boat by being lowered, raised and turned around.

One of the main benefits of these propellers which allow a 180° horizontal turning of the shaft and complete lifting from the water is the capability of navigating in shallow waters or even of reaching the shore without being damaged.

The rapid growth of the economy in the past years and the migration of locals to different regions of the country in the search of jobs and the touristic boom have generated the prompt increase of demand of goods and people transportation. Because of the often proximity of villages and cities to the coast and/or rivers, water transportation plays a key role for locals in Thailand and is expected to significantly grow in the coming years. Statistics have shown that only in Bangkok about 300,000 people currently travel by boat every day. This number is expected to grow up to 526,000 persons/day by 2037.

The low income of most individuals makes it impossible for them to invest on new and efficient water transportation means. For this reason, the most common solution is the use of the traditional longtail boats, long and thin wooden vessels powered by old car and truck engines. The use of old and very inefficient engines is very environmentally harmful, mainly due to the high amount of fuel consumption, subsequent carbon emissions and release of polluting materials like oil, lubricants and solid substanc- es. These substances damage and endanger the survival of thousands of marine ecosystems. On top of that, theses engines are extremely loud and have therefore a very negative impact on the living standards of cities and villages located close to harbours or crowded waters.

3. Results

Description of the project's original objectives.

The main project objectives are the following:

- 1. The engineering of a functioning solar powered e-boat as a proof of concept
- 2. Construction of the prototype boat and short-term testing
- 3. Testing of the boat and handover to local operator for long-term testing

The engineering of the boat will consist of the detailed design and determination of the required parts based on the developed concept, including the electrical configuration, physical placement of all components on the vessel, selection of mounting structure for the panels etc. The full engineering of the boat accompanied by a financial assessment are the proof of concept of the E-longtail Boat.

Once this concept has been proved to be technically and financially viable, the boat will be constructed and a first short-term testing stage will be carried out. This test aims at the identification of deviations from expected performance so that they can be corrected (for example, the addition of storage capacity, the reinforcing of the mounting structure or any technical adjustment if required). Once this stage completed, the functioning prototype will be handed over to a local operator who will test the boat on the long run. In this stage, a remote monitoring of the different components will be carried out in order to optimize their use. The data will be gathered through the battery management system and GPS.

4. Project Review

4.1 Project Implementation

How was the project carried out (approach, partner and project's main steps)?

ZENNA partnered with AERO Solar & Automation in Thailand. A key learning from other international projects, is a reliable local partner. AERO Solar & Automation is a company with solar experience managed by a swiss CEO. The necessary funds to carry out the project were provided by REPIC and CDW a German foundation. After several meetings in Thailand with AERO Solar & Automation, the responsible authorities of the Marine Department in Bangkok and the Pollution Control Department, the project team decided to build the prototype on a river around Bangkok and to execute the long-term testing on a river. The main reasons are lower safety risk, easier permit process and better accessibility for the local partner.



Figure 1: Meeting with the Marine Department in Bangkok

For the construction and engineering of the boat we partnered with Senero, a Swiss based company specialized on marine, outdoor and special solar solutions. Together with Senero, the project team decided to use existing and proofed marine components, to ensure the technical success and minimize the risk. Therefore, we deployed hardware from Mastervolt and Bellmarine for the batteries, solar charger, monitoring devices as well as the motor controller and motor itself.

The haul of the boat has been sourced locally while for all other main components European suppliers were used. The components were all sent to Thailand, where AERO Solar & Automation started with the assembly.



Figure 2: Construction of the Solar Powered E-Longtail Boat

The engineering of the boat resulted in a 15kW AC-motor directly connected to the shaft and propeller. The roof consists of 20 flexible solar panels with a total power of 5.2 kWp, which are charging the 4 batteries with a total capacity of 22 kWh. Beside the charging from the roof, there is the possibility to charge from a 2nd source or backup. The boat is 12m long and 2.5m wide and weighs 2'400 kg including all components and offers space for maximum 28 passengers.



Figure 3: Fact sheet Solar Powered E-Longtail Boat



Figure 4: Technical components Solar Powered E-Longtail Boat

After finishing the construction the boat was set to water east of Bangkok on the Nakhon Nueang Khet Canal successfully at the end of June 2021 for the first test runs.



Figure 5: Transport to the river



Figure 6: Lunch in the shade of the Solar Powered E-Longtail Boat



Figure 7: The boat is lifted from the truck to the river



Figure 8: The boat is safe in the water

In the Nakhon Nueang Khet Canal the short-term test could be executed. The first tests with the boat have been successful. The boat was running and could be charged by solar energy. With the current setting the boat has a range of approximately 30km at an average speed of 17 km/h. The 15kW AC-motor which is connected directly to the shaft and propeller can accelerate the boat to a maximum speed of 19 km/h. The solar system with 20 modules and total power of 5.2 kWp produces roughly 20 kWh on a sunny day. There is still room for optimization especially the shaft and it's bearings which are originally out of wood, cause high friction and vibration.

Due to COVID travel restrictions the project then experienced a hold of around 1 year until June 2022. In June 2022 several meetings have taken place to introduce the Solar Powered E-Longtail Boat to various companies and governmental institutions.

<u>Banpu NEXT</u> a leading smart clean energy solution provider in Asia Pacific with a vision of "Innovating Infinite Energy Solutions to All", among many other things partnered and supports a Thai startup that operates MuvMi electric tuk-tuk services. The Management and Senior Engineers of the electrical vehicle business inspected the Solar Powered E-Longtail Boat and proposed to the senior management to check and consider extending their partnership into electrical boats.



Figure 9: Test ride Solar Powered E-Longtail Boat with Banpu Next

From the contact with <u>south pole</u> in Thailand, a lot of knowledge about the possibilities and main drivers for the CO_2 emissions reduction projects could be gained. South pole is a well know and established company which develops and implements comprehensive emission reduction projects and strategies that turn climate action into long-term business opportunities for companies, governments and organizations around the world.

During a fair organized by the Swiss embassy, the Solar Powered E-Longtail Boat could be introduced to the new elected Governor of Bangkok, the Bangkok Metropolitan Administration, members of the Swiss Embassy including the Swiss ambassador Helene Budliger Artieda. The project encountered a lot of attention since Bangkok is facing serious smog problems, known as PM2.5. Through the embassy contacts to the Pollution Control Department of Thailand could be made.



Figure 10: Introduction of the Solar Powered E-Longtail Boat to the new elected Governor of Bangkok at the Swiss Embassy

In January 2023 the boat has been moved by a truck to a shipyard in Ayutthaya to overhaul the wood body, replace some damaged sections and repaint the body. before it is given to the chosen operator K. Rome, which will operate the boat for a time of at least one year.



Figure 11: Transport of the Solar Powered E-Longtail Boat to the shipyard in Ayutthaya



Figure 12: The Solar Powered E-Longtail Boat in the shipyard ready to be overhauled

Did the project's main objectives have to be modified during the course of the project? Describe any of the modifications made. n/a

The main objectives could all be achieved. The only real change was the place for short-term and long-term testing from the see to a river.

4.2 Achievement of Objectives and Results

To what extent were the objectives achieved? Which results were achieved?

The Solar Powered E-Longtail Boat fully accomplished its 3 main objectives.

- 1. The engineering of a functioning solar powered e-boat as a proof of concept
- 2. Construction of the prototype boat and short-term testing
- 3. Testing of the boat and handover to local operator for long-term testing

Objective 1 - achieved

Firstly the engineering of the boat based on a traditional longtail boat was executed with the support of the company Senero. A detailed design and selection of the required parts were made, including the electrical configuration, physical placement of all components on the vessel, selection of mounting structure for the panels etc.

Objective 2 - achieved

Secondly the main electrical components were sourced in Switzerland and shipped to Thailand. The haul, propeller and shaft have been sourced locally in Thailand. AERO

Solar & Automation then started to assemble the boat. The base of the solar roof was locally made out of aluminium on which the 20 flexible modules could be mounted. During the short term testing various propeller styles/configuration have been tested to find the best match. Strong vibrations on the shaft could be reduced by changing the place and material of the bearings. During the short term testing the maximal speed, range at different speeds and time to charge the batteries have been tested. Following numbers resulted, the boat has a range of approximately 30km at an average speed of 17 km/h with a maximum speed of 19 km/h. The solar system with 20 modules and a total power of 5.2 kWp produces roughly 20 kWh on a sunny day. With a cruising speed of around 9 km/h the boat can run almost self-sustainable on a sunny day. The boat fulfilled all expectation and requirement.

Objective 3 - achieved

Thirdly to test the boat in daily use an operator and place was searched. This turned out to be more challenging than expected. After several meetings with organization, companies, administration the best match could be found in Ayutthaya the former capital of Thailand. The operator K. Rome has experience with boats, the location is also close to the builder of the haul as well as in reachable distance for AERO Solar & Automation. Like this support for technical issues can be ensured. The boat is equipped with a GPS sensor so the boat and number of trips, covered distance and speed can be checked.

Figure 13: The Solar Powered E-Longtail Boat handed over to the operator K. Rome in Ayutthaya

4.3 Multiplication / Replication Preparation

What preparatory work was carried out for the multiplication and replication within the project's framework?

Several steps from start to finish were taken into consideration for the replication of the project. Initially, it was made sure the drive with shaft and the haul are the same as the original boats. This helps to increase the acceptance of the operators and enables the chance to retrofit existing boats in a bigger scale. Even a carbon fiber haul would reduce the weight of the boat and increase the range of the boat, a retrofit wouldn't be possible. Furthermore, the availability of components with lower cost were checked to reduce the CAPEX. Here a visit to the Swiss based company Kyburz was made. Kyburz is the supplier of the electrical three wheeled delivery vehicle among others for the Swiss Post. Kyburz confirmed us, that with some engineering the cost of our main electrical components could be reduced substantially. After the boat was built several meetings with potential investors have taken place to check their position to the Solar Powered E-Longtail Boat. Like described in capture 6, in our opinion private boat owners will not have the capital to invest in an electrical modification. So only big corporate companies in combination with the government can start the electrification of the boats. Where the corporate company invests in hardware to modify existing boats to electrical boats and takes a lease from the boat operators. While the government ensures the access to CO₂ certificates to reduce the risk of the investor/corporate company. The government furthermore should set the general condition on certain areas (islands), that only electrical boats are allowed. Bangkok already has an ongoing issue with fine particles. So if the government decides to prohibit boats with fossil energy, the Solar Powered E-Longtail Boat would be ready to replace some of them.

4.4 Impact / Sustainability

Which impacts were already noticeable up to the end of the project?

This project had several positive impacts. The operator can profit from immediate savings and therefore higher profits, due to the massive dropping operation costs. Especially with the rising gas cost, a big impact. With the proof of concept the awareness and importance of renewable energies and their potential in the transportation sectors raised a lot in the local communities as well as in governmental institutions. The CO₂ and water pollution reduction are not having an immediate impact. But the reduction of the noise is immediately noticeable and improves the living standards of the locals. As well as the reduction of the air pollution, the passengers don't have to breath in the gases of the diesel or gas engine.

5. Outlook / Further Actions

5.1 Multiplication / Replication

What are the next planned steps?

What is being done to promote multiplication / replication?

Which hurdles need to be overcome in order to have successful multiplication / replication?

First the results of the long-term testing over one year must be available to see the reliability of the components in daily use to improve potential weaknesses. In our view the potential would be huge for the islands. A similar boat on the islands could be the next project.

The project and its results have been introduced to several companies and governmental institutions by meetings and newsletters as:

- south pole, Thailand
- Banpu Next, Thailand
- CrossBondary, Thailand
- AVPN, Thailand
- Energy Absolute, Thailand
- Bangkok Metropolitan Administration (BMA), Thailand
 - o Governor of Bangkok Chadchart Sittipunt
- Embassy of Switzerland, Thailand
 - Embassador of Switzerland Helene Budliger Artieda
- SwissThai Chamber of Commerce, Thailand
- Pollution Control Department (PCD), Thailand
- Marine Department, Ship standard bureau, Thailand
- Asian Development Bank (ADB), Thailand
- Grütter Consulting, Switzerland

Due to the project information on the REPIC website, two specific project requests have been issued to ZENNA already. One to build an electrical boat in Indonesia and another one to build an electrical boat in Senegal. The gained experience and knowledge could be shared and helped ZENNA to get a consulting job.

A successful replication in bigger scale is depending on a governmental or institutional program to promote electrical boat. As for example the cooperation of Energy Absolute with Switzerland to commit to reduce the carbon footprint.

5.2 Impact / Sustainability

What are the expected sustainable effects (environmental, socio-economic aspects, CO₂ relevance, resource efficiency, etc.)?

This project solves the environmental issues that long-tail boats imply while fulfilling the transportation needs of Thai locals living close to waterways and/or islands. The Solar Powered E-Longtail Boat solely energy source is the sun. Therefore, the boat will be 100% powered by renewable energy, the CO₂ emissions caused by the old engines will be removed. The replacement of a single traditional long-tailed boat by an electric boat could save up to 3.18 tons of CO₂ emissions every year. At the same time, the use of modern e-motors will drastically reduce the emission of other substances like lubricants or solid parts to the sea, since they specifically engineered for naval use and not for cars. E-motors generate very little noise (especially compared with old truck engines) and offer a very competitive performance.

The rapid growth of the economy in the years before COVID and the migration of locals to different regions of the country in the search of jobs and the touristic boom have generated the prompt increase of demand of goods and people transportation. A big portion of the Thai people leave direct or indirect from the sea. This can be by fishermen or any job related to tourism. Many tourists visit Thailand for its nice beaches and Islands. Emission free boats support the well-being of the sea in the long-term. For example, the famous Maya Beach in Thailand has been closed for tourists for several months to protect the environment.

Economical locals can benefit from the lasting business from tourist due to the intact environment. Local operators can benefit from the very low running costs of the electrical boat. In times where gas and diesel price shot through the roof. And the local people and visitor don't get disturbed by the noise of the constant noise of the diesel longtail boats.

		At the REPIC Project's Com-
Ecological	Unit	pletion
Installed renewable energy ca-	[kW]	5.2
pacity		
Renewable energy produced	[kWh]/year	6'760
Amount of fossil fuel energy	[kWh]/year	Operation is starting March 2023
saved		
Greenhouse gas reduction	[t CO ₂ -eq]/year	Operation is starting March 2023
Economic		
Energy costs (LCOE)	[ct/kWh]	-
Triggered third-party fund-	[CHF]	0
ing/investments		
Local private income generated	[CHF]	Operation is starting March 2023
Social		
Number of beneficiaries	[Number]	1 operator
Number of new jobs	[Number]	0
Number of trained personnel	[Number]	1 operator
		2 staff of builder

6. Lesson Learned/ Conclusions

What are this project's main findings and conclusions?

Which recommendations can be made for similar projects, or within this context? Interesting observations within the project's context: Which of your personal impressions would you like to share?

Findings/Conclusion

With the Solar Powered E-Longtail Boat the project team could proof the feasibility of building a complete emission free longtail boat by keeping the original design and shaft of the boats. The use of approved available marine components resulted in an expected, but high CAPEX. For mass adoption or higher quantities, a corresponding R&D budget has to be included to source locally or from Asian pacific. All main components are available, but the communication and management between the components must be ensured. The transport and import of lithium batteries, can depending on the country, cause high cost and time effort.

To run the boat the whole day on a speed above 10 km/h the solar area is not big enough to provide the needed energy. Given the limiting length and width of the boat, a bigger solar area is not possible, otherwise the entering and exiting of the boat is very inconvenient and the boat loses its balance. This means a solely solar powered longtail boat is good for stop and go trips with adequate stopping time, but not nonstop operations.

Another important conclusion is, there is no "one-fits-all-solution". The variety of forms, materials, dimensions, weights, ranges, speeds, and number of trips per day of the existing boats are uncountable. This makes it very challenging to develop a standardized solution to retrofit existing boats in bigger scale.

A finding about the ownership structure, the bigger boats are all operated by companies, while the small boats are operated by families or individuals. The small boats therefor will be kept in the families for generations. Even there is a proven reduction of the OPEX and payback time of a few years with environmental benefits, the skepticism towards the new technology and relatively long investment horizon, will hold the owners back to switch to an electrical longtail boat.

Recommendations/Learnings

- A reliable project partner in the country of the project is the base and the key for a successful project.
- The local authority responsible for the water transportation should be consulted to learn about the rules, laws and regulations.
- The use case and type of boat should be known/researched before the dimensioning and design of the electrical boat.
- Depending on the size of the boat and the trip length, it might could make sense to build the boat without solar roof, but instead with a charging station at the docks.

- Lithium batteries should by possibility be sourced in the country of the project. Otherwise, the transport and cost and process of import must be checked in an early project stage.
- Light weight solar modules help to cover a maximum area without destabilizing the boat through its weight.
- The ownership structure differs from region to region even within a country. For bigger role-outs the structure should be understood beforehand.
- In theory the business model of a solar powered electrical boat with almost no OPEX is profitable, but there are several challenges to overcome:
 - Investors are quenched to invest due to the many varieties of boats and use cases and therefore limited possibilities to offer a standardized solution.
 - To subsidies/support the switch to electrical boats by CO₂ certificates, the CO₂ which can be compensated by boats is relatively small and therefore a big number of boats would have to be switched to electrical to get a reasonable size of CO₂ reduction to make it interesting for investors.
 - The small boats are usually privately owned and not by companies.
 - Private operators shy away from the investment since the costs to change to an electrical boat are too high compared to the payback time. Especially since in developing countries usually the available saving is relatively low, and the investment-horizons are rather a few months then years.
- To build electrical boats in higher quantities and proof the case in bigger scale, a strategical/political decision must lay the foundation, for example with the decision to announce that in certain areas only electrical boats are allowed. In Thailand a start could be at Maya Bay, a hotspot for tourists. Once this has been successfully implemented the range could be extended to Koh Phi Phi and possibly other island.

7. References

Reference list of publications, reports, etc.

- "REPIC Solar Powered E-Longtail Boat (Nov 21)", uploaded by ZENNA AG https://vimeo.com/649892293
- "REPIC Solar Powered E-Longtail Boat (Jul 21)", uploaded by ZENNA AG https://vimeo.com/578353930

8. Annex

When available: Reports, press articles, brochures, test results, etc

- Solar Powered E-Longtail Boat V1.0 Newsletter 07/2021.pdf
- Solar Powered E-Longtail Boat V1.0 Newsletter 01/2023.pdf
- Solar Powered E-Longtail Boat V1.0 Factsheet.pdf
- Solar Powered E-Longtail Boat V1.0 Handover protocol.pdf

Please include **photos**, easily comprehensible graphics, etc., with this report. Please send the complete final report directly to: <u>info@repic.ch</u> (REPIC Sekretariat, c/o NET Nowak Energy & Technology, Ltd., Waldweg 8, CH-1717 St. Ursen)

Solar Powered E-Longtail Boat - Factsheet 06/2022

This project aims for the construction and proof of concept of a fully functioning prototype of an electric longtail boat powered by solar energy. The E-Longtail Boat will offer an alternative solution to locals while eliminating the damaging emissions (exhaust gases, oil, lubricant and noise) associated with the existing longtail boats. Important for the project was to maintain the "look and feel" of the traditional longtail boats to enhance the chance of broad acceptance of the general public.

Facts			
Dimension:	12m x 2.5m	Max. speed:	20 km/h
Weight empty:	2.5t	Solar system:	20 modules
Location:	Minburi, TH	Battery:	22 kWh Lithium
Max. passengers:	28	Motor	15 kW

Next step/milestone

Find a local operator in Thailand to hand over the boat for long term testing.

Video

https://vimeo.com/zenna/e-longtail-boat

Contact

AERO Solar & Automation Co., Ltd. Mr. Rolf Aeschbacher rolf@aero-engineering.net ZENNA AG Mr. Roland Schlegel mail@zenna.ch

Newsletter 07/2021 – Solar Powered E-Longtail Boat

Two years, after the official project start in spring 2019, we are happy to announce the Solar Powered E-Longtail Boat is built and set to water east of Bangkok on the Nakhon Nueang Khet Canal successfully at the end of June 2021 for the first test runs.

This project aims for the construction and proof of concept of a fully functioning prototype of an electric longtail boat powered by solar energy. The E-Longtail Boat will offer an alternative solution to locals while eliminating the damaging emissions (exhaust gases, oil, lubricant and noise) associated with the existing longtail boats. Important for the project was to maintain the "look and feel" of the traditional longtail boats to enhance the chance of broad acceptance of the general public.

In 2019 we were mainly focused to overcome the bureaucratic barriers to run a boat in Thailand. Several meetings with different government departments haven taken place, mainly with the Pollution Control Department (PDC) and the Marine Department of the Ministry of Transport. Thanks to the great support of the PCD, all the challenges could be solved. One important outcome was the fact, that it was easier to get an approval to run the boat on the rivers of Bangkok then the open sea.

During the construction phase we were looking for a local boat builder and all the mechanical parts needed. The complete assembly has been done by the local partner Aero Solar & Automation Co. Ltd east of Bangkok.

For the mechanical parts it was important for us, to minimize the risk of a failure related to software and communication. Therefore, we decided to use sea proven hardware from Mastervolt and Bellmarine for the batteries, solar charger, monitoring devices as well as the motor controller and motor itself. We used a 15kW AC-motor directly connected to the shaft and propeller. The roof consists of 20 flexible solar panels with a total power of 5.2 kWp, which are charging the 4 batteries with a total capacity of 22 kWh. Beside the charging from the roof, there is the possibility to charge from a 2nd source or backup. The boat is 12m long and 2.5m wide and weighs 2'400 kg including all components and offers space for maximum 28 passengers.

Around two weeks ago the Solar Powered E-Longtail Boat was ready for the first tests in the water.

Over the next weeks all the parts will extensively be tested to improve and optimize the operation of the Solar Powered E-Longtail Boat. The testing will be done on the Nakhon Nueang Khet Canal. The boat will be "parked" and monitored while not in use from a close by temple and its monks.

Location:

- https://goo.gl/maps/5NfyYEpjzHfwu5t5A

Link to video:

- <u>https://vimeo.com/zenna/e-longtail-boat</u>

Thank you to all project partners, which contributed to enable the execution of this project.

Solar Po	wered E-Lon	gtail Boat po	wered by
REPIC 🛡	Schweizerische Eidgenossenschaft Cenfederation suisse Cenfederazione Svizzera Cenfederazione Svizzera State Secretariat for Economic Affairs SECO Swiss Agency for Development and Cooperation SDC Federal Office for the Environment FOEN Swiss Federal Office of Energy SFOE	Soler & Automation Co., Ltd.	SEREPO move on!
	cdw stiftung	BOOTSWERFT WOLF	ER PORTABLES Take your power with you A Take your power you a Take your power you a Take your power you a Take your power you a Take you

For any marketing activities, please contact/confirm with:

AERO Solar & Automation Co., Ltd. Mr. Rolf Aeschbacher rolf@aero-engineering.net ZENNA AG Mr. Roland Schlegel mail@zenna.ch

Newsletter 01/2023 - Solar Powered E-Longtail Boat

The Solar Powered E-Longtail Boat has been handed over to an operator in Ayutthaya to start the one year long time test.

After short term tests have been done successfully, the project team was looking for a suitable operator to execute the long-term test of the boat under real conditions. Furthermore, meetings with potential investors to discuss business and financial models had to be done to achieve the last REPIC milestone.

Several meetings have taken place in July 2022 in Bangkok to discuss business and financial models as well as discussions with potential operators. Regarding business and financial models discussions with following 3 companies have been done.

- <u>south pole</u>
- Energy Absolute PCL
- Banpu Next

With Banpu next two physical meetings and several online meetings have taken place. On 21st July the Vice President, a Senior Manager and a Senior Engineer visited the Solar Powered E-Longtail Boat for a test ride and inspection.

The project also could be introduced to a delegation of the swiss embassy in Bangkok and the governor of Bangkok Mr. Chadchart Sittipunt, which was highly interested.

Regarding the business model, following conclusion could be taken. Private operators shy away from the investment since the costs to change to an electrical boat are too high compared to the payback time. Especially since in developing countries usually the available saving is relatively low, and the investment-horizons are rather a few months then years. And potential Investors are quenched to invest due to the many varieties of boats and use cases and therefore limited possibilities to offer a standardized solution.

To build electrical boats in higher quantities and proof the case in bigger scale, a strategical/political decision must lay the foundation, for example with the decision to announce that in certain areas only electrical boats are allowed. In Thailand a start could be at Maya Bay, a hotspot for tourists. Once this has been successfully implemented the range could be extended to Koh Phi Phi and possibly other island.

After intensive surge for a suitable operator, none of the big companies was able to commit. But we came across a small boat operator in Ayutthaya 1.5 hours north of Bangkok. The operator is at the moment operating a small long-tail boat in Ayutthaya, bringing school students and local people from Na Wang Market to places nearby. The operator K. Rome

visited our Solar Powered E-Longtail Boat and spent one day of running the boat with instructions given by Rolf Aeschbacher. With K. Rome an agreement could be done to operate the boat for one year in Ayutthaya.

The boat has been moved by a truck to a shipyard in Ayutthaya to overhaul the wood body, replace some damaged sections and repaint the body before it is given to K. Rome.

The Solar Powered E-Longtail Boat is at the shipyard in Ayutthaya ready to be overhauled. Where all the repairs should be finished until February 2023.

The handover papers of the Solar Powered E-Longtail Boat to operate it for one year could be signed on January 2023.

With a small ceremony the boat will be handed over to K. Rome in February 2023 for the operation of one year. The local government will be invited to the ceremony with some free rides for officials from various departments and government agencies.

Thank you to all project partners, which contributed to enable the execution of this project.

For any marketing activities, please contact/confirm with:

AERO Solar & Automation Co., Ltd. Mr. Rolf Aeschbacher rolf@aero-engineering.net ZENNA AG Mr. Roland Schlegel mail@zenna.ch

ข้อตกลงระยะนำร่อง: โครงการเรือหางยาวพลังงานแสงอาทิตย์ในประเทศไทย (SOLAR POWERED E-LONGTAIL BOAT)

ข้อตกลงนี้ทำขึ้น ณ วันที่ 6 มกราคม 2566 ซึ่งเป็นข้อตกลงระหว่าง ZENNA AG (ซึ่งต่อไปนี้เรียกว่า "ZENNA"), AERO Solar & Automation Co. Ltd. (ซึ่งต่อไปนี้เรียกว่า "AERO") และ K.Rome (ซึ่งต่อไปนี้ เรียกว่า "K.Rome") สำหรับเรือหางยาวพลังงานแสงอาทิตย์ (ซึ่งต่อไปนี้เรียกว่า "เรือ") เมื่อทำการพิจารณาร่วมกัน และตามข้อกำหนดและเงื่อนไขที่กำหนดไว้ด้านล่าง ผู้ร่วมโครงการดังกล่าวมีข้อตกลงร่วมกันดังนี้

- ระยะเวลา: ระยะนำร่องมีวัตถุประสงค์เพื่อใช้เรือในการทดสอบความน่าเชื่อถือและประสิทธิภาพของส่วนประกอบ นอกจากนี้ จะต้องมีการทดสอบการบังคับใช้สำหรับการใช้งานประจำวันและการยอมรับของผู้ปฏิบัติงานและลูกค้า ระยะนำร่องจะมีระยะเวลา 12 เดือน ตั้งแต่ วันที่ 1 กุมภาพันธ์ 2566 ถึง วันที่ 31 มกราคม 2567 และสามารถ ขยายระยะเวลาได้ไม่จำกัดในข้อตกลงร่วมกันหลังจาก 12 เดือน
- 2. การดำเนินการ: K.Rome จะใช้เรือในกิจกรรมเชิงพาณิชย์ในการขนส่งผู้คนรอบๆ จังหวัดอยุธยา
- **3. ค่าใช้จ่าย:** ไม่มีค่าใช้จ่ายในการซื้อหรือเข่าเรือ K.Rome สามารถเรียกเก็บค่าธรรมเนียมสำหรับค่าบริการและเก็บ กำไรทั้งหมดไว้
- การบำรุงรักษา: K.Rome รับผิดชอบในการบำรุงรักษาและซ่อมแซมเรือรวมถึงเพลาและใบพัด และรับผิดชอบ ค่าใช้จ่ายทั้งหมดที่ไม่รวมกับระบบไฟฟ้า ซึ่งทาง AERO จะบำรุงรักษาและซ่อมแซมตามต้องการโดยไม่มีค่าใช้จ่าย โดยต้องรายงานความเสียหายหรือความผิดปกติใดๆ ต่อ AERO ทันที
- อื่นๆ:
 - K.Rome รับผิดชอบเกี่ยวกับใบอนุญาตต่างๆที่ถูกต้องตามกฎหมายและใบอนุญาตในการดำเนินการเดินเรือ
 - K.Rome รับผิดชอบความปลอดภัยของผู้โดยสาร
 - K.Rome มีหน้าที่ดำเนินการเดินเรือตามระเบียบและข้อบังคับปัจจุบัน
 - ZENNA และ AERO สามารถตกลงและแจ้งล่วงหน้าจองเรือเพื่อใช้งานได้โดยไม่มีค่าใช้จ่าย

ZENNA, 6 ม.ค. 2566

AERO, 6 ม.ค. 2566

K.Rome, 6 ม.ค. 2566

Roland Schlegel, Partner

4

Rolf Aeschbacher, CEO

K.Rome

AGREEMENT PILOT PHASE - "SOLAR POWERED E-LONGTAIL BOAT" in Thailand

This Agreement is made as of 06.01.2023, by and between the project partners ZENNA AG (hereinafter referred to "ZENNA"), AERO Solar & Automation Co. Ltd. (hereinafter referred to "AERO") and the K.Rome (hereinafter referred to "K.Rome") for the Solar Powered E-Longtail boat (hereinafter referred to "BOAT"). Upon mutual consideration and upon the terms and conditions set forth below, the said project partners agree as follows:

1. DURATION:

The pilot phase is aimed, to use the BOAT on a regular basis to test the components' reliability and performance. Furthermore, the applicability for daily use and the acceptance of the operator and customer shall be tested. The pilot phase shall last for 12 months from 01.02.2023 to 31.01.2024 and can be extended unlimited in mutual agreement after 12 months.

2. OPERATION:

K. Rome shall use the BOAT on a regular basis in commercial activity as people transport around Ayutthaya.

3. COST:

There is no buying or leasing cost for the BOAT. K.Rome can charge a fee for its services provided and keep all the gains.

4. MAINTENANCE:

K.Rome is responsible for the maintenance and repairs of the BOAT including the shaft and propeller and cover its cost. Excluded is the complete electrical system, which on demand will be maintained and repaired by AERO at no cost. Any damage or malfunction must be reported immediately to AERO.

5. MISCELLANEOUS:

- K. Rome is responsible for a legitimate license and permit to operate the BOAT.
- K. Rome is responsible for the safety of the passengers.
- K. Rome is responsible to operate the BOAT according to the present regulations.
- ZENNA and AERO can in agreement and advanced notice book the BOAT for use at no cost.

ZENNA, 06.01.2023

AERO, 06.01.2023

K. Rome, 06.01.2023

Roland Schlegel Partner

Rolf Aeschbacher, CEO

K. Rome

1) If not sufficient income can be generated, ZENNA Will Support for the maintainace. Accidente are also excluded from the cost of K. Rome.

BOM - "SOLAR POWERED E-LONGTAIL BOAT" in Thailand

The Solar Powered E-Longtail boat (hereinafter referred to "BOAT") taken over by K. Rome (hereinafter referred to "K. Rome") contains following main components.

Item	Model	Amount
Boat hull	TATA Srisiam Enterprise Co. Ltd.	1
PV Modules	DAS Energy, 255 Wp, 1.4 m2	20
Motor + Inverter, Accessoirs	Bellmarine Drivemaster 15kW/48V	1
	Bellmarine Monochromdisplay	1
	Bellmarine cooling system	1
	Bellmarine control lever	1
	Bellmarine flange for shaft	1
	Mastervolt East View 5, Display	1
Battery + Battery container	MLI Lithium Ultra 24/5500	4
Charge controller	Mastervolt Mass 48/50-2	1
Mounting structure	Localy produced	1
DC-DC Converter	Mastervolt SCM 60 MPPT 900 - 3600 kWp	2
DC Distributor	Mastervolt DC Distributor 500	1
DC Cable, Fuses	Latching Relay 24V/500A	2
	Mounting rack for T-Fuse 225-400A	2
	Mastervolt T-Fuse small 400A	2
	Shaft with Propeller	1
Life jackets		20

All project partner confirm the content and amount of the BOM.

ZENNA, 06.01.2023

Roland Schlegel Partner

AERO, 06.01.2023

Rolf Aeschbacher, CEO

K. Rome, 06.01.2023

K. Rome

Attached are the related datasheets and schematic.