SELKIE logistics tool – user guide

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Document information

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Abbreviations

CM	Corrective maintenance
EBA	Energy-base availability
LCOE	Levelized Cost of Energy
MC	Monte Carlo Simulation
O&M	Operation and Maintenance
OE	Ocean Energy
ORE	Offshore Renewable Energy
PM	Preventative maintenance
TBA	Time-base availability
TEC	Tidal Energy Converter
TRL	Technology Readiness Level
WEC	Wave Energy Converter
WES	Wave Energy Scotland
WW	Weather Window

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1 Introduction

The SEKLIE project developed a decision-support tool that will compliment and/or fill the gaps in the existing models. The tool is open-access, user-friendly and flexible, developed to be able to assess a wide range of different technologies with varying levels of information available. This will be a key challenge considering the large range of technologies and concepts for wave and tidal energy.

The SELKIE O&M and logistics model considers synergies and learning from existing tools including the DTOcean installation and O&M modules; the Wave Energy Scotland O&M model [1]; and existing tools for the offshore wind sector, particularly the LEANWIND Financial model. Feedback was gathered from key industry players to ensure the model can simulate the strategies and scenarios of most interest to industry.

The key objectives of the tool is to allow users to:

- model operations across the lifecycle considering uncertain factors e.g. weather and failures and their impact on the costs and duration of a project
- optimise the logistics required for the installation and O&M phase e.g. port, offshore vessel fleet, activity schedule etc.

This document provides an overview of the SELKIE model and a how-to-guide for setting up and using the tool. A user guide video will also be provided on the SELKIE website.

2 System requirements

The tool is compatible with windows, coded using C#. Model and code (open-source) has been made available on GitHub and can be viewed using Visual Studio community edition (free). This section details the software requirements needed to set up and run the model on a standard PC.

Download the latest version of the Visual Studio Community edition. System requirements to install Visual Studio Community 2022 are as follows:

Supported Operating Systems

- Windows 11 version 21H2 or higher: Home, Pro, Pro Education, Pro for Workstations, Enterprise, and Education
- Windows 10 version 1909 or higher: Home, Professional, Education, and Enterprise.
- Windows Server 2022: Standard and Datacenter.
- Windows Server 2019: Standard and Datacenter.
- Windows Server 2016: Standard and Datacenter.

Hardware

- 1.8 GHz or faster 64-bit processor; Quad-core or better recommended
- Minimum of 4 GB of RAM.
- Hard disk space: Minimum of 850 MB
- Video card resolution of 1920 by 1080 or higher.

Additional Requirements and Guidance

- Administrator rights are required to install or update Visual Studio.
- Read/write Excel functionality requires Microsoft Office latest version.

3 Set-up

3.1 Save model in folder

To set up the model, save the model files to a folder on your PC e.g. "Documents".

3.2 Open tool and GUI

To open the tool select the visual studio solution file "SELKIE.sln" and select "Program.cs" and the start button to load the GUI. Create a project and run a scenario following the steps outlined in section 5.

The user can also create a shortcut to the GUI by selecting the "bin" folder; "Debug" folder; right click the SELKIE application and select "send to" desktop. The user can then open the GUI directly from their desktop.

The user is advised to prepare their Metocean and Power Matrix or Power Curve input data in advance of creating their first project, following the instructions in section 3.3 and 7.

3.3 Format data

Format a Metocean data time series and a Power Matrix (if relevant) using the format tools provided and described in section 7. A sample Power Matrix and Metocean data are provided using the sample case study data described in section 5.4. A Power Curve input file template (for tidal and wind devices) has also been provided, but no formatting tool is needed as this is a standard for power curves.

4 Model overview

The Selkie model has been designed to consider the key logistics activities for the installation and O&M phase of an ocean energy array (wave and tidal). This includes:

1. Installation of the device and substructure.
2. O&M for components specified by the user.

Figure 4.1 present an overview of the SELKIE O&M and logistics model and how they interact.

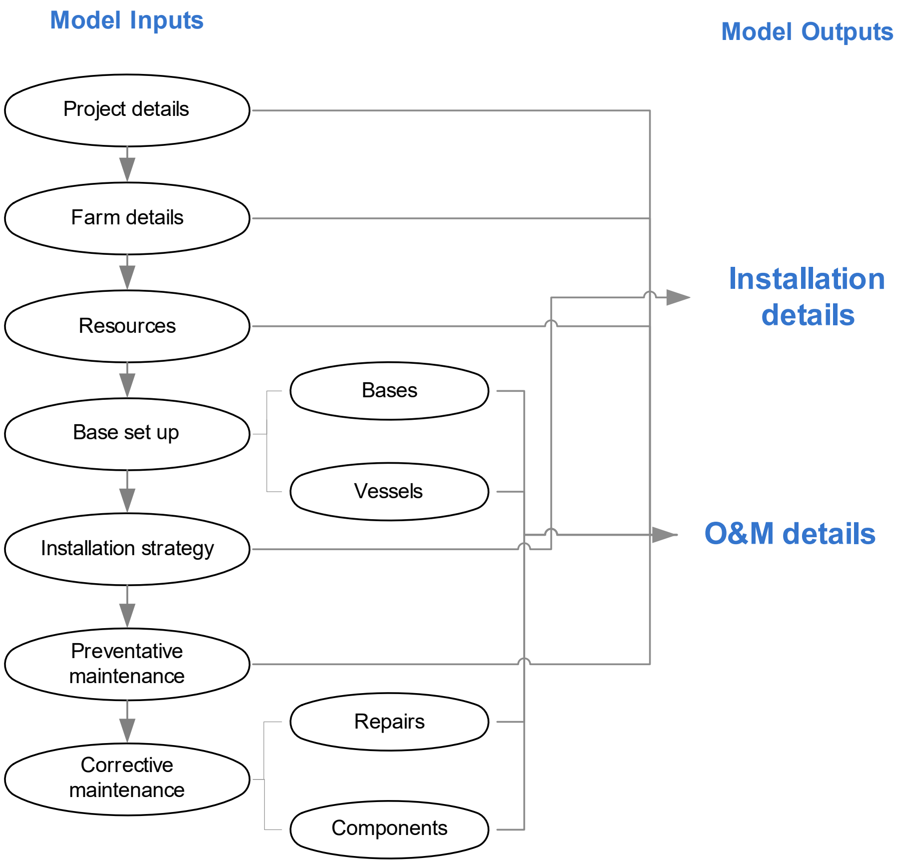


Figure 4.1 SELKIE O&M and logistics model - overview

Section 5 describes the inputs and outputs; Section 5.4 provides an overview of the processing logic.

5 SELKIE model

5.1 Inputs

The following details the inputs required by the model to run an installation and/or O&M scenario and the outputs that can be expected. When loaded (either using the shortcut installed on your desktop or by running the visual studio solution file), Figure 5.1 is the main screen the user will see.

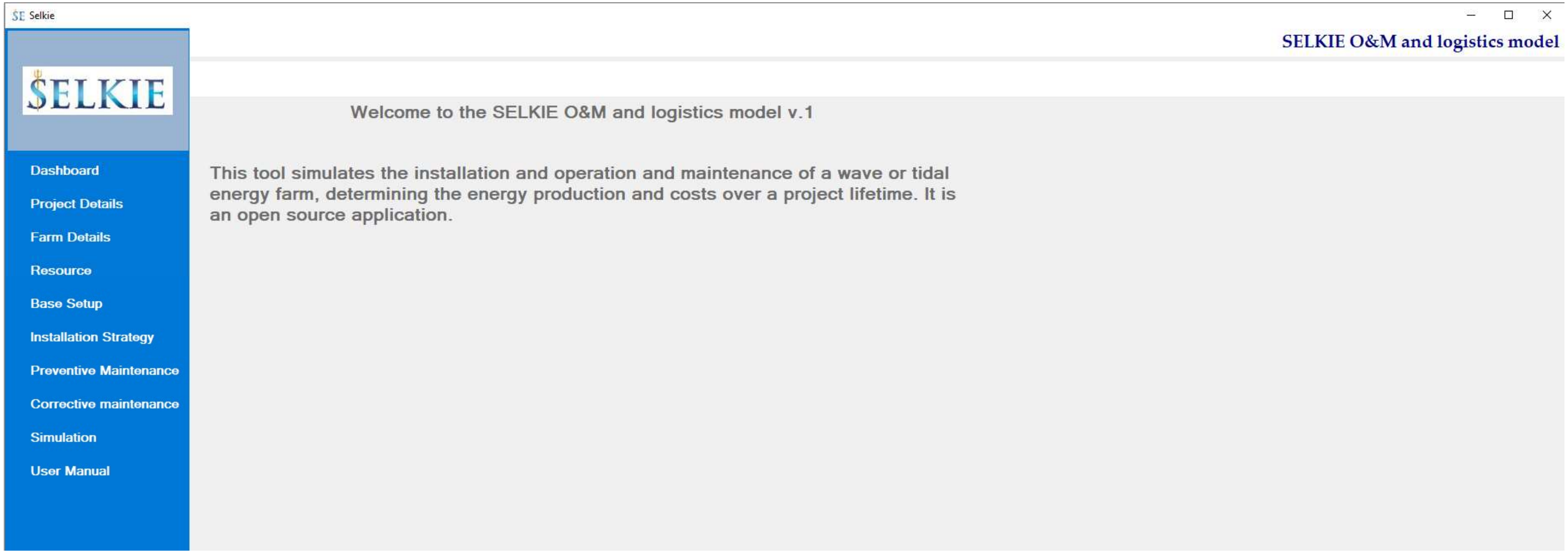


Figure 5.1 Main screen

5.1.1 Dashboard

The dashboard (Figure 5.2) allows the user to:

- Create their own project by selecting the “create own” button;

- Save inputs as a project ("Save Project") that will appear in the window list and can be loaded again at any time or deleted by selecting "Load" or "Delete" for the relevant project in the list.[1]
- Saved projects will be stored in the SELKIE roaming folder "C:\Users\username\AppData\Roaming\Selkie\Projects" (automatically created when you first run the model). They can then be edited directly using the excel file or the GUI, ensuring the user saves the project after changes.

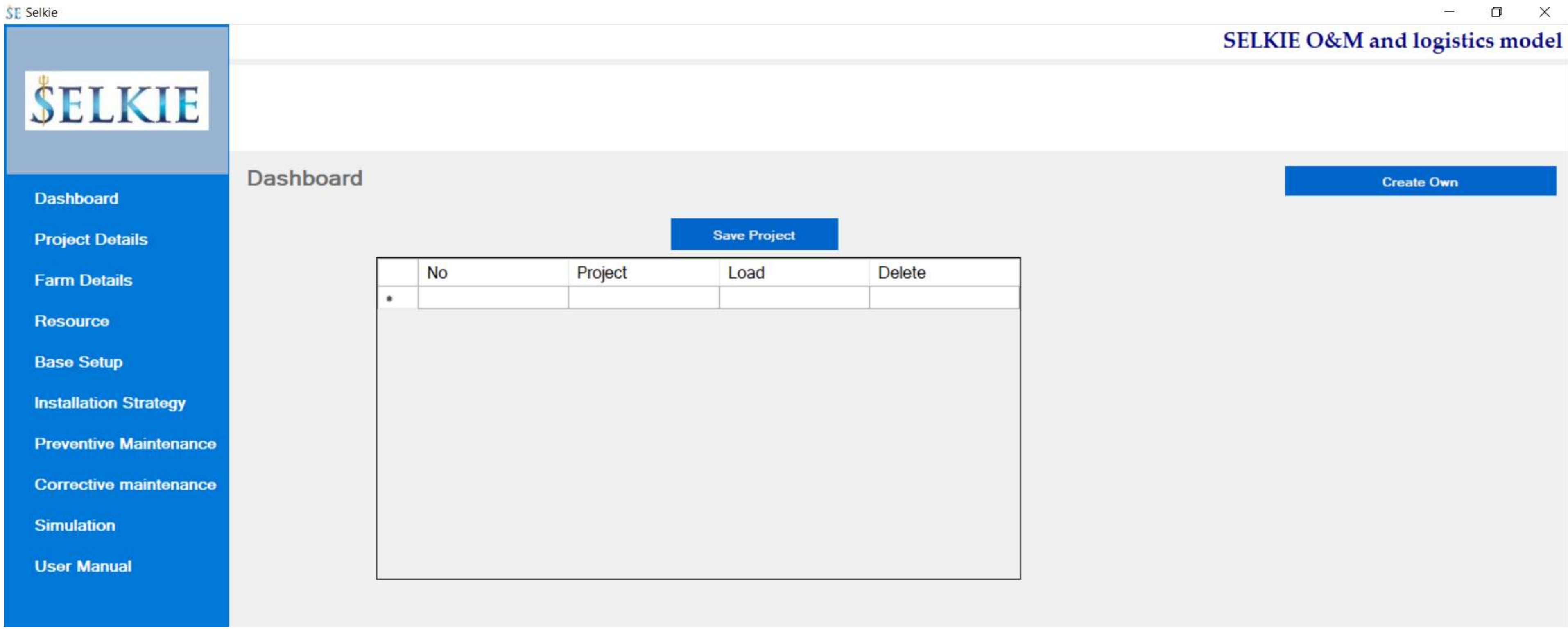


Figure 5.2 Dashboard

5.1.2 Project details

To begin a new project, the user should select the tabs on the left in sequence starting with "Project Details." This will display the screen shown in Figure 5.3. Figure 5.4 provides details of each input category including the unit, description, and the data limits.

[1] If the user creates their own project but does not save it, then their inputs will be lost if they close the tool and re-open.

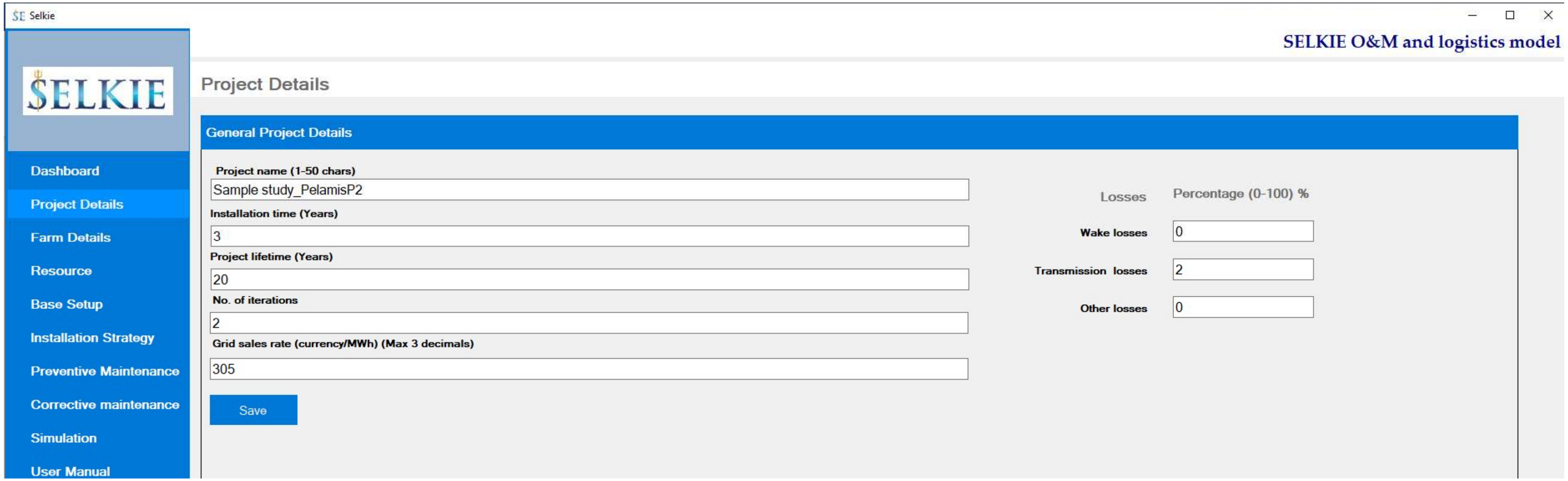


Figure 5.3 Project details – model screen

Field	Unit	Description	Data limits
Project details			
Project name	text	Unique description of scenario e.g. Monitor validation case-study	Min 1 - max 200 characters
Installation time	years	Expected number of years to install array	Min 0 - max 10 years
Project lifetime	years	Lifetime of the project	Min 0 - max 60 years
No. of iterations	integer	Specify number of iterations of the scenario to process	Min 1 - max 5000 iterations
Grid sales rate	€/MWh	What the wind farm operator is paid for electricity generated	Min 0.00 - max 1000.00
Wake losses	%	Losses due to presence of devices in the wind/wave/current flow	Min 0.00 - max 100%
Transmission losses	%	Energy losses due to the transmission of electricity over long distances (e.g. via cabling)	Min 0.00 - max 100%
Lost production due to downtime of elements not simulated	%	Represents the availability of elements not considered in O&M simulation e.g. electrical infrastructure	Min 0.00 - max 100%

Figure 5.4 Project details - inputs

Notes:

- Installation time refers to the expected number of years it will take to install an array. If a scenario requires additional time, it will extend this estimate automatically. However, selecting a realistic timeframe will help speed up scenario processing.
- It is important to always click the “save” button before you leave a tab in the model or any changes will be lost.
- The number of iterations refers to the number of Monte Carlo simulations the model will complete. For each iteration, the model will vary the failure occurrence and weather data, allowing the user to see the impact of uncertainty in these key areas on results which will be displayed per iteration and an average across all simulations.

5.1.3 Farm Details

Selecting “Farm Details” will display the screen shown in Figure 5.5. Figure 5.6 provides details of each input category including the unit, description and the data limits.

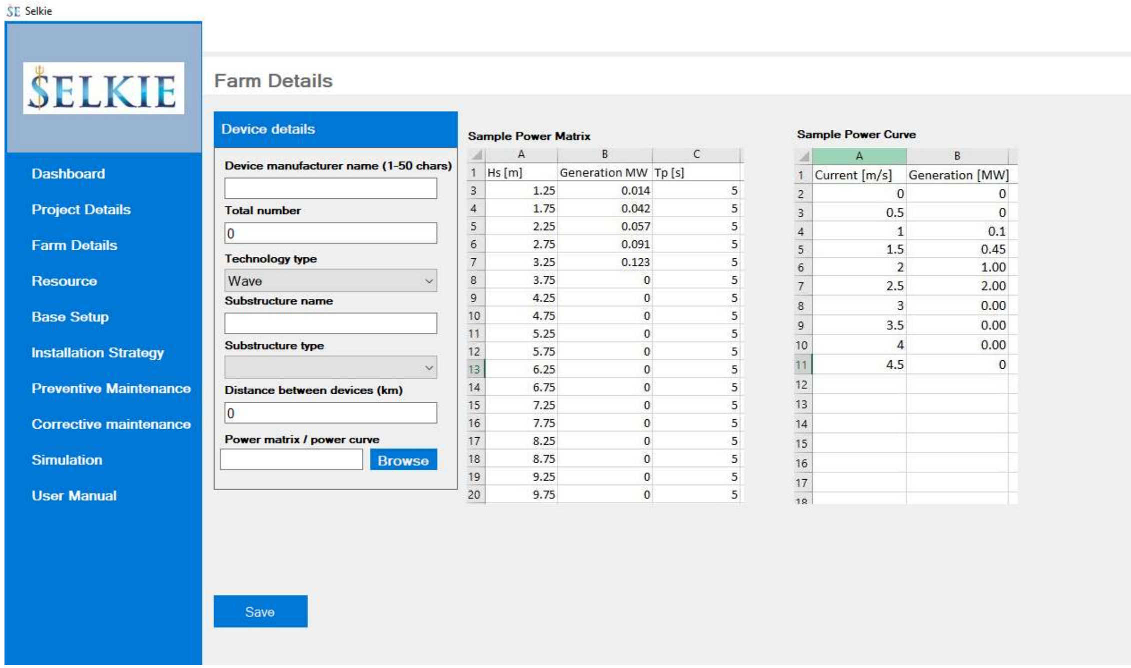


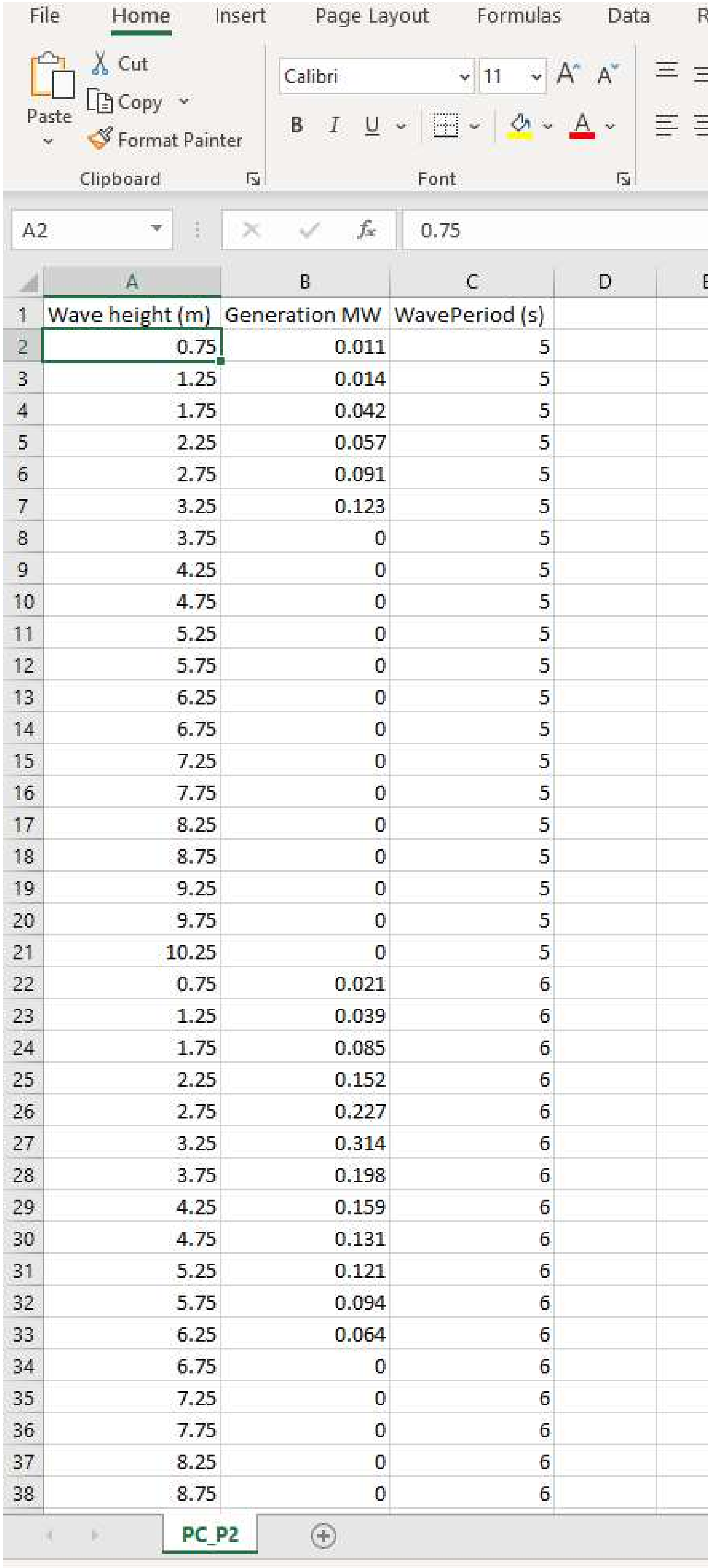
Figure 5.5 Farm Details - model screen

Field	Unit	Description	Data limits
Farm details			
Device manufacturer name	text	Name of manufacturer (reference only)	Min 0 - max 200 characters
Total number	integer	No. of devices in the wind farm	Min 1 - max 500
Technology type	select	Specify if this is wind, wave or tidal	Dropdown list
Specify power matrix/power curve	integer	Insert in Power calculation tab	Insert in powe
Substructure name	text	Name of substructure (reference only)	Min 0 - max 200 characters
Substructure type	select	Type of substructure fixed/floating	Dropdown list
Distance between devices	km	Specify distance to travel between devices in farm	Min 0.00 - max 1000.00

Figure 5.6 Farm details – inputs

The power matrix or power curve for wave or tidal respectively should be input by creating in excel file in the format shown in Figure 5.5. The user is advised (but not required) to save these in the SELKIE roaming folder “C:\Users\username\AppData\Roaming\Selkie\PC” (created when you first run the model). The file should then be selected in the model using the “Browse” button.

While the power curve is simply formatted as a list in excel of the current speed (m/s) and the corresponding power output (kW or MW); the power matrix is currently required in an unconventional input format with 3 columns listing the significant wave height (m); Power output (kW or MW); and wave period (s). An example matrix is shown in Figure 5.7 and is included with the sample case study. A small tool has been created (compiled in Matlab), to help convert data from a standard power matrix into the SEKLIE model excel format required. Further details are provided in Section 7.



	A	B	C
1	Wave height (m)	Generation MW	WavePeriod (s)
2	0.75	0.011	5
3	1.25	0.014	5
4	1.75	0.042	5
5	2.25	0.057	5
6	2.75	0.091	5
7	3.25	0.123	5
8	3.75	0	5
9	4.25	0	5
10	4.75	0	5
11	5.25	0	5
12	5.75	0	5
13	6.25	0	5
14	6.75	0	5
15	7.25	0	5
16	7.75	0	5
17	8.25	0	5
18	8.75	0	5
19	9.25	0	5
20	9.75	0	5
21	10.25	0	5
22	0.75	0.021	6
23	1.25	0.039	6
24	1.75	0.085	6
25	2.25	0.152	6
26	2.75	0.227	6
27	3.25	0.314	6
28	3.75	0.198	6
29	4.25	0.159	6
30	4.75	0.131	6
31	5.25	0.121	6
32	5.75	0.094	6
33	6.25	0.064	6
34	6.75	0	6
35	7.25	0	6
36	7.75	0	6
37	8.25	0	6
38	8.75	0	6

Figure 5.7 Power matrix excel format - example based on Pelamis P2 [2]

5.1.4 Resource

Figure 5.8 is a screenshot of the "Resource" tab. Figure 5.9 provides further details of each input. A yearly timeseries of Metocean data must be included for the model to operate. Based on input data, the model randomly mixes up the years of data per iteration e.g. bootstrap method to generate a synthetic times series for Monte Carlo simulations (see 5.1.2 for more details).

Ideally the user will provide at least 10 years of data in an excel file formatted as shown in Figure 5.8 including the Hour; wind speed (m/s); significant wave height Hs (m); wave period (Tp/Te as relevant) (s); and current speed (m/s). If the user does not have an element e.g. current speed as they are looking at wave energy, they should input a column of zeros. Data should be split into tabs by year, always starting with the year 2000 irrespective of the actual data year. An example file of a 20 year timeseries in included with the sample case study using data for Farrpoint generated by the Wave Energy Scotland model [1]. A small tool has been created (compiled in Matlab), to help convert data from a standard power matrix into the SEKLIE model excel format required. Further details are provided in Section 7.

Once formatted and saved in a folder, the user selects "browse" to identify the excel file of Metocean data. The user is advised (but not required) to save their Metocean data files in the SELKIE roaming folder "C:\Users\username\AppData\Roaming\Selkie\WW" (created when you first run the model).

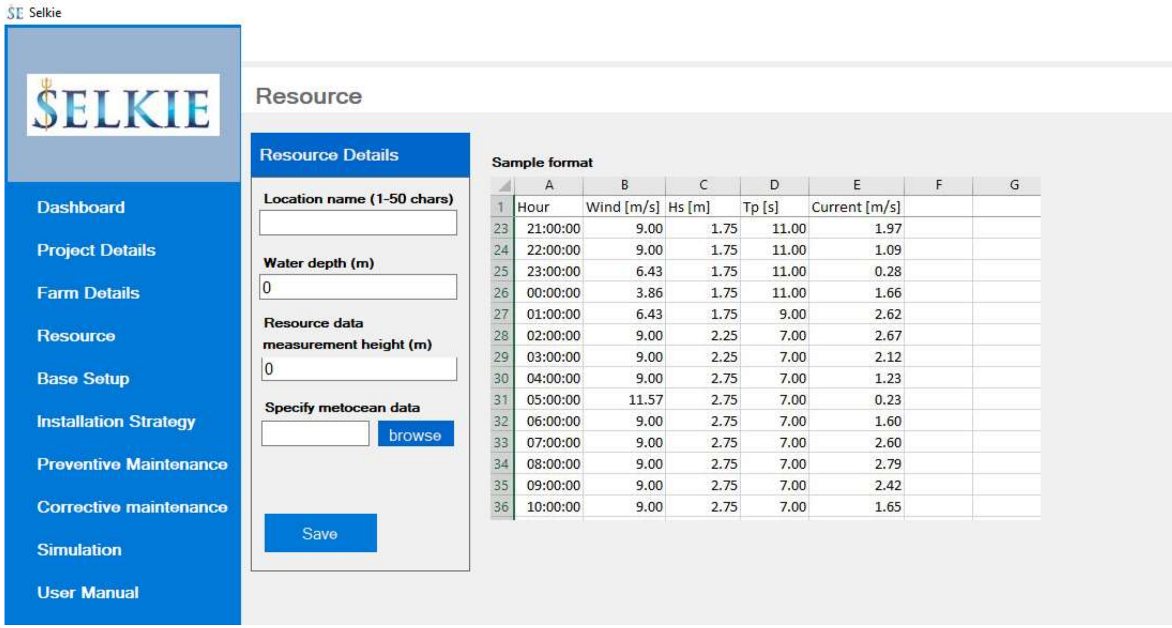


Figure 5.8 Resource - model screen

Field	Unit	Description	Data limits
Resource details			
Location name	text	Location for resource data (reference only)	Min 0 - max 200 characters
Water depth	m	Water depth at site (reference only)	Min 0.00 - max 1000.00
Resource data measurement height	m	Height at which resource data measured (wind = height above sea-level; tidal - height above seabed) (reference only)	Min 0.00 - max 1000.00
Specify metocean data	integer	Insert in Metocean data tab	Insert in m

Figure 5.9 Resource – inputs

5.1.5 Bases

The user can specify up to 3 different bases for activities by selecting the "Base Setup" and then "Bases" tab, and "Add Bases" as per Figure 5.10 and inputting the data requested in Figure 5.11. Input requirements are further detailed in Figure 5.12.

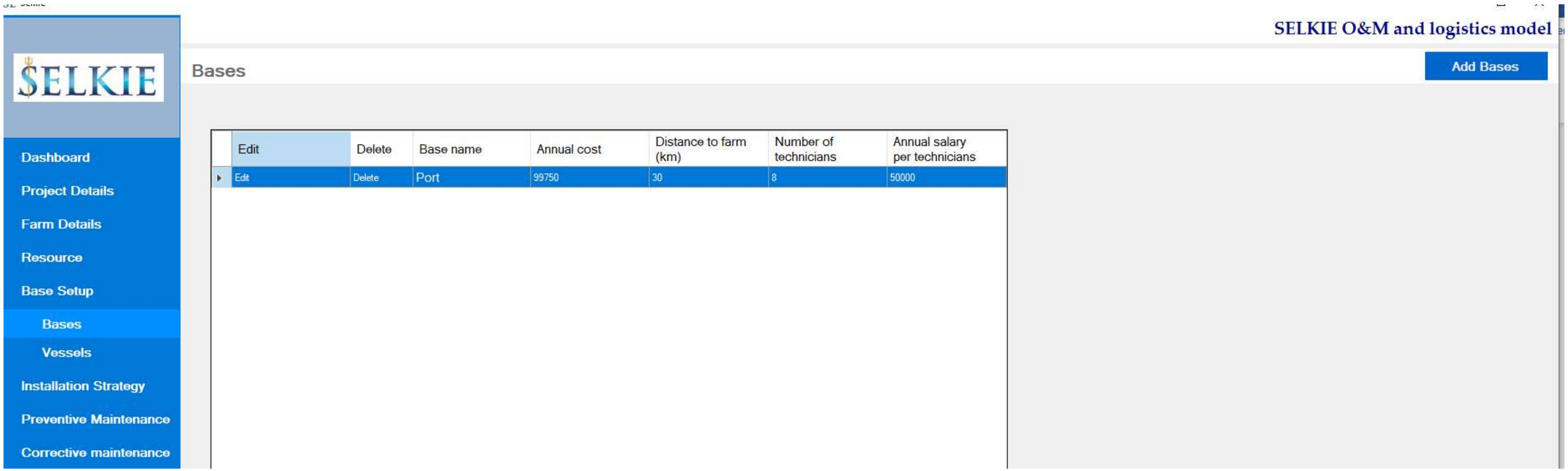


Figure 5.10 - Base Setup - Bases - model screen

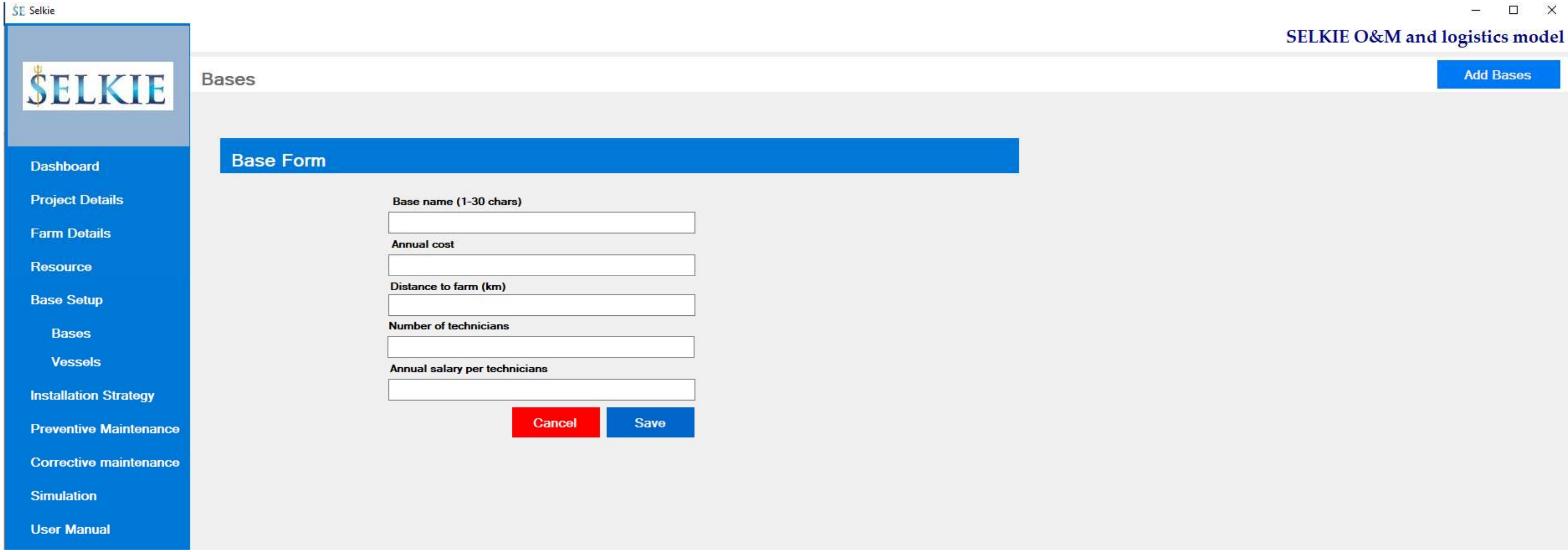


Figure 5.11 Add Bases - model screen

Field	Base name	Annual cost	Distance to farm	Number of technicians	Annual salary per technician
Unit	Text	€	km	integer	€
Description	Name of base	Annual cost associated with maintaining/leasing an onshore base	Distance of the base to the wind farm. Used to calculate vessel transit times.	Number of full-time technicians employed at the base available to carry out repairs.	Used to calculate the cost of technicians.
Data limits	Min 1 - max 200 characters	Min 0 - max 10000000000	Min 0.00 - max 1000.00	Min 0 - max 10000	Min 0 - max 1000000
Input data					
Input data					
Input data					
Input data					
Input data					
Input data					

Figure 5.12 Bases – inputs

Notes:

- It is important that the number of technicians specified here is enough to carry out the tasks undertaken from that base. For example if the user says it will take 6 technicians from Base A to install a device but they have only specified that 2 technicians are available at Base A, then the task cannot be completed.

5.1.6 Vessels

The user can specify up to 6 types of vessels that can be used for activities (installation and/or O&M). Figure 5.13-Figure 5.16 show the model screen inputs for adding a purchased and a rented vessel type. Figure 5.17 provides further details of the inputs.

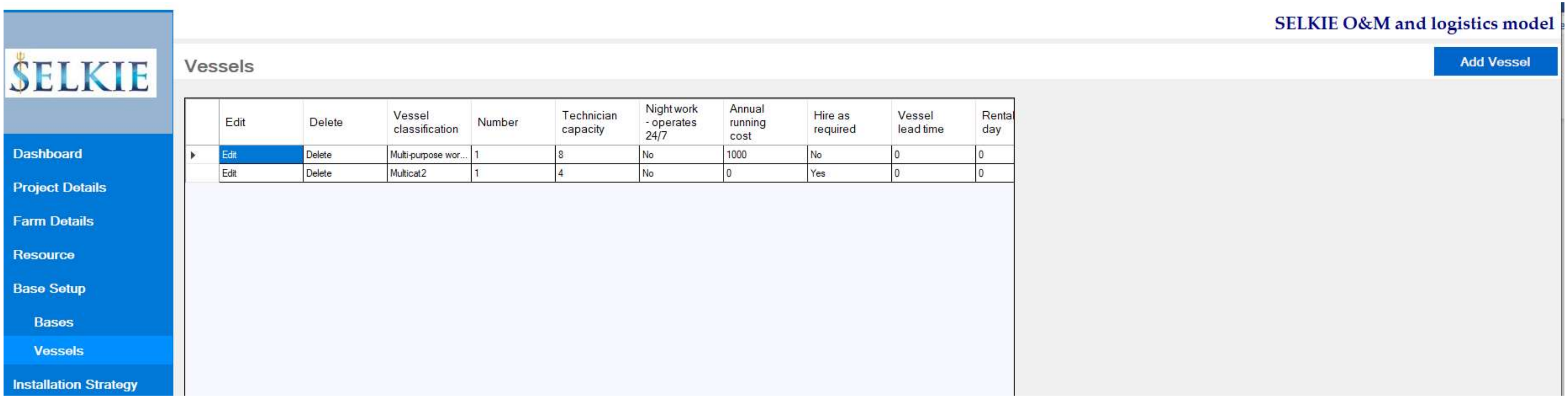


Figure 5.13 Base Setup - Vessels - model screen

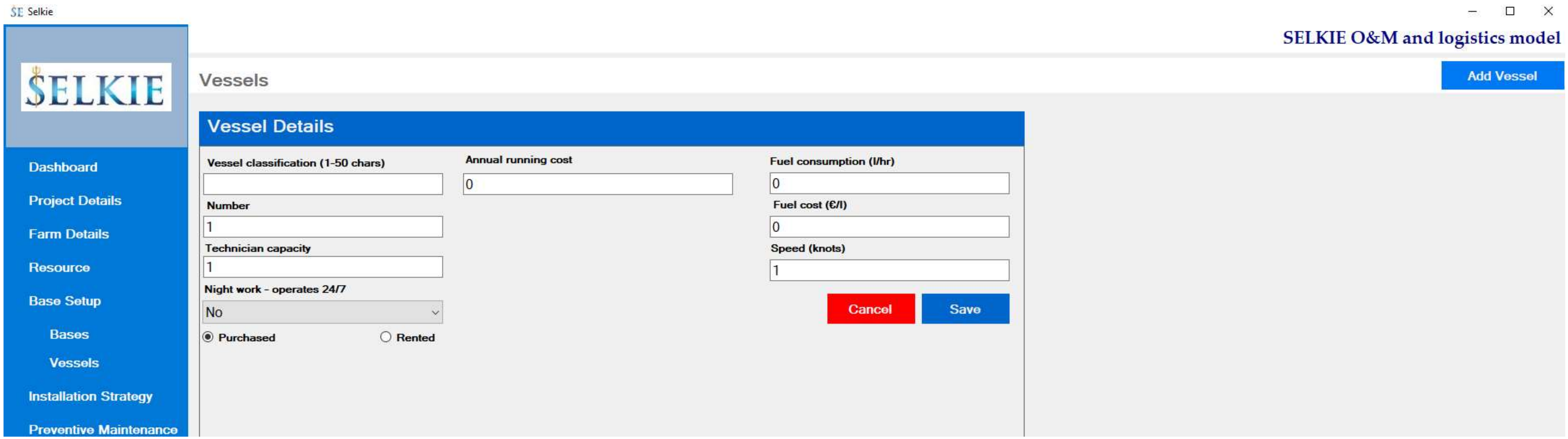


Figure 5.14 Add purchased Vessel - model screen

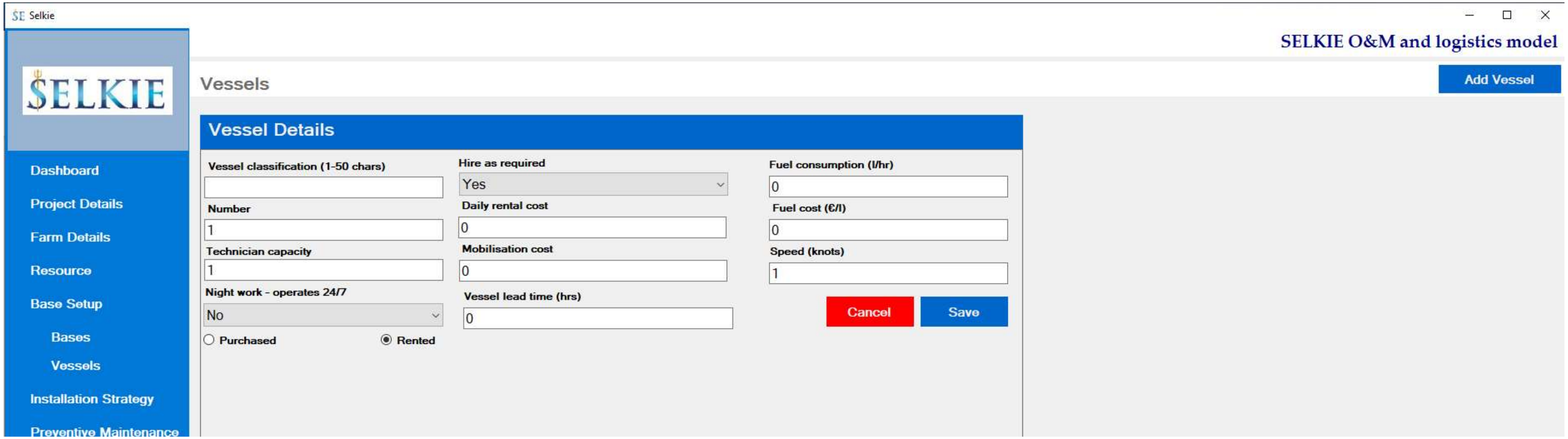


Figure 5.15 Add vessel hire as required – model screen

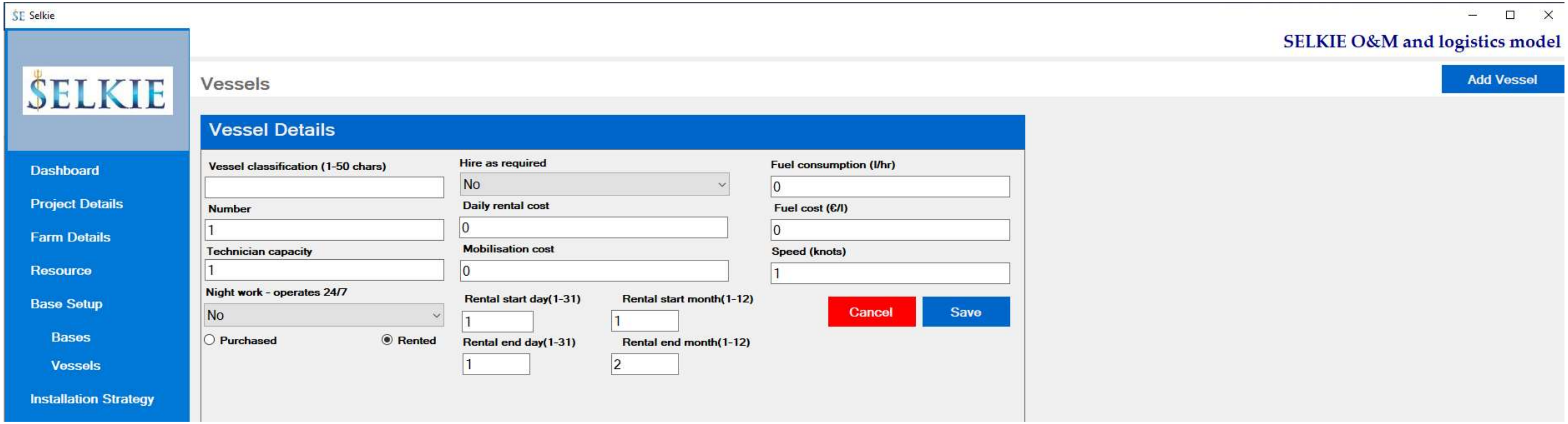


Figure 5.16 Add rented vessel - model screen

Field	Vessel classification	Number	Technician capacity	Night work	Purchased/rented	Annual running cost	Hire as required	Vessel lead time	Annual rental start month	Annual rental end month	Daily rental cost	Mobilisation cost	Fuel consumption	Fuel cost	Speed
Unit	text	integer	integer	select	select	€	select	hrs	select	select	€	€	l/hr	€/l	knots
Description	Vessel type	Number of vessels of this type available either purchased or available to rent	Number of technicians vessel can carry	Can vessel undertake work at night *(only O&M model)*	Specify whether vessel is purchased or chartered	If purchased, annual cost of maintaining vessel	*NB option only available for O&M activites.* If rented, specify if rented for a season or hire as required. Each time vessel hired, it is hired for the duration of an activity.	If hire as required, time needed for vessel to arrive at port.	If rented for a season, month that rental starts each year	If rented for a season, month that rental ends each year	Daily cost of renting vessel either for a season or hire as required	Cost of mobilising vessel if rented	Vessel fuel consumption	Cost per litre	Vessel transit speed
Data limits	Min 1 - max 200 characters	Min 1 - max 10	Min 1 - max 1000	Dropdown list	Dropdown list	Min 0 - max 1000000000	Dropdown list	Min 0-max 10000	Dropdown list	Dropdown list	Min 0 - max 1000000000	Min 0 - max 1000000000	Min 0.00 - max 100000.00	Min 0.00 - max 1000000.00	Min 0.01 - max 1000.00
Input	Multi-purpose workboat	1	12	No	Rented		No		May	Sep	4000	5000	0	0	5
Input															
Input															
Input															
Input															
Input															

Figure 5.17 Vessels – inputs

Notes:

- While only 6 vessel classifications can be added, an unlimited number of each vessel type can be specified e.g. you can have 1 tug or 3 workboats available to the project.
- Nightwork refers to whether a vessel can undertake work any time of day or only during daylight hours (currently assumed to be from 7am-7pm).
- The user should be careful if day time work is selected when the travel time takes a large portion of the 12 hours daytime. In this case, several days will be used to complete tasks adding considerably to vessel hire and fuel costs.
- Vessels can be purchased with an annual running cost; hire as required with a lead time to consider any wait time before a vessel can start work; or rented for a season.
- If rented a mobilisation cost will be added annually.
- It is important that the user ensures the technician capacity is large enough for any tasks assigned to it. For example, if it requires 6 technicians to install a device but the selected vessel can only carry 2, the task cannot be completed.

5.1.7 Installation strategy

The user can consider the installation of the substructure and device. Figure 5.18 shows the main model screen for Installation Strategy inputs while Figure 5.19 shows the form to input the device or substructure installation task details. Figure 5.20 provides further information on input requirements. For any activity the user can specify the base where the vessel, technicians and equipment will come from and the vessel type required to complete that activity. They can also specify the weather restrictions for that operation. For example, an offshore operation that takes 5 hours can only be completed where the significant wave height (Hs, m) is under the wave height limit specified.

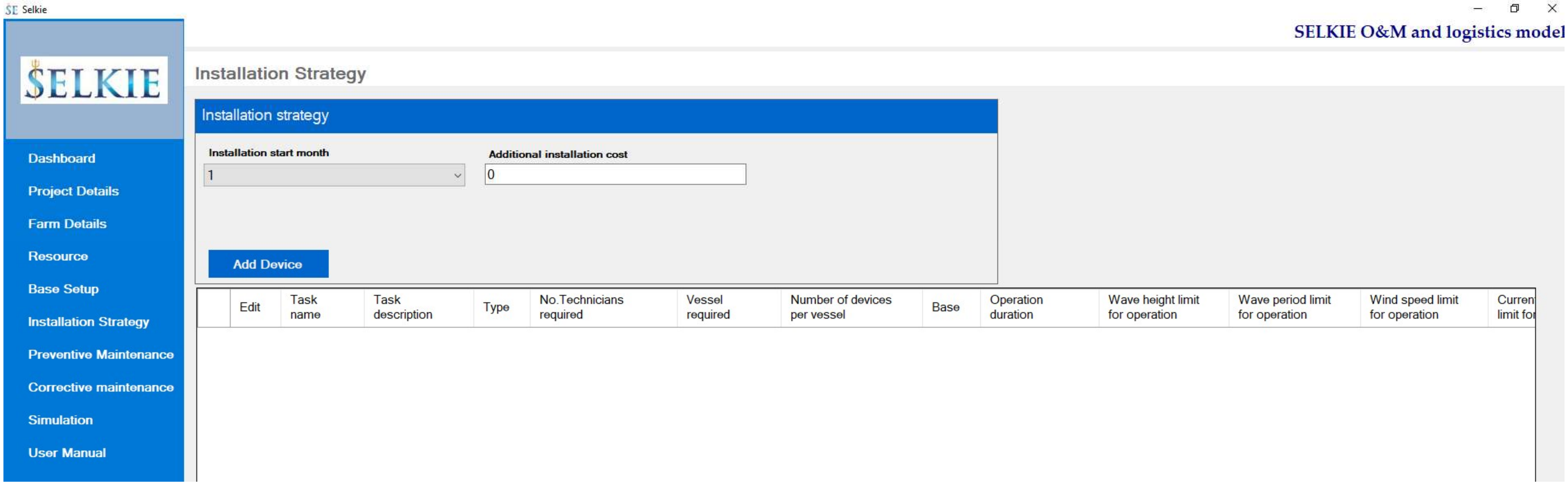


Figure 5.18 Installation Strategy - model screen

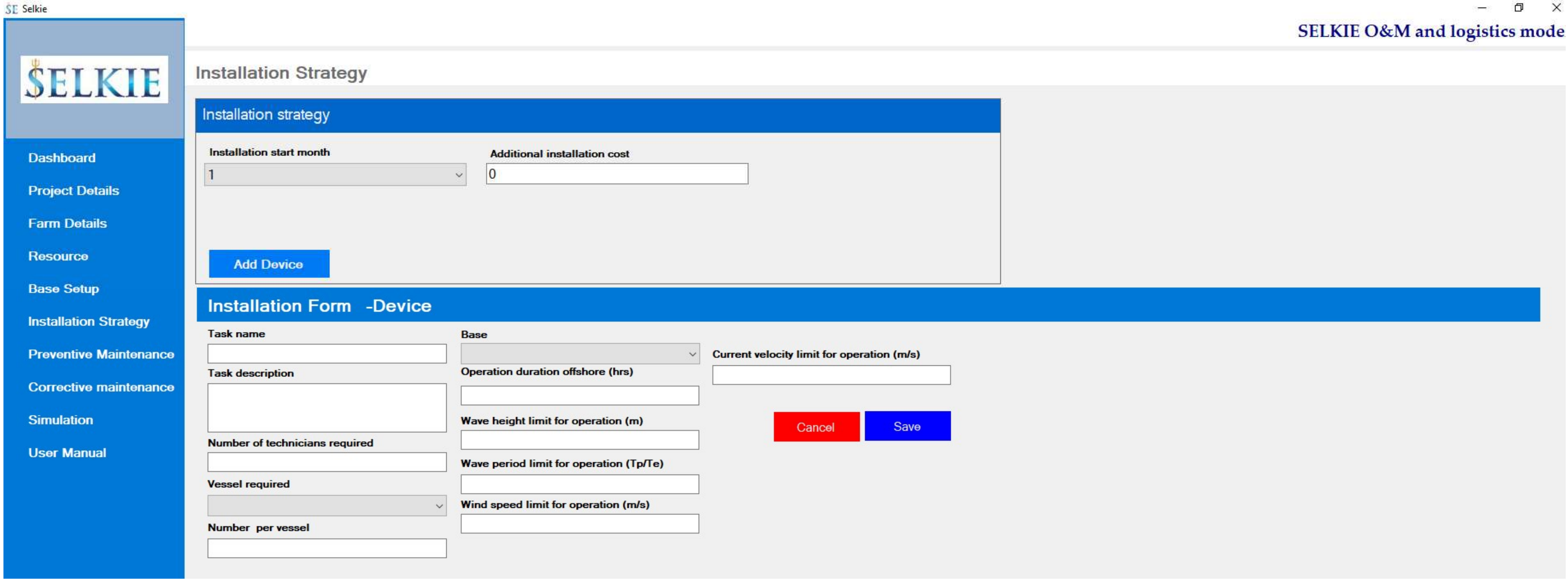


Figure 5.19 Installation form - device/substructure - model screen

Field	Unit	Description	Data limits	Input data
Installation start month	integer	Specify month of year installation activities to commence	Min 1 - max 12	
Additional installation costs	€	Cost to install elements not included in simulation e.g. electrical infrastructure. Added to final total	Min 0 - max 10000000000	

Field	Task name	Task description	No. of technicians required	Vessel required	Number of devices per vessel	Base	Operation duration	Wave height limit for operation	Wave period limit for operation	Wind speed limit for operation	Current velocity limit for operation
Unit	select	text	integer	select	integer	select	hrs	m	s	m/s	m/s
Description	Specify task name (for reference only)	Additional details of operation (for reference only)	No. of technicians required to carry out the operation.	Select from vessels specified	No. of devices a vessel can carry and will be installed per trip	Select base the vessel comes from	Time taken to complete installation per device	This is a general wave height limit for completing the operation	This is a general wave period limit for completing the operation	General wind speed limit for completing the operation	General current velocity limit for completing the operation
Data limits	Min 0 - max 200 characters	Min 0 - max 1000 characters	Min 0 - max 100	Dropdown list	Min 1 - max 100	Dropdown list	Min 0.01 - max 1000.00	Min 0.00 - max 100.00	Min 0.00 - max 100.00	Min 0.00 - max 100.00	Min 0.00 - max 100.00
Input											

Figure 5.20 Installation Strategy – inputs

Notes:

- The model currently simulates the installation of a substructure and device. If the user wishes to consider balance of plant in the outputs, they can include an estimated cost under “Additional installation costs”.
- It is important to note that the weather restrictions specified for any task will be applied by the model for the operation offshore but also the vessel transit to and from site. For example, if the wave height restriction to install the device is set to 1m Hs, wave period is 8s Tp and wind speed is 14m/s; installation takes 2 hours; and transit is 30 mins, the model must find a window length of 3 hours where the weather is within the specified limits.
- The number per vessel is the number of devices or substructures that can be carried on the vessel per trip. If the user specifies 2, then the model will increase the operation duration by 2 to consider the time required. The weather window needed will also extend accordingly assuming all devices need installation in 1 trip.
- It should also be noted that if installation takes more than 12 hours, the default technician shift, the model will assume that 2 crews are required to complete the task. Therefore, the user should be careful to ensure the vessel assigned has capacity for 2 crews and that there are enough technicians available at the base to be assigned. Otherwise, the task cannot be completed.

5.1.8 Preventive maintenance

The user can simulate 2 preventive maintenance tasks using the input screens shown in Figure 5.21 and Figure 5.22. Inputs are further detailed in Figure 5.23.

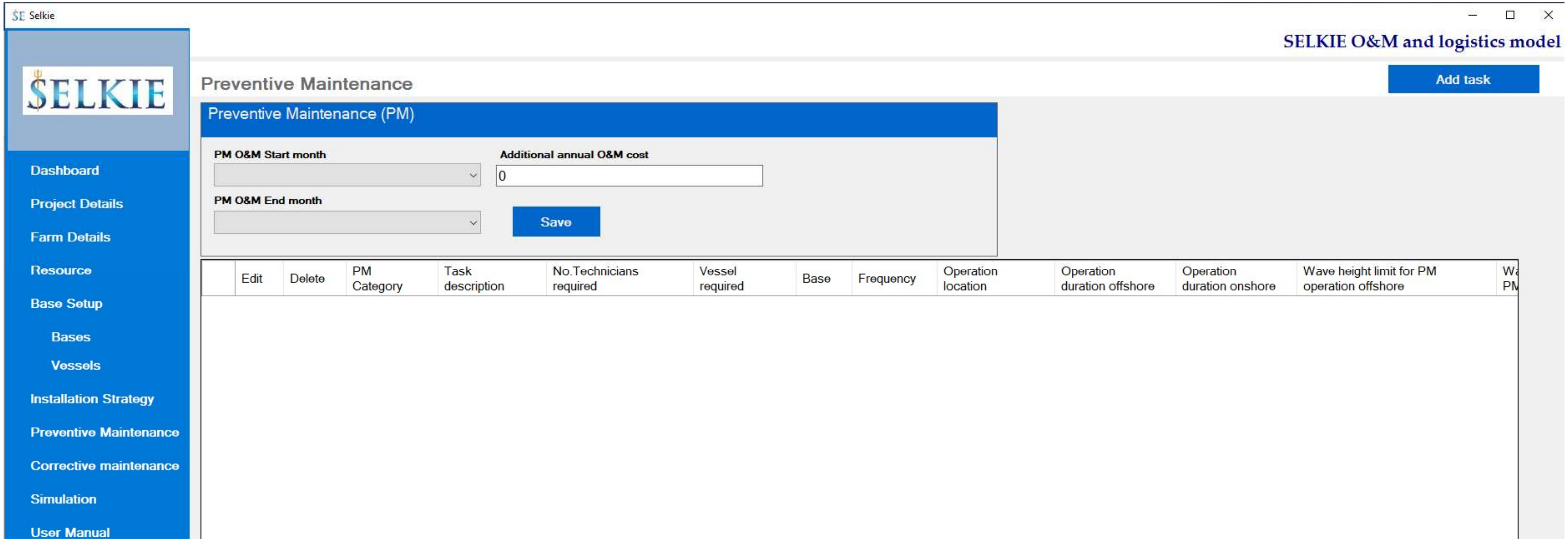


Figure 5.21 Preventive Maintenance - model screen

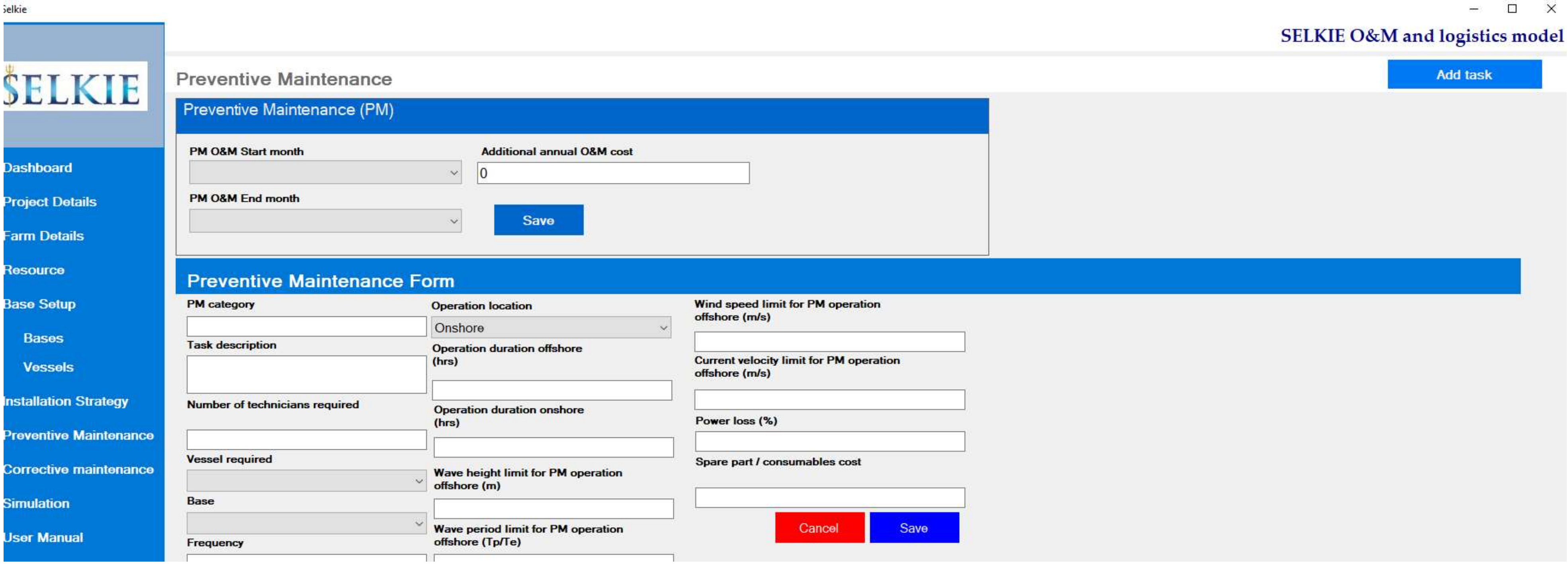


Figure 5.22 Preventive Maintenance - Add Task - model screen

Field	Unit	Description	Data limits
PM O&M start month	select	Specify season start month for PM to commence	select
PM O&M End month	select	Specify season start month for PM to end	select
Additional annual O&M costs	€	Cost to maintain elements not included in simlulation e.g. electrical infrastructure. Added to annual total	Min 0 - max 10000000000

Field	PM category	Task description	No. of technicians required	Vessel required	Base	Frequency	Operation location	Operation duration offshore	Operation duration onshore	Wave height limit for PM operation offshore	Wave period limit for operation offshore	Wind speed limit for PM operation offshore	Current velocity limit for PM operation offshore	Power loss	Spare part/consumables cost
Unit	text	text	integer	select	select	integer	select	hrs	hrs	m	s	m/s	m/s	%	€
Description	Name of Preventive Maintenance Activity	Additional details of repair (for reference only)	No. of technicians required to carry out the operation.	To specfiy details under vessels/equipment	Select base the vessel comes from and/or repair occurs	Specify frequency of PM task per year.	Does the operation take place offshore or must the device be towed to shore for maintenance	Operation duration offshore e.g. if operation onshore this could represent the time required to detach the device to tow to shore	Operation duration onshore if applicable	This is a general wave height limit for completing PM	This is a general wave period limit for completing PM	General wind speed limit for completing PM	General current velocity limit for completing PM	Power loss when PM is being undertaken i.e. if the turbine is fully stopped until the repair is complete, the power loss is 100 %	Cost of any spare parts/consumables necessary for operation
Data limits	Min 1 - max 200	Min 0 - max 200	Min 0 - max 100	Dropdown list	Dropdown list	Min 0.01 - max 100.00	Dropdown list	Min 0.00 - max 1000.00	Min 0.00 - max 1000.00	Min 0.00 - max 100.00	Min 0.00 - max 100.00	Min 0.00 - max 100.00	Min 0.00 - max 100.00	Min 0 - max 100%	Min 0 - max 1000000000
Input															
Input															
Input															
Input															
Input															
Input															

Figure 5.23 Preventive Maintenance - inputs

Notes:

- Preventive maintenance can be undertaken all year round, but the user can also specify a season to ensure it is only taken e.g. when the weather is likely to be good and/or production is likely to be low.
- Similarly to installation, the user can add additional costs annually for maintenance to consider items not currently included in the scope of this model such as additional operational costs.
- The user specifies the task similarly to an installation operation with a few additional items including the frequency of occurrence, operation location, power loss and spare part/consumables cost.
    - Frequency determines how often a PM task is undertaken e.g. 1 means annually; 0.1 means every 10 years for a 20 year project.

- Operation location refers to whether maintenance occurs on or offshore. If it is onshore, the user must also specify the onshore operation duration. The task will be broken down into 3 separate consecutive operations: retrieve device; onshore maintenance; and redeploy device. No weather restrictions apply during the onshore maintenance operation.
- Power loss refers to whether the device is turned off for maintenance or whether it can continue producing energy. If the operation is onshore, the model will automatically make this 100%.
- The user can add a cost of maintenance for consumables (e.g. oil) or spare parts required.

5.1.9 Corrective Maintenance

Corrective maintenance tasks can be specified by completing the “Repairs” and “Components” tabs. The Repairs are added first, detailing a list of repair activities including their operation location, the vessel required, the base etc.

Then a list of components is added, the number per device, specifying their annual failure rate, and linking each failure to a repair. It is hoped that this will reduce the number of inputs the user has to make since it is likely a number of failures will require the same response in terms of repair operation.

5.1.9.1 Repair Categories

Figure 5.24 and Figure 5.25 display the screens shown when you select the “Repairs” tab while Figure 5.26 provides further detail for each input required.

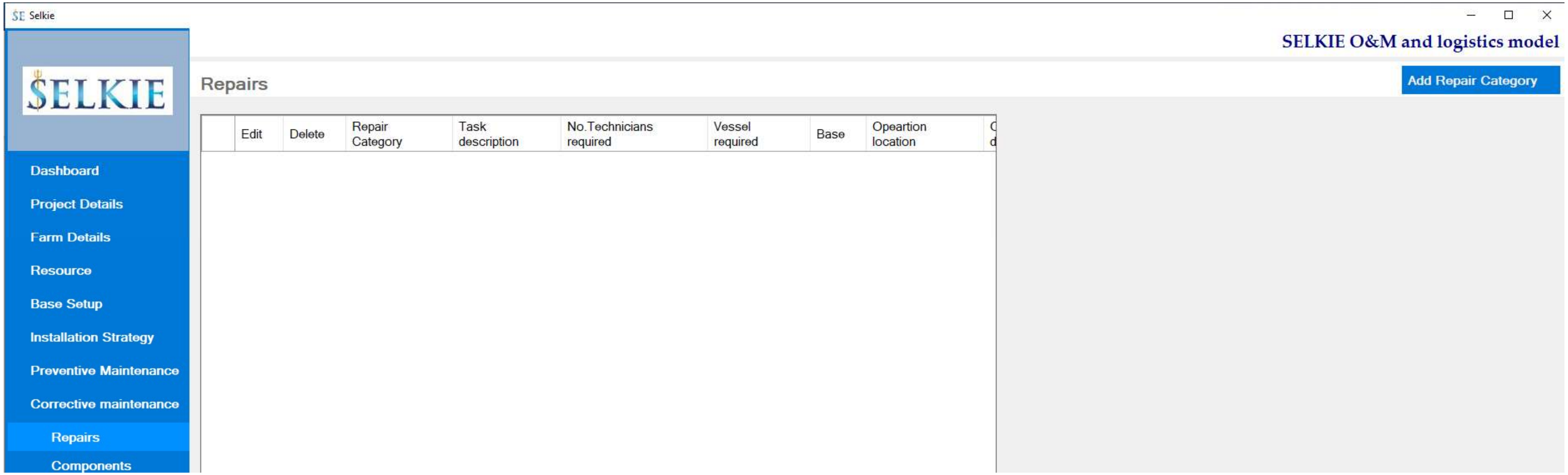


Figure 5.24 Repairs - model screen

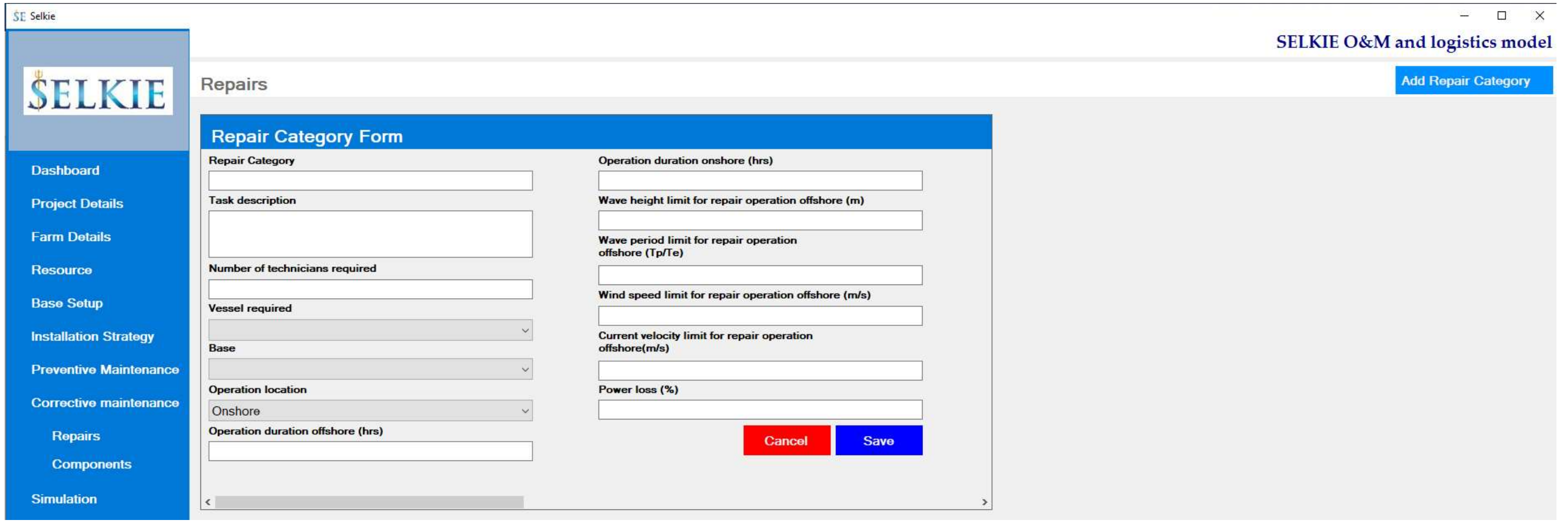


Figure 5.25 Add Repair Category - model screen

Field	Task name	Task description	No. of technicians required	Vessel required	Base	Operation location	Operation duration offshore	Operation duration onshore	Wave height limit for repair operation offshore	Wave period limit for operation offshore	Wind speed limit for repair operation offshore	Current velocity limit for repair operation offshore	Power loss
Unit	text	text	integer	select	select	select	hrs	hrs	m	s	m/s	m/s	%
Description	Name of repair	Additional details of repair (reference only)	No. of technicians required to carry out the operation.	To specfiy details under vessels/equipment	Select base the vessel comes from and/or repair occurs	Does the repair take place offshore or must the device be towed to shore for maintenance	Operation duration offshore e.g. if operation onshore this could represent the time required to detach the device to tow to shore	Operation duration onshore if applicable	This is a general wave height limit for completing operation offshore	This is a general wave period limit for completing operation offshore	General wind speed limit for completing operation offshore	General current velocity limit for completing operation offshore	Power loss when PM is being undertaken i.e. if the turbine is fully stopped until the repair is complete, the power loss is 100 %
Data limits	Min 1 - max 200	Min 0 - max 200	Min 0 - max 100	Dropdown list	Dropdown list	Dropdown list	Min 0.00 - max 1000.00	Min 0.00 - max 1000.00	Min 0.00 - max 100.00	Min 0.00 - max 100.00	Min 0.00 - max 100.00	Min 0.00 - max 100.00	Min 0 - max 100%
Input													
Input													
Input													
Input													
Input													
Input													
Input													
Input													
Input													
Input													

Figure 5.26 Repair categories – inputs

5.1.9.2 Components

Figure 5.27 and Figure 5.28 display the model screen when you select the "Components" tab and "Add Components". Figure 5.29 provides further detail about the inputs required.

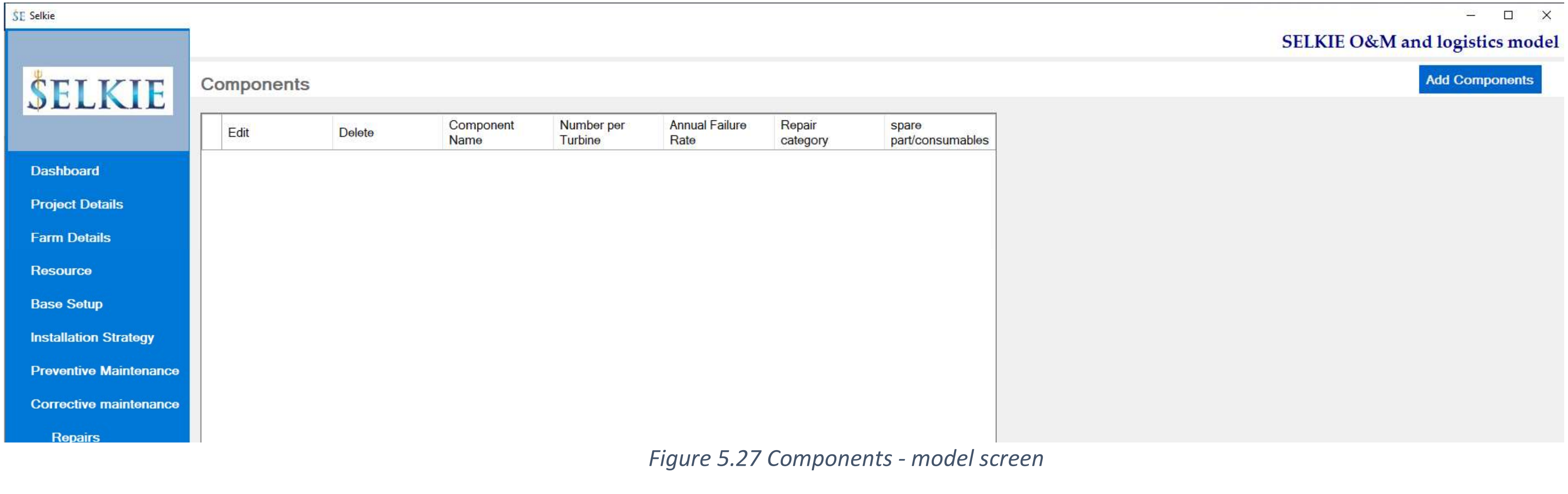


Figure 5.27 Components - model screen

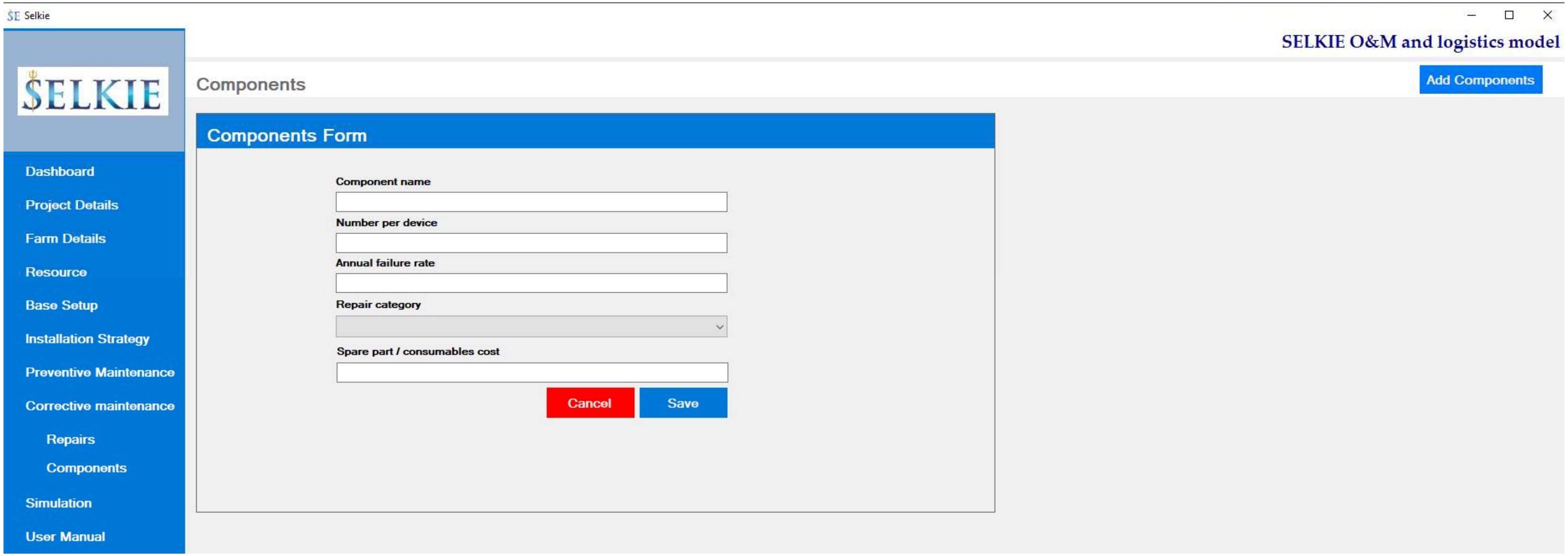


Figure 5.28 Add Components - model screen

Field	Component name	Number per device	Annual failure rate	Repair Category	Spare parts/consumables costs
Unit	text	integer	integer	select	€
Description	Name of component	Number of components on each device	Annual failure rate of component. E.g. if the component is expected to fail once in five years, the annual failure rate is 0.2.	Apply a repair defined in the previous section to the component	Cost of spares/consumables necessary for operation
Data limits	Min 1 - max 200	Min 1 - max 10	Min 0.01 - max 100.00	Dropdown list	Min 0 - max 1000000000
Input					
Input					

Figure 5.29 Components - inputs

5.2 Simulation

Once you have loaded a project or input and saved a new project, the user can select the “Simulation” tab as shown in Figure 5.30 and select the “Start Simulation” button. This will lock the project to avoid further changes being made while a scenario is in process and check the inputs to ensure nothing vital is missing. A progress bar will then show the model simulating installation tasks and O&M tasks, providing time taken and progress message updates as well as identifying how many iterations out of the max specified have been completed.

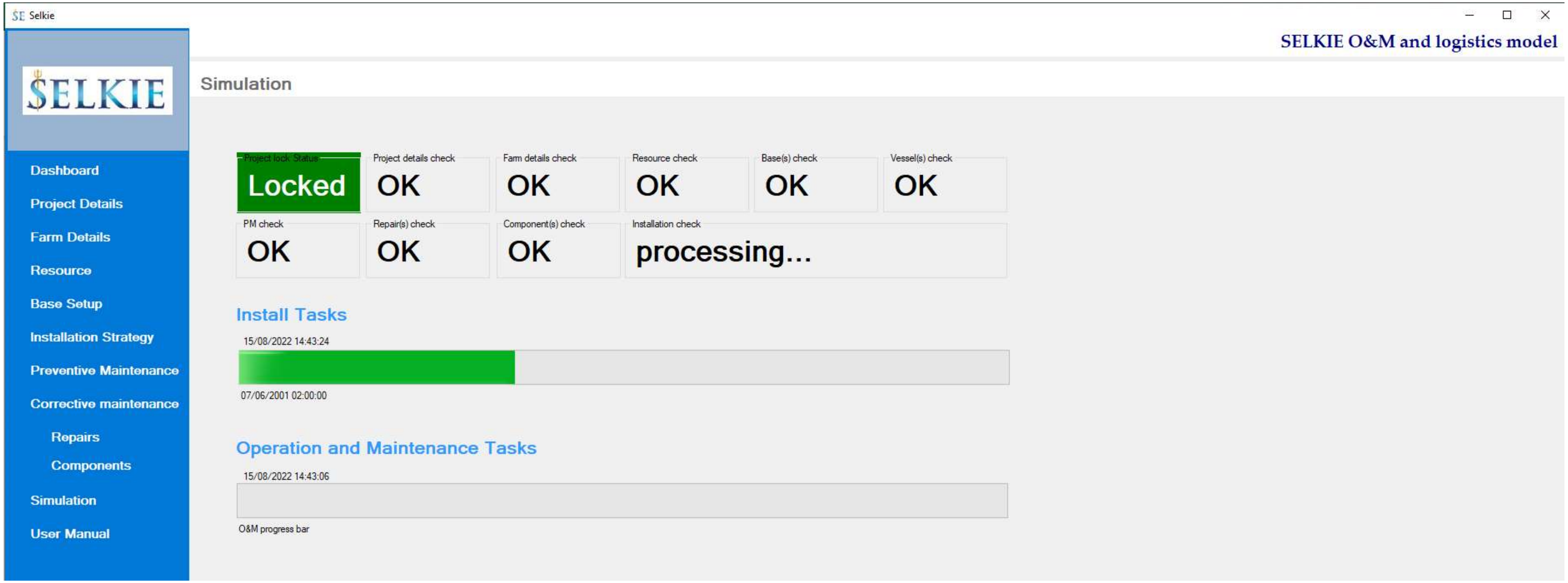


Figure 5.30 Simulation - processing - model screen

5.3 Outputs

Once completed, the user can export results using the "Export Reports" button as shown in Figure 5.31. This allows the user to save to any folder, including (but not restricted to) the "Reports" folder in their Roaming SELKIE folder.

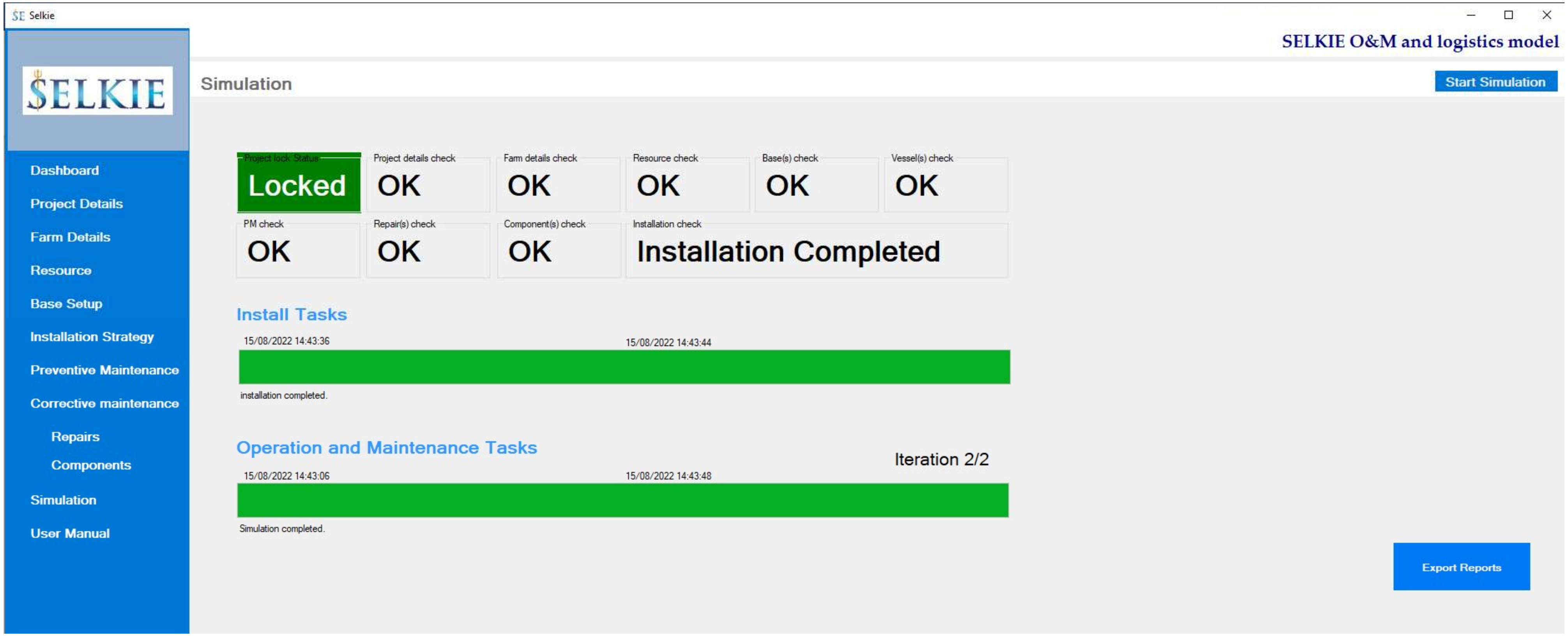


Figure 5.31 Simulation - Export Results – model screen

Results are exported as an excel file with the project name and include 4 sheets:

Inst_Yearly_Results = the yearly results per iteration

Iteration no.	Year	Base Costs	Additional Costs	Vessel fixed/rental Costs	Tech Costs	Vessel fuel costs	Total installation cost

Inst_Device_Results = details of installation activities per iteration

Iteration no.	Device Id	Device type	JOB	Start	End	Status	Install time in hrs

O&M_Results_AnnualAverage = annual average results per iteration

Total O&M cost	Vessel Fuel Costs	Vessel fixed/rental Costs	Tech Costs	Base Costs	Spare parts/repair Costs	Additional O&M costs	Energy Theoretical	Energy Produced	Energy-based Availability	Total hours	Downtime	Time-based Availability	Income

OM_Results_Yearly = yearly OM results per iteration

Iteration no.	Year	Total Annual O&M cost	Vessel Fuel Costs	Vessel fixed/rental Costs	Tech Costs	Base Costs	Spare parts/repair Costs	Additional O&M cost	Energy Theoretical	Energy Produced	Energy-based Availability	Total hours	Downtime	Time-based Availability	Income

5.4 Case study

The model includes a sample case study. This is an indicative scenario adapted from the Pelamis2 device case study provided in Gray et. Al [2] and using the FarrPoint metocean data provided as part of the Wave Energy Scotland model [1]. These can be found in the folder “Sample case study”.

Having opened the model and loaded the GUI as per section 3.2; the user can then locate a “Selkie” folder in their roaming folder (C:\Users\username\AppData\Roaming\Selkie\). They will see 3 key folders “Projects”; “PC”; and “WW” which are used by the tool to store saved projects; power curve or power matrices; and Metocean data respectively.

To use the sample case study, place the “Sample_CS” in the Projects folder. You will then be able to load this via the tool Dashboard tab. Select the “PelamisP2_PowerMatrix” under Farm Details and the “WES_model_metoceandata” under the Resource tab, remembering to save each time. Then run that simulation and export results for viewing.

6 Processing logic

Full details of the model processing logic and assumptions are provided in project Deliverable D8.2. For the purposes of this guide, the logic is summarised for installation in Figure 6.1 and Figure 6.2 for O&M.

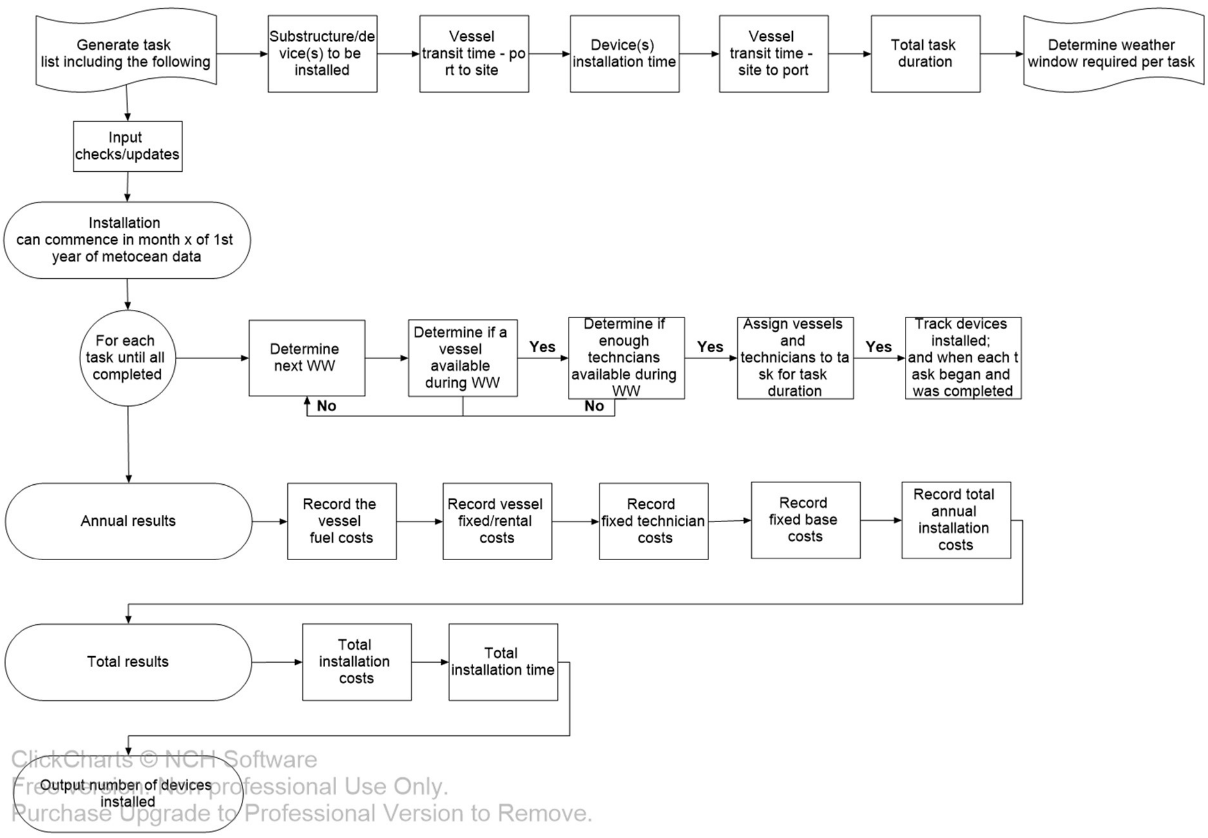


Figure 6.1 Installation processing logic

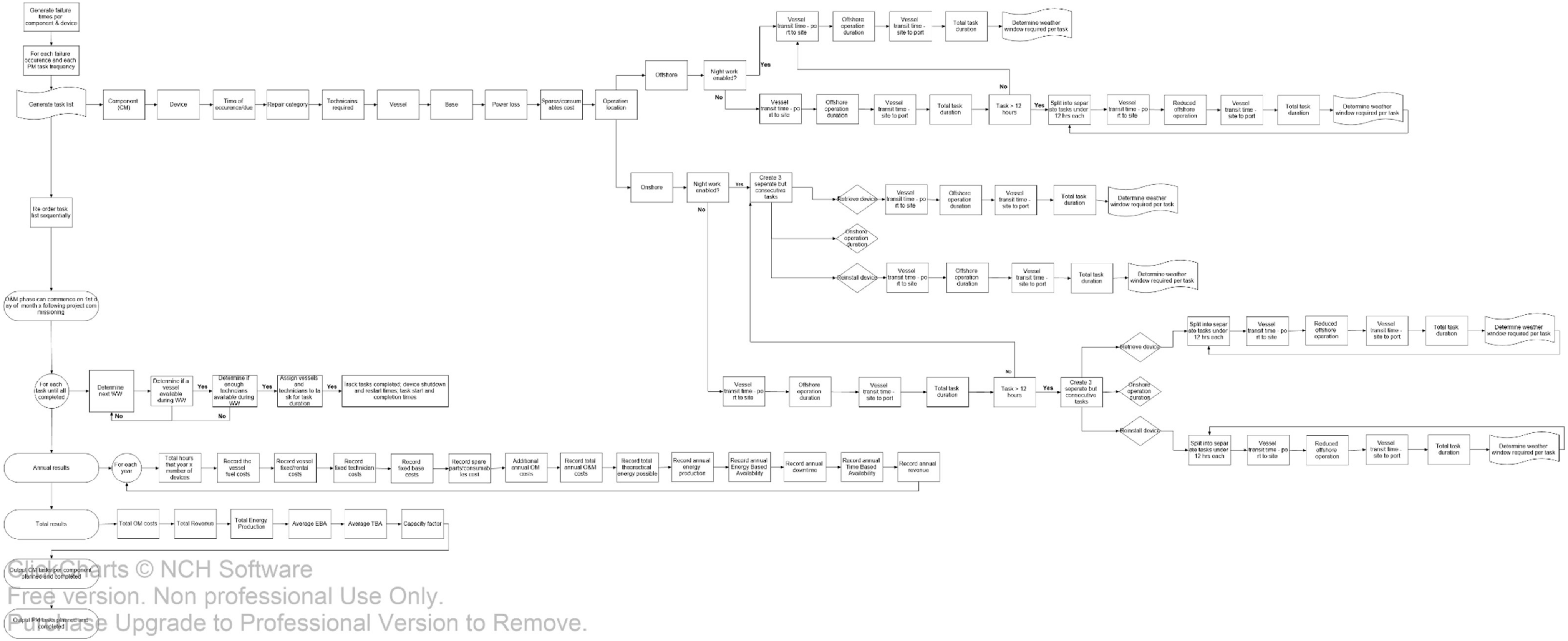


Figure 6.2 O&M processing logic

7 SELKIE format tools

In addition to the main installation and O&M tool, we have provided 2 tools developed in Matlab to help users arrange their Power Matrix and Metocean data into the format required by the SELKIE model.

These tools have been compiled as standalone executables; but in order to run any Matlab program on a machine that doesn't have Matlab installed you will need to install the Matlab Compiler Runtime (MCR). These tools were developed using Matlab R2015a (8.5) and will therefore require installation of the corresponding (free) runtime software via [MATLAB Runtime - MATLAB Compiler - MATLAB (mathworks.com)]

The formatting tools comprise the following:

- Excel input files "Metocean_data_input" and "PM_input" containing sample information based on the Pelamis P2 power matrix and FarrPoint Metocean data [1] [2].
- Matlab executables "SELKIE_Metocean_data_format_tool" and "SELKIE_PowerMatrix_format_tool".
- Excel template files that show the format required by the SELKIE tool "Metocean_data_template" and "PM_data_template".

To use the tools, put data in the input files according to the sample data provided. Double click the appropriate executable and wait for the progress bar to show that processing is complete.

Output will be provided as a new, timestamped excel file in the correct format, ready for use in the SELKIE tool.

Users can also use the template files directly to manually prepare inputs for the SELKIE tool.

Bibliography

[1] 29 10 2020. [Online]. Available: https://library.waveenergyscotland.co.uk/other-activities/design-tools-and-information/tools/om-simulation-tool/wes-om-tool-and-user-guide_rev2/.

[2] A. Gray, B. Dickens, T. Bruce, I. Ashton and L. Johanning, "Reliability and O &M sensitivity analysis as a consequence of site specific characteristics for wave energy converters," *Ocean Engineering,* vol. 141, pp. 493-511, 2017.