

RENEWABLE ENERGY SYSTEM FOR AN ELECTRIC BOAT

[1] The present application claims the filing date of earlier Singapore patent application number 10202401390W as its priority, which was filed with IPOS on 16 May 2014. Content or subject matter of the priority application is hereby incorporated entirely or wherever relevant by reference.

[2] The present application relates to renewable energy production. More particularly, the present application is a system to charge an electric boat by harnessing renewable-energy.

[3] The advent of electric propulsion in electric boat has marked a significant transition from traditional fossil fuel-based systems towards more sustainable practices in the maritime industry. This shift has been propelled by the increasing concern for environmental preservation and the stringent regulations on emissions. The technology introduced in the field of marine electric vehicles (MEVs) promises reduced greenhouse gas emissions, lower operational costs, and quieter operations compared to their internal combustion counterparts.

[4] However, the integration of electric propulsion systems into electric boat has not been without challenges. One of the primary shortcomings of prior art in this field has been the limited range of MEVs due to the lower energy density of batteries compared to traditional fuels. This has necessitated frequent recharging, posing a significant obstacle for boat that operate for extended periods or traverse remote areas where charging infrastructure is scarce or non-existent.

[5] Another critical issue has been the prolonged time required for recharging batteries, which increases operational downtime. The lack of fast-charging infrastructure at ports further exacerbates this problem, leading to inefficiencies and delays in marine operations. Moreover, the initial costs associated with establishing such charging facilities can be prohibitive, hindering the widespread adoption of MEVs.

[6] Additionally, prior art has often overlooked the need for robust and secure battery storage systems within the electric boat. Safety concerns related to battery operation, such as thermal management and the risk of fire, have not been adequately addressed. The harsh marine environment also poses challenges in terms of corrosion, necessitating the development of corrosion-resistant materials and connectors that can endure prolonged exposure to saltwater.

[7] The existing technologies also fail to provide an adequate solution for the rapid swapping of batteries to allow for continuous boat operation. The manual replacement of batteries can be labour-intensive and time-consuming, creating a need for an automated system that can quickly and safely swap batteries, thereby minimizing the physical burden on the crew.

[8] While the technology of electric propulsion for electric boat presents a greener alternative to traditional maritime transportation, it is impeded by limitations in range, recharging time, infrastructure costs, safety, and the practicality of battery handling.

[9] Therefore, the subject application aims to address these challenges by introducing a comprehensive system that comprises a floating docking facility with solar-powered charging stations and automated battery swapping mechanisms, creating a more efficient, cost-effective, and safe operation for MEVs.

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[10] The present application and relevant invention provide an electric boat that is configured to harness renewable-energy, substantially as herein described and illustrated. The present application and relevant invention further provide a method of swapping batter of an electric boat that is configured to harness renewable-energy,
10 substantially as herein described and illustrated, whether manually or automatically.

[11] The present application is described hereinafter by various embodiments. This application may, however, be embodied in many different forms and should not be construed as limited to the embodiment set forth herein.

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[12] The present invention operates on the principle of integrating sustainable energy practices with marine technology to provide an efficient, automated, and safe system for electric boat. It harnesses renewable-energy through a network of panels, stores this energy in modular and swappable batteries, and features an automated,
20 centralized docking facility that allows for rapid battery exchanges and recharging. This system addresses the limitations of current electric boat technology by reducing dependence on shore-based infrastructure, minimizing operational downtime, and incorporating safety measures for reliable and continuous marine operation.

[13] According to an aspect of the present application, a system to charge an electric boat by harnessing renewable-energy is provided. In accordance with an embodiment of the present invention, the renewable energy system comprises a floating charging station that comprises at least one renewable-energy harvester in order to generate
5 electricity on water, an electric boat that is configured to be attached to and/or detached from the floating charging station, and one or more swappable battery that is configured to be charged by the floating charging station as well as swapped between the floating charging station and the electric boat. With generation, storage and exchange co-located on a single floating platform, the boat can obtain fresh
10 propulsion energy anywhere on the water without fixed shore infrastructure, while the swappable-battery architecture eliminates long plug-in times and maximises boat utilisation.

[14] In accordance with an embodiment of the present invention, the renewable-
15 energy system further comprises an electric boat that is configured to be attached to and/or detached from the floating charging station for receiving or releasing the one or more swappable batteries. By allowing the electric boat to dock only long enough to exchange swappable batteries, the arrangement eliminates extended plug-in times, lets the vessel depart immediately with full energy, and frees the floating charging
20 station to service additional craft.

[15] In accordance with an embodiment of the present invention, the renewable energy system comprises a floating docking facility that carries the at least one renewable-energy harvester such as a first array of solar panels, configured to convert
25 incident sunlight into electrical energy. Mounting a dedicated solar array on the

docking facility guarantees a continuous renewable supply independent of grid availability and allows the charging station to operate in remote or environmentally sensitive waters.

5 [16] In accordance with an embodiment of the present invention, the renewable energy system is arranged so that the one or more swappable battery is removably installable in at least one battery housing of the electric boat. Tool-free installation into a dedicated housing streamlines the swap process, secures the battery against motion, and provides a sealed environment that protects both the module and the hull
10 from water ingress.

[17] In accordance with an embodiment of the present invention, the renewable energy system provides a charging station on the floating docking facility electrically coupled to the first array of solar panels and arranged to recharge one or more of the
15 swappable batteries while the facility floats on a body of water, and comprises battery-handling apparatus configured to extract a depleted swappable battery from the housing through an access opening in a sidewall of a hull of the electric boat and to insert a charged swappable battery in its place; wherein the electric boat derives at least propulsion power from the installed swappable batteries. The integrated charger
20 delivers renewable energy directly to each module, while the battery-handling apparatus completes a rapid, watertight exchange so the boat departs with full propulsion power minutes after arrival, minimising downtime and crew labour.

[18] In accordance with an embodiment of the present invention, the electric boat is
25 implemented as a catamaran formed by two parallel hulls of substantially equal

dimensions, each hull defining a longitudinal housing with a watertight side opening sized to admit a swappable battery; the battery-handling apparatus simultaneously extracts and inserts swappable batteries through these openings. This twin-hull configuration distributes battery mass symmetrically, preserves hydrodynamic balance, and permits rapid concurrent swappable battery exchange, thereby reducing turnaround time at the dock.

[19] In accordance with an embodiment of the present invention, the electric boat is embodied as a monohull that incorporates multiple internal battery housings accessible through at least one watertight door cut into a hull sidewall, the door dimensioned for lateral insertion and removal of the swappable batteries. Locating the housings as integrated structures within a hull minimises structural complexity and enables conventional hull manufacturing techniques while still allowing efficient side-loading of energy packs.

[20] In accordance with an embodiment of the present invention, the battery-handling apparatus associated with the catamaran embodiment employs paired electrical mechanical actuator, each arm positioned adjacent a respective hull, to withdraw depleted swappable batteries from both hulls in synchrony and reinstall charged swappable batteries. Coordinated dual-arm manipulation halves the dwell time required for a full boat refit, improving operational throughput and reducing labour dependency.

[21] In accordance with an embodiment of the present invention, the battery-handling apparatus of the monohull embodiment utilises a

linear-actuator-driven tray that translates swappable batteries laterally between the interior stowage position and the side door aperture. The tray provides positive mechanical support throughout the transfer, mitigating crew effort and lowering the risk of swappable batteries damage or misalignment.

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[22] In accordance with an embodiment of the present invention, the floating docking facility further incorporates an energy storage bank that accumulates surplus energy harvested from the first array of solar panels and supplies the charging station during periods of diminished solar input. Buffer storage decouples boat-charging capability
10 from instantaneous insolation, guaranteeing service continuity under variable weather conditions.

[23] In accordance with an embodiment of the present invention, the charging station mounted on the docking facility is equipped with an automatic coupler that
15 mates to complementary contacts on the Swappable batteries without manual intervention. Automated engagement enhances electrical safety, eliminates connector wear caused by improper handling, and speeds the initiation of every recharge cycle.

[24] In accordance with an embodiment of the present invention, the docking facility
20 additionally carries a generator set capable of providing alternating-current power to the charging station when the state of charge of the energy storage bank drops below a predetermined threshold. The auxiliary generator safeguards against service interruption during extended low-sunlight intervals or unusually heavy boat traffic.

[25] In accordance with an embodiment of the present invention, a power-management controller monitors real-time solar irradiance, battery bank condition, and generator output, automatically switching between renewable and auxiliary sources to satisfy charging demand with optimal efficiency. Dynamic source
5 selection maximises renewable utilisation while preserving battery life and fuel economy.

[26] In accordance with an embodiment of the present invention, each swappable battery is realised as a sealed lithium-iron-phosphate pack configured to provide high
10 cycle life and thermal stability, whereas the rugged casing protects against the marine environment, collectively promoting long-term reliability. Each swappable battery is enclosed within a casing that is configured to shield the battery from exposure to water, salt spray, and environmental contaminants.

15 [27] In accordance with an embodiment of the present invention, the swappable battery is enclosed within a protective casing that comprises a casing lining configured to enhance thermal dissipation and mechanical protection. The lining, which may feature fin-like structures, ribs, or channels, is formed from marine-grade, corrosion-resistant, non-conductive material and may be disposed internally or externally on the
20 casing. This structure promotes passive cooling, prevents environmental contamination, and contributes to the safety and longevity of the battery in marine conditions.

[28] In accordance with an embodiment of the present invention, the first array of
25 solar panels is mounted on a frame having an adjustable-tilt mechanism that positions

the panels for maximum solar flux throughout the day. Improved incidence control boosts energy yield, permitting a smaller array to achieve requisite charging throughput.

5 [29] In accordance with an embodiment of the present invention, the floating docking facility is supported by buoyant floats fabricated from high-density polyethylene, furnishing positive stability in wave conditions while bearing the combined mass of docked boats, batteries, and ancillary equipment. The material resists ultraviolet degradation and marine growth, lowering maintenance costs.

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[30] In accordance with an embodiment of the present invention, every hull access opening is sealed by a mechanically or electrically actuated watertight door that interlocks with boat-propulsion controls to remain shut whenever the boat is underway. The interlock ensures hull integrity and crew safety during navigation.

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[31] In accordance with an embodiment of the present invention, each swappable battery is formed with integrated lifting lugs dimensioned to engage a quick-release gripper at the terminus of the battery-handling apparatus. Standardised mechanical interfaces allow the same tooling to service diverse boats and reduce mis-grip
20 incidents.

[32] In accordance with an embodiment of the present invention, the battery-handling apparatus is further arranged to lower a removed swappable battery into the surrounding water such that the swappable battery floats vertically before

retrieval by dock machinery. Water-assisted neutral buoyancy lessens mechanical load on the handling device and provides a fail-safe should power be lost mid-transfer.

[33] In accordance with an embodiment of the present invention, at least one
5 proximity sensor is disposed proximate the hull opening to verify correct alignment between the handling apparatus and the battery housing prior to swappable battery movement. Alignment confirmation prevents collision damage and ensures reliable electrical connection after insertion.

10 [34] In accordance with an embodiment of the present invention, the docking facility comprises multiple parallel charging bays capable of servicing several electric boats simultaneously. Concurrent charging enlarges system throughput and shortens queue times during peak operating periods.

15 [35] In accordance with an embodiment of the present invention, the power-management controller records charging-cycle statistics for swappable batteries and transmits the data wirelessly to a remote monitoring server. Cloud-based analytics facilitate predictive maintenance and fleet-wide energy-use optimisation.

20 [36] In accordance with an embodiment of the present invention, the docking facility is anchored by adjustable tension-leg moorings that maintain a substantially constant freeboard, permitting the battery-handling apparatus to couple predictably with approaching hull openings irrespective of tide or boat displacement. Stable relative positioning minimises transfer misalignment.

[37] In accordance with an embodiment of the present invention, the battery-handling apparatus is driven by a programmable logic controller that sequences extraction, transfer, insertion, and locking steps in a single automated routine. Full automation minimises crew requirements and standardises procedure
5 across varying operator skill levels.

[38] In accordance with an embodiment of the present invention, the charging station employs chemistry-specific charging algorithms that regulate current and voltage to extend swappable battery service life. Tailored charging profiles mitigate
10 degradation mechanisms such as lithium plating or electrolyte breakdown.

[39] In accordance with an embodiment of the present invention, the electric boat integrates a seawater-based cooling circuit that conveys heat away from each installed battery via a hull-mounted heat-exchange plate. Maintaining cell temperatures within
15 optimal limits promotes efficiency and suppresses thermal-runaway risk.

[40] In accordance with an embodiment of the present invention, a mechanical locking mechanism secures every swappable battery against vertical and longitudinal movement whenever the hull door is closed, ensuring structural integrity under boat
20 acceleration and sea state loads.

[41] In accordance with an embodiment of the present invention, the battery-handling apparatus comprises a telescopic boom that compensates for relative heave between the floating docking facility and the electric boat, sustaining precise
25 swappable battery-handling geometry even in moderate wave action.

[42] In accordance with an embodiment of the present invention, the first array of solar panels installed on the docking facility is dimensioned to deliver at least fifty kilowatts of peak electrical power, affording sufficient capacity to recharge multiple high-energy batteries within practicable turnaround intervals.

[43] In accordance with an embodiment of the present invention, the energy storage bank may be constituted by lithium-ion, sodium-ion, or zinc-air cells selected according to climatic and regulatory considerations, enabling bespoke optimisation of energy density, cost, and environmental resilience.

[44] In accordance with an embodiment of the present invention, the electric boat further comprises a second array of solar panels disposed at a roof of the electric boat, connected with an on-board inverter that converts direct-current power from the second array of solar panels to charge the swappable batteries on the electric boat; and a charger, adapted to connect with an output of the charging station, configured to charge the swappable batteries. This dual-source arrangement lets the boat harvest sunlight autonomously while under way and draw high-current energy from the docking facility when berthed, thereby shortening dockside dwell time and extending cruising endurance without adding range-limiting weight.

[45] In accordance with an embodiment of the present invention, the charging station onboard the floating docking facility comprises a solar input inverter, connected with the first array of solar panels, configured to convert direct-current power from the first array of solar panels to charge an energy storage bank or the swappable batteries

or a combination thereof, on the floating docking facility; and/or an AC input, configured to charge the energy storage bank or the swappable batteries on the floating docking facility; and an output power socket connected with the energy storage bank, adapted to connect with a charger onboard the electric boat, configured to

5 charge the swappable batteries on the electric boat. By combining a dedicated solar inverter, a grid- or generator-fed AC port and a protected output power socket, the station can deliver renewable, auxiliary or blended power through a single interface, guaranteeing rapid, uninterrupted battery replenishment regardless of weather or shore-power availability.

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[46] In accordance with an embodiment of the present invention, the battery-handling apparatus reads an RFID tag on swappable batteries and verifies that its state of health meets a predetermined criterion before installation, thereby preventing degraded swappable batteries from entering service and safeguarding

15 operational reliability.

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[47] In accordance with an embodiment of the present invention, the docking facility provides an auxiliary shore-power connector allowing the charging station to draw grid electricity while berthed at a pier, affording operational flexibility when renewable

generation is constrained.

[48] In accordance with an embodiment of the present invention, the docking facility further carries an overhead gantry crane that moves swappable batteries between the charging bays and a storage rack where swappable batteries may undergo long-term

balancing or scheduled maintenance, thereby rationalising spatial utilisation on the platform.

[49] In accordance with an embodiment of the present invention, at least one wind turbine is erected on the docking facility to harvest aerodynamic energy, augmenting solar-derived power and furnishing generation diversity in variable climatic conditions.

[50] In accordance with an embodiment of the present invention, submerged hydraulic turbines affixed beneath the docking facility convert tidal or current flow into electrical energy that is fed to the charging station, leveraging local hydrodynamics to boost total renewable yield.

[51] In accordance with an embodiment of the present invention, motorised thrusters under autonomous navigation control enable the docking facility to reposition toward regions of higher solar irradiance or to rendezvous with approaching boats, ensuring optimal energy harvest and reducing boat detour.

[52] In accordance with an embodiment of the present invention, an artificial-intelligence identification swappable battery cooperates with a blockchain ledger to authenticate each boat at arrival and to record battery-exchange transactions immutably, delivering secure, transparent billing without manual processing.

[53] In accordance with an embodiment of the present invention, all underwater portions of the docking facility bear an anti-fouling coating and are periodically cleaned by autonomous robots that return to an onboard charging cradle, preventing marine growth that would otherwise impair buoyancy and hydrodynamics.

[54] In accordance with an embodiment of the present invention, every solar panel surface is treated with a self-healing nano-coating that repairs micro-scratches and repels salt spray, maintaining high conversion efficiency and prolonging service life in
5 harsh maritime climates.

[55] In accordance with an embodiment of the present invention, the first array of solar panels is mounted on dual-axis trackers actuated by light-intensity sensors that continuously orient each panel toward the sun, maximising daily energy capture across all seasons and latitudes.

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[56] In accordance with an embodiment of the present invention, a telescopically actuated superstructure on the docking facility expands automatically to create additional berths when multiple boats are detected by approach sensors and contracts after service completion, conserving mooring-field footprint during idle periods.

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[57] In accordance with an embodiment of the present invention, a battery-carrying aerial drone can ferry a charged swappable battery from the docking facility to a boat located within a predetermined radius and return with the depleted swappable battery, enabling mid-route replenishment without docking.

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[58] In accordance with an embodiment of the present invention, sonar sensors mounted on the docking facility detect marine fauna within a predefined exclusion zone and activate a low-frequency acoustic emitter to encourage the animals to vacate the area before battery-handling operations commence, thereby safeguarding local
25 ecosystems from mechanical interference.

[59] In accordance with an embodiment of the present invention, the renewable energy system provides an electric boat may comprise a plurality of battery housings formed in the hull, the plurality of battery housings being optionally identical to one another or non-identical in configuration, each housing being sized to receive a swappable battery module. Multiple hull-integrated housings let adjust capacity and weight distribution identical bays simplify manufacturing and logistics, while non-identical bays permit mixed-size swappable batteries for fine-tuning range, trim or redundancy, all without altering the external hull form.

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[60] The accompanying Figures (Figs.) illustrate embodiments and serve to explain principles of the disclosed embodiments. It is to be understood, however, that these Figures are presented for purposes of illustration only, and not for defining limits of relevant applications. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this application and are therefore not to be considered limiting of its scope, for the application may admit to other equally effective embodiments.

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[61] These and other features, benefits, and advantages of the present application will become apparent by reference to the following text Figure, with like reference numbers referring to like structures across the views, wherein:

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[62] Fig.1 illustrates a system to charge an electric boat by harnessing renewable-energy, in accordance with an embodiment of the present invention;

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[63] Fig.2 illustrates a perspective view of the renewable energy system, in accordance with an embodiment of the present invention;

[64] Fig.3 illustrates a charging station, in accordance with an embodiment of the
5 present invention;

[65] Fig.4 illustrates a electric boat, in accordance with an embodiment of the present invention;

10 [66] Fig.5 illustrates perspective view of the electric boat with catamaran hull, in accordance with an embodiment of the present invention;

[67] Fig.6 illustrates a front view of the electric boat with the catamaran hull, in accordance with an embodiment of the present invention;

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[68] Fig.7 illustrates perspective view of the electric boat with monohull, in accordance with an embodiment of the present invention;

[69] Fig.8 illustrates a front view of the electric boat with the monohull, in accordance
20 with an embodiment of the present invention;

[70] Fig.9 illustrates a boat-mounted charger, in accordance with an embodiment of the present invention;

[71] Fig.10 illustrates docking of the electric boat into the docking facility, in accordance with an embodiment of the present invention;

[72] Fig.11 illustrates working of the renewable energy system, in accordance with
5 an embodiment of the present invention;

[73] Fig.12 illustrates energy storage bank in the renewable energy system, in accordance with an embodiment of the present invention;

10 [74] Fig.13 illustrates battery removal from the catamaran hull, in accordance with an embodiment of the present invention; and

[75] Fig.14 illustrates battery removal from the monohull, in accordance with an embodiment of the present invention.

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[76] The present application is described hereinafter by various embodiments with reference to the accompanying drawing, wherein reference numerals used in the accompanying drawing correspond to the like elements throughout the description.

20 [77] While the present application is described herein by way of example using embodiments and illustrative drawings, those skilled in the art will recognize that the application is not limited to the embodiments of drawing or drawings described and are not intended to represent the scale of the various components. Further, some components that may form a part of the application may not be illustrated in certain
25 Figures, for ease of illustration, and such omissions do not limit the embodiments

outlined in any way. It should be understood that the drawings and detailed description thereto are not intended to limit the application to the particular form disclosed, but on the contrary, the application is to cover all modifications, equivalents, and alternatives falling within the scope of the present application as defined by the appended claim.

5 As used throughout this description, the word "may" is used in a permissive sense (i.e., meaning having the potential to), rather than the mandatory sense, (i.e., meaning must). Further, the words "a" or "an" mean "at least one" and the word "plurality" means "one or more" unless otherwise mentioned. Furthermore, the terminology and phraseology used herein is solely used for descriptive purposes and should not be
10 construed as limiting in scope. Language such as "including," "comprising," "having," "containing," or "involving," and variations thereof, is intended to be broad and encompass the subject matter listed thereafter, equivalents, and additional subject matter not recited, and is not intended to exclude other additives, components, integers or steps. Likewise, the term "comprising" is considered synonymous with the
15 terms "including" or "containing" for applicable legal purposes.

[78] Fig.1 illustrates a system to charge an electric boat by harnessing renewable-energy, in accordance with an embodiment of the present invention. As shown in Fig.1, the renewable energy system (100) comprises a floating docking
20 facility (102), which may be a buoyant platform that supports all shore-side equipment required for renewable charging and battery exchange. The floating docking facility (102) may be moored on the water surface and it may form the physical hub of the renewable energy system. The floating docking facility (102) provides the primary structural platform for the renewable energy system (100); it may be a buoyant deck—
25 formed, for example, from high-density-polyethylene, aluminium or ferro-cement

floats—sized to berth one or more electric boats. All subsequent hardware is fixed to or housed within this facility, which can assume a rectangular, catamaran or telescopic form according to site constraints.

5 [79] In accordance with an embodiment of the present invention, as shown in Fig.1, mounted on the floating docking facility (102) is at least one renewable-energy harvester (1044, 1045). As shown in Fig.1, the least one renewable-energy harvester (1044, 1045) is a first array of solar panels (1044) that converts incident sunlight to direct-current power. The first array of solar panels (1044) may be fixed on the roof of
10 the floating docking facility (1022). The solar panels (1044) are secured to either fixed support frames (1024) or an adjustable-tilt/dual-axis tracker that pivots the swappable batteries (105) for optimum insolation. The at least one swappable battery (105) may have connectors (e.g., magnets or holders) for joining end-to-end longitudinally in order to be coupled to the floating charging station (1042) or the electric boat (106)
15 together.

[80] Further, electrical energy produced by the solar panels (1044) is routed to an Energy storage bank (not shown in Fig.1) —a stationary storage pack that may employ lithium-ion, sodium-ion or zinc-air chemistry—thereby buffering renewable input and
20 delivering high-current output on demand.

[81] Connected with the Energy storage bank (1050) is a charging station (1042). Fig.3 illustrates a charging station, in accordance with an embodiment of the present invention. As shown in Fig.3, containing power-conversion electronics, comprising a
25 solar-input inverter (122), AC input port (124) and output power socket (126). The

charging station (1042) may terminate in an automatic coupler that connects with complementary contacts on each swappable battery (105); the coupler may embody pin-and-socket, magnetic pogo or inductive designs.

5 [82] A one or more swappable battery (105), such as, but not limited to, sealed LiFePO_4 packs with may be, but not limited to, lifting lugs, RFID tags and coolant interfaces, reside either in charging bays on the docking facility (102) or in battery housings within the electric boat (106). The swappable batteries (105) may be dimensioned for placement by the dedicated exchange equipment. Each swappable
10 battery (105) is enclosed within a casing (108) that is configured to shield the battery from mechanical damage, water ingress, and environmental contaminants. The casing (108) may be formed from a non-conductive, corrosion-resistant, marine-grade material and is dimensioned to fully encapsulate the battery during all operational states. The swappable batteries (105) may be dimensioned for precise placement and
15 removal by the dedicated exchange equipment, with the casing (108) providing an additional layer of structural and environmental protection during handling, transport, and operation.

[83] In accordance with an embodiment of the present invention, the casing (108) is
20 further provided with a casing lining (109), which may comprise, but is not limited to, fin-like structures. The casing lining (109) is adapted to enhance thermal dissipation, improve mechanical rigidity, and prevent direct contact between the battery surface and environmental contaminants. It may be disposed internally or externally on the casing (108), and may comprise a plurality of thermally conductive or convectively
25 optimized features, such as ribs, channels, or protrusions, formed from corrosion-

resistant, marine-grade, non-conductive material. The casing lining (109) facilitates passive cooling of the swappable battery (105) and contributes to operational safety, structural durability, and extended service life under maritime operating conditions.

5 [84] Fig.4 illustrates an electric boat, in accordance with an embodiment of the present invention. Fig.4 illustrates a top view of the electric boat (106). The electric boat (106) itself may be provided in two structural alternatives. Fig.5 illustrates perspective view of the electric boat with catamaran hull and Fig.6 illustrates a front view of the electric boat with the catamaran hull, in accordance with an embodiment
10 of the present invention as shown in Fig.5 and Fig.6, the first and second parallel hull bodies (1063, 1064) each house a longitudinal battery housing (1070) integrating to the hull and accessed by watertight side doors (1066) aligned with the paired electrical mechanical actuator (1065) as shown in Fig.6. Further, Fig.7 illustrates perspective view of the electric boat with monohull and Fig.8 illustrates a front view of the electric
15 boat, in accordance with an embodiment of the present invention. As shown in Fig.7 and Fig.8, in the monohull embodiment a hull (1067) is present. Further, as shown in Fig.8, multiple battery housings (1070) structurally integrated into the hull (1067) and are served by the linear tray through a watertight side door (1066).

20 [85] The battery-handling apparatus removes depleted swappable batteries (1051) and installs charged swappable batteries (1052): in the catamaran and the monohull embodiment the apparatus employs paired electrical mechanical actuator. In accordance with an additional embodiment, the catamaran and the monohull may be supplemented by a telescopic boom that compensates for relative motion between the
25 electric boat (106) and the docking facility (102).

[86] Each battery housing (1070) as shown in Fig.6 and Fig.8, incorporates a locking mechanism (1046) that clamps a swappable battery (105) against vertical and longitudinal movement, and is closed by a mechanically or electrically actuated watertight side door (1066) interlocked with the helm to remain sealed while under way. In an additional or alternative embodiment of the present invention, during transfer, one or more handling arms or tray grip the swappable battery's lifting lugs, the telescopic boom compensates for wave-induced motion, and the automatic coupler engages to complete the electrical path. In accordance with additional embodiment, a cooling circuit, typically a seawater loop through plate heat exchangers, may maintain battery temperature within operational limits.

[87] In accordance with an embodiment of the present invention, each battery housing (1070) integrated into the hull (1067) of the electric boat (106) may be positioned above, below, or substantially at the boat's static waterline, depending on hydrodynamic, structural, and buoyancy design considerations, as illustrated in Fig.6 and Fig.8. A battery housing (1070) located above the waterline facilitates ease of access, simplifies sealing mechanisms, and reduces exposure to hydrostatic pressure. The housing (1070) positioned below the waterline, when properly sealed, offers improved center-of-gravity distribution, contributing to enhanced boat stability. Placement substantially at the waterline provides a balanced compromise between accessibility and hydrodynamic performance. In all configurations, each battery housing is equipped with a watertight sealing system designed to prevent water ingress and to ensure safe and reliable operation of the enclosed swappable battery (105) under maritime conditions.

[88] A generator set—diesel, LNG, fuel-cell or micro-turbine—may be mounted on the docking facility (102) to provide alternating-current back-up whenever the state of charge of the Energy storage bank (1050) falls below a predefined threshold. Energy routing between solar, wind, tidal, generator and load is supervised by a power-management controller, implemented as a programmable-logic controller or industrial PC networked to all inverters, trackers and sensors.

[89] Fig.2 illustrates a perspective view of the renewable energy system, in accordance with an embodiment of the present invention. As shown in Fig.2, supporting structures comprise buoyant floats (107) for freeboard and stability, tension-leg anchors for station-keeping, and a deck-spanning overhead gantry crane that marshals the swappable batteries (105) between storage racks and charging bays. Optionally, at least one renewable energy harvester (1044, 1045) may be, but not limited to, mast-mounted wind turbines and submerged hydraulic turbines, each tied electrically to the same DC bus as the first array of solar panels (1044).

[90] The docking facility (102) may further carry motorised thrusters (not shown) for self-propulsion toward stronger sunlight or an incoming boat, and a shape-changing superstructure driven by telescopic actuators (not shown) that enlarges or contracts the berth envelope according to traffic.

[91] In accordance with an additional embodiment of the present invention, the renewable energy system (100) may comprise ancillary subsystems which may comprise a battery-carrying aerial drone (not shown) for mid-route swappable battery

(105) delivery, anti-fouling robotic cleaners that patrol submerged surfaces, sonar sensors coupled to a low-frequency acoustic emitter for marine-life exclusion, and proximity sensors that verify alignment of the handling apparatus prior to swappable battery (105) movement.

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[92] Fig.9 illustrates a boat-mounted charger, in accordance with an embodiment of the present invention. As shown in Fig.9, on the electric boat (106) side, an output power socket (126) on the docking facility (102) may link to a boat-mounted charger (130), which in turn replenishes the swappable batteries (105); a downstream
10 on-board inverter may convert swappable battery DC to three-phase AC for the propulsion motors (1040). Further, a second array of the solar panels (1062) disposed on the roof (1061) of the electric boat (106) connected with the on-board inverter, configured to charge the swappable batteries (105) along with the charger (130).

15 [93] The invention works in a following manner:

[94] The method of working begins with a system (100) to charge the electric boat (106) by harnessing renewable-energy. Fig.10 illustrates the electric boat (106) moving towards (shown with the arrows in Fig.10) the floating docking facility (102). At
20 its core is the floating docking facility (102) that carries the first array of solar panels (1044) configured to convert incident sunlight into electrical energy. The first array of solar panels (1044)—optionally disposed on an adjustable-tilt frame that optimises panel inclination relative to the sun throughout the day or on a dual-axis tracking mechanism actuated by light-intensity sensors to continually adjust panel orientation
25 for maximum incident sunlight—delivers direct-current power to the charging station

(1042) on the docking facility (102) electrically coupled to the first array of solar panels (1044) and arranged to recharge one or more of the swappable batteries (105) while the docking facility (102) floats on a body of water.

- 5 [95] In accordance with an additional or alternative embodiment of the present invention, the floating docking facility (102) may reposition under motorised thrusters and an autonomous navigation controller. In an embodiment, position, attitude, irradiance and electric boat (106)-approach sensors may feed the autonomous navigation controller. When the controller detects either stronger sunlight or an arriving
10 electric boat (106), it may send thrust-vector commands to the electric motorised thrusters of the floating docking facility (102). The thrusters may re-orient the floating docking facility (102) to the new waypoint; once the GPS and inertial sensors confirm arrival, the controller may stop thrust and hold the floating docking facility (102).
- 15 [96] Fig.11 illustrates working of the renewable energy system, in accordance with an embodiment of the present invention. The charging station (1042) onboard the floating docking facility (102) comprises a solar input inverter, connected with the first array of solar panels (1044), configured to convert direct-current power from the first array of solar panels (1044) to charge an energy storage bank (1050) or the swappable
20 batteries (105) or a combination thereof, on the floating docking facility (102), as shown in Fig.11. Further, the charging station (1042) comprises an AC input port (124), configured to charge the energy storage bank (1050) or the swappable batteries (105) on the floating docking facility (102). The charging station (1042) further comprises an output power socket (126) connected with the energy storage bank (1050), adapted

to connect with the charger (130) onboard the electric boat (106), configured to charge the swappable batteries (105) on the electric boat (106) as shown in Fig.3 and Fig.4.

[97] For example, in accordance with an embodiment of the present invention, when
5 the electric boat approaches the floating docking facility (102) and one or more swappable battery (105) installed onboard has reached a predefined low state of charge, the renewable energy system initiates an automated battery exchange operation. The battery-handling apparatus is configured to extract the depleted swappable battery (1051) from its corresponding battery housing and transfer it onto
10 the docking facility (102) for recharging, maintenance, or temporary storage. Subsequently, or in parallel, a charged swappable battery (1052) is retrieved from the docking facility (102) and inserted into the vacated battery housing (1070) of the electric boat (106). The depleted swappable battery (1051) remains stationed at the docking facility (102) for restoration. This automated process significantly reduces
15 turnaround time, enhances boat availability, and obviates the need for plug-in recharging infrastructure or manual battery replacement procedures.

[98] Fig.12 illustrates energy storage bank in the renewable energy system (100), in accordance with an embodiment of the present invention. Any surplus generation is
20 buffered in the energy storage bank (1050) on the docking facility (102) that stores surplus solar energy and supplies the charging station (1042) during periods of insufficient insolation as shown in the Fig.12 (flow of energy depicted with arrows from the energy storage bank (1050) to the charging station (1042). When that state of charge drops, may be the generator set mounted on the docking facility (102) is
25 configured to provide alternating-current power to the charging station (1042). A

power-management controller may automatically select between solar-panel power and generator power based on real-time solar irradiance and battery-state feedback. Also, the power-management controller may be logging charging-cycle data for each swappable battery (105) and communicates the data wirelessly to a remote monitoring
5 server.

[99] The charging station (1042) onboard the floating docking facility (102) may further incorporate a power-flow synchronizer such as a solid-state bidirectional converter or paralleling controller—interposed between (i) the solar input inverter that
10 receives direct-current power from the first array of solar panels (1044) and (ii) the AC input that receives shore grid or generator power. The synchronizer continuously matches voltage, frequency and phase of the two sources and allocates real-time current according to a programmed algorithm. Consequently, the charging station (1042) can (a) deliver combined solar-derived and AC-derived power concurrently to
15 charge the energy storage bank (1050) and/or the swappable batteries (105); (b) isolate either source so that charging proceeds from only the first array of solar panels (1044) or only the AC input; or (c) blend the sources in any selectable proportion. Because the synchronizer maintains source-to-bus synchronism, seamless transitions occur without interrupting the output delivered through the output
20 power socket (126) to the electric boat (106) mounted charger (130), thereby ensuring stable, efficient charging under fluctuating solar irradiance or intermittent AC availability.

[100] As shown in Fig.10, the electric boat (106) approaching the floating docking
25 facility (102). In accordance with an additional or alternative embodiment of the

present invention, the electric boat (106) may comprise a battery-state controller connected with the swappable batteries (105) and propulsion motors (1040) of the electric boat (106). When the battery-state controller detects that the swappable batteries (105) have reached a preset low-charge level, it may trigger a command
5 auto-approach mode. GNSS and infrared docking sensors connected with the battery-state controller on the electric boat (106) may guide the electric boat (106), by commanding the propulsion motors (1040), toward the floating docking facility (102). The electric boat (106) may align its watertight door with the battery-handling apparatus, and maintains position for automatic battery exchange.

10

[101] The electric boat (106) either having a catamaran hull having first and second parallel hull bodies (1063, 1064) or a monohull (1067). Fig.13 illustrates battery removal from the catamaran hull, in accordance with an embodiment of the present invention. In the catamaran hull case, as shown in Fig.13, the battery-handling
15 apparatus comprises paired electrical mechanical actuator (1065) individually mounted adjacent the respective hull bodies (1063, 1064) to synchronously withdraw the depleted swappable batteries (1051) from both hull bodies (1063, 1064).

20

[102] In accordance with an embodiment of the present invention, the swappable battery (105) is designed with positive buoyancy, allowing it to float vertically on the water surface when removed from the electric boat (106). This buoyant feature enables easy retrieval during manual or automated battery exchange operations and serves as a passive safety mechanism to prevent the battery (105) from sinking if unintentionally dropped. Additionally, it reduces the lifting effort required by the

handling apparatus, thereby minimizing mechanical strain and enhancing overall efficiency in marine conditions.

[103] Each swappable battery (105) further comprises an automatic electrical
5 coupling interface that is configured to self-align with complementary contacts located within the battery housing of the electrical boat (106) or docking facility (102). This interface eliminates the need for manual connection, enabling consistent, secure engagement during every battery exchange. Features such as alignment guides, spring-loaded contacts, or magnetic elements may be used to facilitate precise
10 docking. The combination of buoyant design and automatic coupling ensures reliable electrical performance, faster swap cycles, and greater system autonomy for electric boats.

[104] Further, Fig.14 illustrates battery removal from the monohull, in accordance
15 with an embodiment of the present invention. As shown in Fig.14, in the monohull case, the battery-handling apparatus comprises a paired electrical mechanical actuator (1065) translates each swappable battery (105) laterally between the hull (1067) interior and the watertight side door (1066) opening. Each hull presents an access opening in a sidewall of the hull of the electric boat (106) where the access
20 opening in the hull (1067) is fitted with a mechanically or electrically actuated watertight side door (1066) that is interlocked to remain sealed during electric boat (106) navigation. Alignment may be confirmed by at least one proximity sensor positioned adjacent the access opening. A depleted swappable battery (1051) may be housed in a corrosion-resistant casing (108) is removed.

[105] In accordance with an additional embodiment, the apparatus can, if desired, lower a removed depleted swappable battery (1051) into water such that the swappable battery (105) floats vertically before being conveyed onto the docking facility (102) for recharging. A charged swappable battery (1052) is inserted, latched
5 by a locking mechanism (1046) that secures each swappable battery against both vertical and longitudinal movement when the hull door is shut. The swappable batteries (105) may be coupled electrically through an automatic coupler that connects with complementary contacts on each swappable battery. From that point the electric boat (106) derives at least propulsion power from the swappable batteries (105).

10

[106] In this embodiment the boat—catamaran or monohull—uses the same access opening and actuated watertight door. When the door opens, a depleted swappable battery (1051) disengages from the automatic coupler, and floats upright beside the hull by its own buoyancy. The battery-handling apparatus—paired robotic arms on the
15 catamaran or the linear actuator-driven tray on the monohull—grips the floating battery, moves it to a charging bay on the floating docking facility (102), and returns with charged swappable batteries (1052). The replacement battery is guided into the housing, locked by the locking mechanism, and re-coupled electrically, completing the swap without removing any section of the hull. The housing (1070), the at least one
20 casing (108) or both are near a waterline of the renewable energy system (100) for supporting the one or more swappable battery (105) when transferring between at least one housing (1070) and the at least one casing (108) by buoyancy.

[107] Therefore, as shown in the Fig.11, the depleted swappable batteries (1051) from
25 the electric boat (106) are extracted and placed on the floating docking facility (102).

Further, as shown in Fig.12, the charged swappable batteries (1052) from the floating docking facility (102) are transferred to the electric boat (106) while the depleted swappable batteries (1051) are placed in the battery housing (1070).

5 [108] In accordance with an additional or alternative embodiment of the present invention, a cooling circuit may direct seawater through a heat-exchange plate proximate each swappable battery (105).

[109] In accordance with an additional or alternative embodiment of the present
10 invention, the floating docking facility (102) may grow or shrink berth space via a shape-changing structure driven by telescopic actuators.

[110] By way of example, consider a coastal route equipped with multiple identical floating docking facilities (102) spaced fifty nautical miles apart. The electric boat (106)
15 may depart the first facility with multiple fully charged swappable batteries (105) locked in their battery housing (1070). Mid-voyage the on-board processor (power-management controller) may monitor state of charge; when a first swappable battery (105) drops below the preset threshold, the controller flags it as depleted swappable battery (1051) and initiates an approach routine to the next floating docking facility
20 (102). Upon arrival, the facility's battery-handling apparatus extracts the swappable battery (1051) and inserts a charged swappable battery (1052) supplied by the facility's charging station (1042)—all while the vessel remains afloat alongside.

[111] The electric boat (106) then continues further of the journey using the newly
25 installed charged swappable battery (1052) in combination with the remaining original

swappable battery (105). When the second charged swappable battery (1052) in service reaches its low-charge threshold, the processor again triggers auto-approach, this time to the third floating docking facility (102). The same swap procedure occurs: the battery-handling apparatus removes the depleted swappable battery (1052),
 5 installs a fresh one from the facility's charging station (1042), and the electric boat (106) immediately resumes transit. By repeating this detect-and-swap cycle at successive docking facilities, the electric boat (106) can cover an extended route well beyond the single-charge range of any individual swappable battery (105) without prolonged layovers or reliance on land-based infrastructure.

10

[112] In case of the Catamaran hull the electric boat (106) leaves a first docking facility (102) with one fully-charged swappable battery (1052) in the port hull housing (1070) and another in the starboard hull housing (1070). Mid-passage the on-board power-management controller may detect that the port-side battery has reached its
 15 low-charge threshold. The controller steers the vessel to next floating docking facility (102). At this docking facility (102) the paired-arm battery-handling apparatus may open the watertight access doors in both hulls (1063, 1064), extract the depleted port battery through its access opening, and inserts a charged swappable battery (1052) taken from the dock's charging station (1042); the starboard battery remains
 20 untouched. Propulsion resumes immediately, and when the starboard battery later depletes the catamaran repeats the process at the next docking facility (102), exchanging only the affected hull's battery while the other stays in service.

In case of the monohull the electric boat (106) departs the first docking facility (102)
 25 with multiple charged swappable batteries (1052) stacked in a longitudinal battery

housing (1070) behind a single watertight side door. After some times the controller flags the forward battery as depleted. The electric boat (106) approaches next docking facility (102), where the linear-actuator-driven tray battery-handling apparatus slides the depleted battery out through the side-door opening, lifts it clear, and installs a charged replacement from the dock's charging station (1042) while the aft battery remains in place. The monohull continues may voyage; when the aft battery nears depletion the controller diverts the vessel to next docking facility (102), and the same tray swaps that battery, allowing long-distance travel without extended lay-overs.

10 [113] In a self-sustaining variant the electric boat (106) comprises a second array of solar panels (1062) disposed at a roof of the electric boat (106), connected with an on-board inverter that converts direct-current power from the second array of solar panels (1062) to charge the swappable batteries (105) on the electric boat (106). Further, the electric boat (106) comprises the charger, adapted to connect with an
 15 output of the charging station (1042), configured to charge the swappable batteries (105) so that the same packs can be replenished either alongside or under way. In an embodiment of the present invention, the renewable energy system (100) comprises one or more renewable-energy generator (1047) on the electric boat (106), one the floating charging station (1042), or both for converting renewal energy into electricity
 20 in order to charge the at least one swappable battery (105). The renewable-energy generator (1047) may comprise a second array of solar panels (1062), a thermoelectric generator, a wind turbine, a wave energy converter or a combination of any of these.

[114] The electric boat (106) carries a second array of solar panels (1062) disposed at a roof of the electric boat (106), connected with an on-board inverter that converts direct-current power from the second array of solar panels (1062) to charge the swappable batteries (105) on the electric boat (106); and a charger, adapted to connect with an output of the charging station (1042), configured to charge the swappable batteries (105). The electric boat (106) may comprise a compact synchronizer—for example, a bidirectional DC/DC combiner or multi-source charge controller—wired between the on-board inverter and the electric boat (106)-mounted charger (dock source). The synchronizer monitors voltage and current from both inputs, matches their electrical parameters and allocates charging current so that the swappable batteries (105) can be replenished (i) simultaneously from the roof-mounted the first array of solar panels (1044) and the charging-station output, (ii) exclusively from the first array of solar panels (1044) when away from the dock, or (iii) exclusively from the charger when rapid replenishment alongside is preferred. By blending or isolating sources on demand, the synchronizer ensures seamless, efficient battery charging under variable sunlight and docking conditions without manual reconfiguration of cabling or switches. The on-board inverter converts the direct-current power stored in the swappable batteries (105) into three-phase alternating current, which is then fed to the boat's (106) propulsion motors (1040). In accordance with an additional or alternative embodiment of the present invention, the electric boat (106) may have an auxiliary shore-power connector adapted to accept grid input whenever the facility is pier-side.

[115] In accordance with an additional or alternative embodiment of the present invention, the docking facility (102) can service several boats simultaneously because

the docking facility (102) may comprise multiple parallel charging bays, each bay framed by buoyant floats (107) formed of high-density polyethylene that provide positive stability under wave action and held on station by adjustable tension-leg anchors that maintain a constant vertical datum.

5

[116] In accordance with an additional or alternative embodiment of the present invention, heavy logistics may be handled by an overhead gantry crane operable to transfer swappable batteries (105) between the charging bays and a storage rack for long-term balancing or maintenance.

10

[117] In accordance with an additional or alternative embodiment of the present invention, renewable capacity of the renewable energy system (100) can be expanded through the at least one renewable energy harvester (1044, 1045) such as at least one wind turbine mounted on the floating docking facility (102) and/or a set of
15 submerged hydraulic turbines fixed beneath the docking facility (102). The wind turbine and the submerged hydraulic turbines may be connected with onboard generators or inverter to provide power to the energy storage bank (1050) and/ or charging station (1042).

20

[118] In accordance with an additional or alternative embodiment of the present invention, a submerged portions of the docking facility (102) may be coated with an anti-fouling material and may be periodically swept by autonomous robotic cleaners. Further, in accordance with another alternative embodiment of the present invention the renewable energy system (100) may comprise sonar sensors and a low-frequency
25 acoustic emitter to protect marine fauna. Finally, for boats that cannot dock, a

battery-carrying aerial drone may be operable to deliver the charged swappable batteries (1052) and to return the depleted swappable battery (1051) to the charging station (1042).

5 [119] The renewable energy system (100) possess various advantages over the existing prior arts. The renewable energy system's (100) advantage over the short operational range of the electric boat (106) is the inclusion of swappable batteries (105), which can quickly replace depleted batteries and extend the range. This overcomes the inherent limitation of battery energy density compared to petrol fuel,
10 allowing boat (106) to carry fewer batteries with the option to swap them on the go or at the docking facility (102).

[120] The presence of an integrated charging station (1042) at the floating docking facility (102) eliminates the need for individuals to have personal charging
15 infrastructure at their dockside. The charging station (1042) is designed to support multiple electric boat (106), providing convenient and centralized charging capabilities that can serve a fleet of boat (106), making the process of owning an electric boat (106) more practical. The invention circumvents the high costs associated with laying electrical cables and obtaining engineering approvals for construction work by
20 centralizing the charging infrastructure on the floating docking facility (102). This shared infrastructure reduces the individual investment required for charging points, promoting a more cost-effective transition to electrification. The renewable energy system's (100) modular battery design enables boat 106 owners to tailor the number of batteries to their specific range requirements. This modularity can potentially lower

the upfront cost of the electric boat (106) since owners can choose to purchase additional batteries as needed rather than paying for maximum capacity upfront.

[121] The floating docking facility's (102) ability to float and its provision of secure
5 mooring points and bumpers contribute to the operational stability and longevity of the infrastructure. The modular nature of the renewable energy system (100) allows for scalability and adaptability as technology evolves or as operational requirements change. By centralizing the charging and battery swapping infrastructure, the renewable energy system (100) provides a serviceable and convenient solution for
10 electric boat (106) energy needs, encouraging the adoption of electric boat (106).

[122] In the application, unless specified otherwise, the terms "comprising", "comprise", and grammatical variants thereof, intended to represent "open" or "inclusive" language such that they comprise recited elements but also permit
15 inclusion of additional, non-explicitly recited elements.

[123] Various modifications to these embodiments are apparent to those skilled in the art from the description and the accompanying drawings. The principles associated with the various embodiments described herein may be applied to other embodiments.
20 Therefore, the description is not intended to be limited to the embodiments shown along with the accompanying drawings but is to be providing broadest scope consistent with the principles and the novel and inventive features disclosed or suggested herein. Accordingly, the application is anticipated to hold on to all other such alternatives, modifications, and variations that fall within the scope of the present
25 application and the appended claims.

Reference Numerals

- 100 – System
- 102 – Docking facility
- 1022 – Roof of the Docking facility
- 5 1024 – Fixed support frames
- 1040 – Propulsion motors
- 1042 – Charging station
- 1044 – First Array of Solar panels
- 1045 – At least one renewable energy harvester
- 10 1046 – Locking mechanism
- 1047 – Renewable-energy generator
- 105 – One or more swappable batteries
- 1050 – Energy storage bank
- 1051 – Depleted swappable battery
- 15 1052 – Charged swappable battery
- 106 – Electric boat
- 1061 – Roof of the Electric boat
- 1062 – Second Array of Solar panels
- 1063 – First parallel hull body
- 20 1064 – Second parallel hull body
- 1065 – Electrical/mechanical actuator
- 1066 – Watertight side doors
- 107 – Buoyant floats
- 108 – Casing
- 25 109 – Casing lining

1070 – Battery housing

122 – Solar-input inverter

124 – AC-input port

126 – Output power socket

5 130 – Charger

Claims

1. A renewable energy system for an electric boat, the renewable energy system comprising:

5 a floating charging station that comprises at least one renewable energy harvester in order to generate electricity on water;

 at least one battery housing for receiving one or more swappable batteries that are configured to be charged by the floating charging station as well as swapped between the floating charging station internally between different
10 housing s or externally with another floating charging station.

2. The renewable energy system as claimed in claim 1 further comprising an electric boat that is configured to be attached to and/or detached from the floating charging station for receiving or releasing the one or more swappable batteries.

15

3. The renewable energy system as claimed in claim 1 comprising a floating docking facility that carries the at least one renewable energy harvester such as, a first array of solar panels, configured to convert incident sunlight into electrical energy.

20

4. The renewable energy system as claimed in claim 3 wherein the charging station on the floating docking facility electrically coupled to a first array of solar panels and arranged to recharge one or more of the swappable batteries while the facility floats on a body of water; and

5 battery-handling apparatus configured to extract a depleted swappable battery from the housing through an access opening in a sidewall of a hull of the electric boat and to insert a charged swappable battery in its place;

wherein the electric boat derives at least propulsion power from the swappable batteries.

10

5. The renewable energy system of claim 3, further comprising an energy storage bank on the docking facility that stores surplus solar energy and supplies the charging station during periods of insufficient insolation.

- 15 6. The renewable energy system of claim 4, further comprising a generator set mounted on the docking facility and arranged to provide alternating-current power to the charging station when a state of charge of the energy storage bank falls below a predefined threshold.

7. The renewable energy system of claim 2, wherein the electric boat comprises:

a second array of solar panels disposed at a roof of the electric boat, connected with an on-board inverter that converts direct-current power from the second array of solar panels to charge the swappable batteries on the electric boat; and

a charger, adapted to connect with an output of the charging station , configured to charge the swappable batteries .

8. The renewable energy system of claim 3, wherein the charging station onboard the floating docking facility comprises:

a solar input inverter, connected with the first array of solar panels, configured to convert direct-current power from the first array of solar panels to charge the energy storage bank or the swappable batteries or a combination thereof, on the floating docking facility; and/or

an AC input, configured to charge the energy storage bank or the swappable batteries on the floating docking facility; and

an output power socket connected with the energy storage bank, adapted to connect with the charger onboard the electric boat, configured to charge the swappable batteries on the electric boat.

9. The renewable energy system of claim 3, wherein the docking facility incorporates buoyant floats formed of high-density polyethylene that provide positive stability under wave action while supporting the mass of docked boats and on-board equipment.

10. The renewable energy system of claim 4, wherein the battery-handling apparatus is further configured to lower a removed swappable battery into water such that the swappable battery floats vertically before being conveyed onto the docking facility for recharging.

5

11. The renewable energy system of claim 4, wherein the floating docking facility is moored by adjustable tension-leg anchors that maintain a constant vertical datum for reliable mating of the battery-handling apparatus with a boat hull regardless of tide or load.

10

12. The renewable energy system of claim 3, wherein the docking facility comprises motorised thrusters and an autonomous navigation controller configured to reposition the facility toward either (i) an area of higher solar irradiance or (ii) a point selected for an approaching electric boat.

15

13. The renewable energy system of claim 1, wherein the docking facility incorporates a shape-changing structure driven by telescopic actuators that (a) expands to create additional berths when sensors detect multiple approaching boats and (b) contracts to a compact configuration after charging is complete.

20

14. The renewable energy system of claim 1, wherein at least one housing, the at least one casing or both are near a waterline of the renewable energy system for supporting the one or more swappable battery when transferring between at least one housing and the at least one casing by buoyancy.

25

15. The renewable energy system of claim 2, wherein the electric boat is a catamaran having a first and a second parallel hull body, each body defining a longitudinal battery housing sized to receive one or more of the swappable batteries and provided with a watertight lateral opening through which the
5 battery-handling apparatus conducts swappable battery exchange.
16. The renewable energy system of claim 2, wherein the electric boat is a monohull defining a plurality of internal battery housings formed within the hull and accessible through at least one watertight side door sized to pass the swappable
10 batteries for side-extraction and installation.
17. The renewable energy system of claim 4, wherein the battery-handling apparatus comprises paired electrical mechanical actuator individually mounted adjacent the respective hull bodies to synchronously withdraw the swappable batteries
15 from both hull bodies during a swapping operation.
18. The renewable energy system of claim 4, wherein the battery-handling apparatus comprises a linear actuator-driven tray that translates each swappable battery laterally between the hull interior and the side-door opening watertight side door.
20
19. The renewable energy system of claim 14, wherein the casing lining is disposed on an internal or external surface of the protective casing and is formed from a corrosion-resistant, marine-grade, non-conductive material, the casing lining being configured to enhance passive thermal dissipation and provide structural
25 protection to the swappable battery.

20. The renewable energy system of claim 1, comprising plurality of housings, preferably formed in hull of the electric boat, the plurality of housings being optionally identical to one another or non-identical in configuration, each housing
5 being sized to receive the corresponding the one or more swappable batteries.