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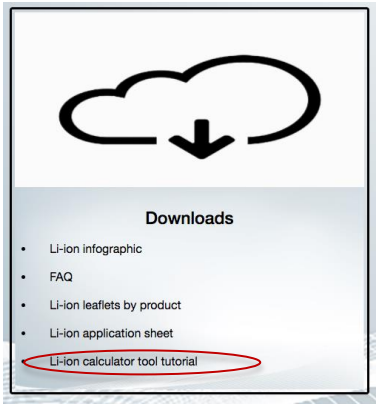
Lithium-ion Battery Calculator Tool Tutorial

Welcome to the Lithium-ion Battery Calculator Tool tutorial.

The tool has been designed to check the suitability of Li-ion in a given application, enable the best Li-ion battery and charger configuration and estimate the costs compared to Lead Acid.
The tool can be found in the EMEA Dealer Extranet as shown below (Truck Sales>> Product Information>>Lithium-ion Battery Calculator Tool)

Step 1 – Survey form
In order to use the tool, you need to know the application data from your customer. This data can be collected using the Lithium-ion Application Sheet, a survey form that can be downloaded from the Download section of the Lithium-ion Sales Tool, which can be found in Truck Sales >> Sales Tools.



This one-page form consists of different sections. An example is shown below.
The first section includes the customer details.
The second section includes the list of trucks in the fleet.
For each truck, you need to know:

- Model name
- Brand
- Quantity
- Energy consumption - this should be possibly measured using a battery logging device

- Idle time - the time when the truck should be in use but effectively the energy from the battery is not used, including paper work, loading and unloading, not scheduled breaks etc.
- Battery voltage and capacity for the current battery
- Working hours per year
- Possible conversion to Li-ion.

Lithium-ion Application Sheet

Date: xxx

Customer Details

Company Name	xxxx	Contact Name	xxxx	
Site Address	xxxx	Contact Details	xxxx	mobile
Forklift Truck Dealer	xxxx		xxxx	email address

Truck Fleet

Model Name	Brand	Qt	Energy Consumption (KWh/h)	Idle time (%) incl. paper work etc.. (excl. breaks)	Current battery Voltage and Capacity (V/Ah)	Working hours per year	Possible conversion to Lithium-ion? (Yes/No)
ERP16VT_MWB	Yale	5	3.5	20%	48/575	3200	Yes
MO20	Yale	5	0.9	30%	24/465	2900	Yes

The third section includes the Application and Daily Schedule.

- Start time, end time and the breaks in between that can be used to opportunity-charge the Li-ion battery
- Days per week
- Operator pay rate per hour – to estimate the battery handling costs
- Electricity cost - to estimate the energy costs
- Operating temperature.

Application and Daily Schedule

Start Time	06:00

	Break 1	Break 2	Break 3	Break 4	Break 5	Break 6
Break Start Time	08:30	10:30	12:30	15:30	18:00	20:00
Break Duration (mins)	15	15	40	15	15	15

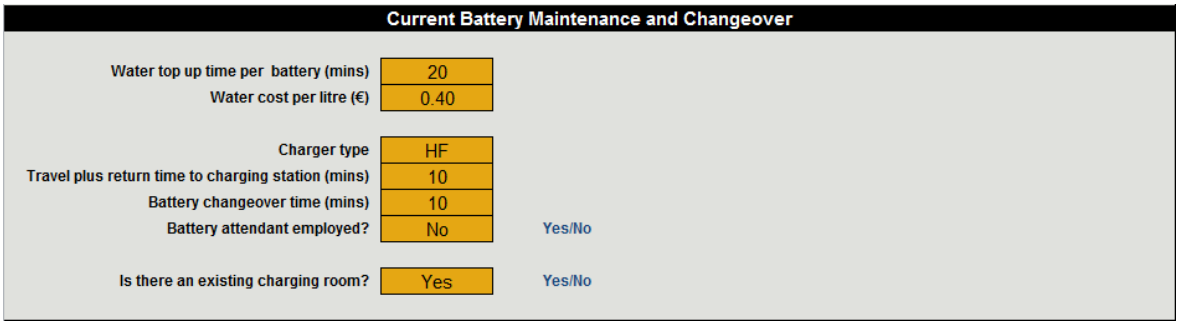
	Break 7	Break 8	Break 9	Break 10	Break 11	Break 12
Break Start Time						
Break Duration (mins)						

	Break 13	Break 14	Break 15	Break 16	Break 17	Break 18
Break Start Time						
Break Duration (mins)						

End Time	22:00	
Days per week	6	
Operator hourly rate (€)	€ 30.00	
Electricity cost (€/kWh)	0.12	
	Min	Max
Operating Temperature (°C)	5	35

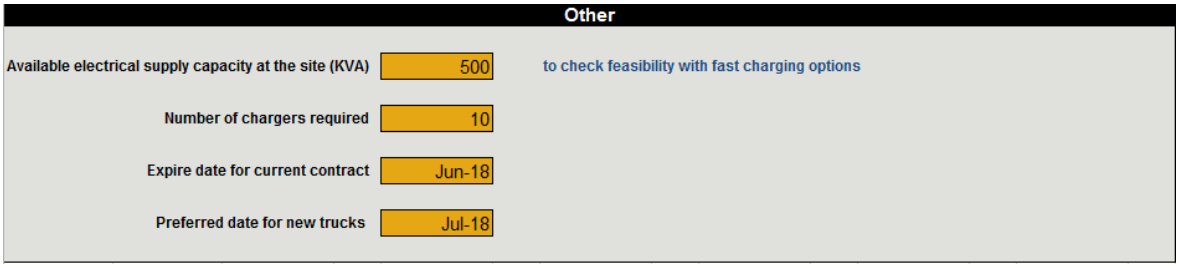
The forth section is for the Lead Acid battery and includes:

- Time taken to top up the water and the water cost – to estimate the maintenance costs
- Type of charger used for the lead-acid battery - 50 Hz or High Frequency
- Time required to go and come back to and from the charging room
- Time required to exchange the battery
- Is there any employee that takes care of the battery exchange?
- Is it an existing or new facility? If it is a new facility, the cost for a charging room plus the additional equipment should be considered for Lead Acid.



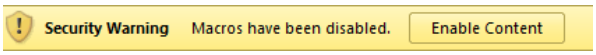
The last section includes:

- Available electrical supply capacity at the site to check the feasibility with Li-ion fast chargers (1 hr chargers) as these might require high power from the mains
- Number of chargers required
- Expire date for current contract if any
- Preferred date for new trucks.

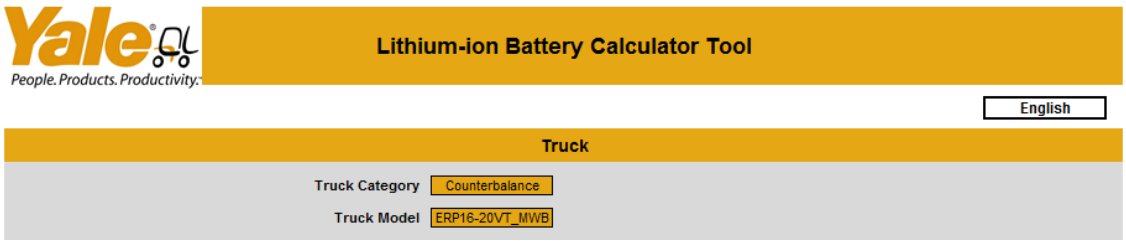


Step 2 – Calculator tool (Inputs)

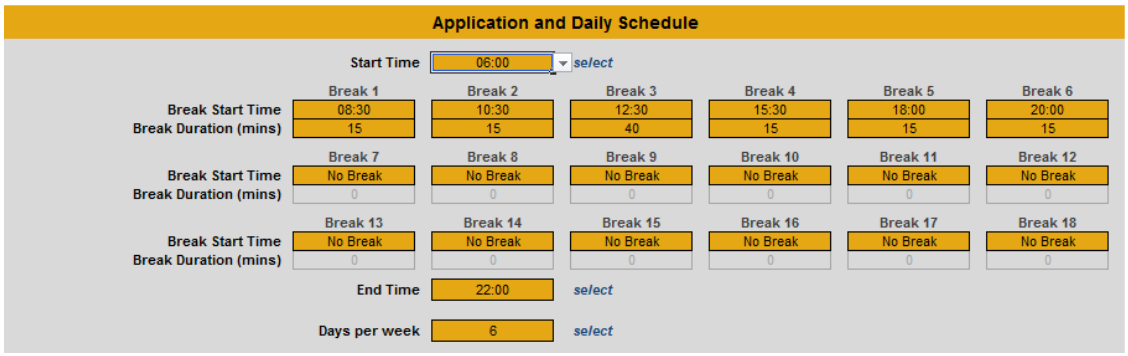
Once you have all these inputs, you can start the simulation using the calculator tool.
Macros must be enabled at the top of the page.



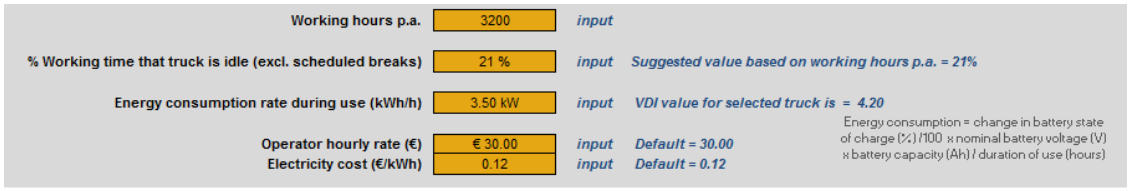
In the tool you have to select one truck at a time using the drop down menu.



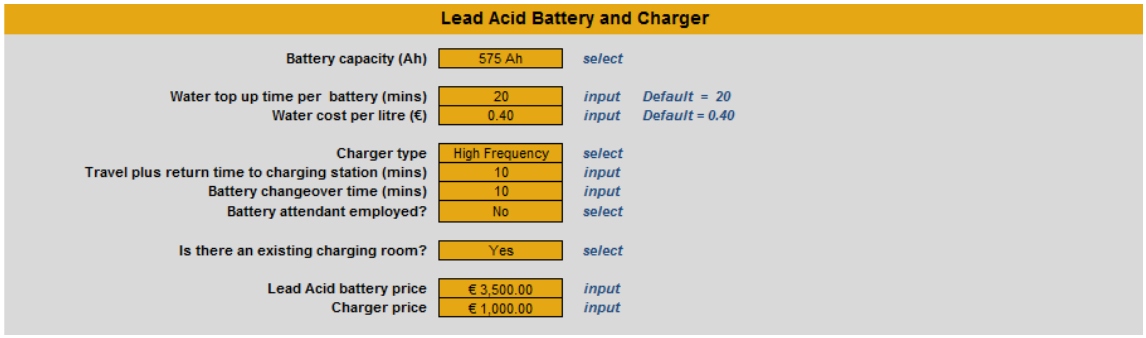
The drop down menu with a 24 hour clock is used for the time, the breaks and the break duration.
It is also possible to select the days per week ranging from 5 to 7.



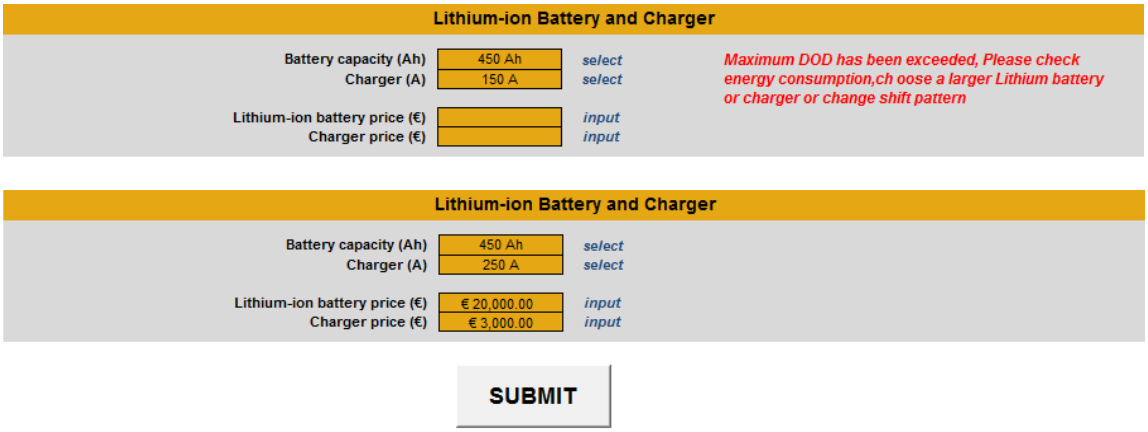
If you input the working hours per year, the tool will suggest an idle time based on this input as the tool compares the working hours per year with the shift schedule.
If you don't have this input, the tool will suggest a value for the idle time based on the type of truck selected, e.g. the tow tractor will have a higher idle time due to the manual loading/unloading required. Your costumer might also suggest a different idle time, that needs to be cross-checked with the value based on the working hours per year and/or the value suggested based on the truck type.
For the energy consumption, you should use the real value if possible as shown in this example. If not provided, you can use the VDI energy consumption suggested, based on the truck selected, but it should be considered that this value is usually higher than in real applications.
You can lower this value or increase the idle time to offset it.
There is also a simple formula reported here in grey that will help you estimate the battery consumption based on the duration of the current battery.
Operator hourly rate and electricity cost are simply copied from the survey form.



Same comment for the inputs in the next section, the one dedicated to Lead Acid.
The tool will suggest some default values if you don't know the actual ones.
The battery and charger prices are left blank and you should fill in these fields with the net prices, considering the discount and the margin. Please note that the prices shown in this example are approximate.

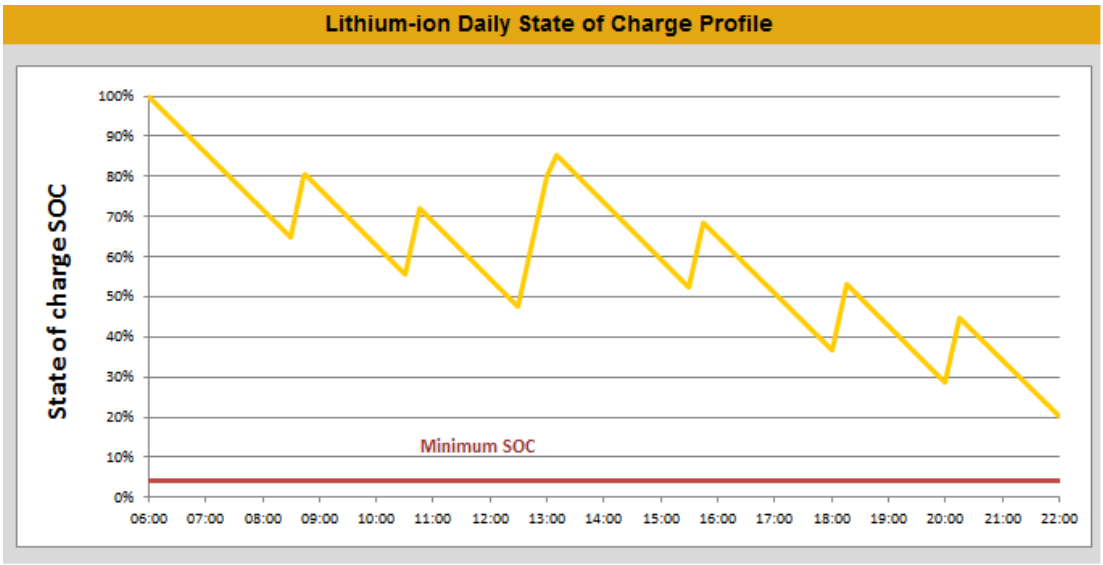


The last section is about Li-ion.
The drop down menu shows the list of battery capacities and charger available for the truck selected. You should start always with the smallest battery capacity and charger and upgrade them if the tool gives you a warning message that tells you that this battery and charger configuration is not suitable for the application.
If you select the fastest charger, your customer should be aware that a connector upgrade may be necessary as well as a suitable electrical infrastructure in case many trucks are charged at the same time.
For the 2017 range available with Li-ion, the prices of batteries and chargers are available on the Warehouse Price List/Counterbalance SPED Price List. For the 2018 range, please contact the SPED team.
Please note that the prices in this example are approximate.



Step 3 – Calculator tool (Outputs)
After checking that all the values have been selected or inserted, pressing the Submit button will generate the outputs in the lower part of the page.

The graph shows the state of charge of the Li-ion battery during the discharging and charging phases. The battery and charger configuration is suitable if the yellow line is well above the red line, which indicates the minimum state of charge.



The estimated costs per truck are also listed.
The investment costs include the purchase costs and the cost of the charging room and equipment if required for Lead Acid in a new facility.
Usually the investment cost is higher for Lithium-ion.
The annual cost per year includes:

- The energy cost, usually lower for Li-ion due to the higher efficiency of the battery and charger
- The battery handling cost, usually lower for Li-ion as the travel to the charging room and battery exchange is not required
- Battery maintenance cost, usually lower for Li-ion as water top up is not required.

Investment Costs per truck

	Lead Acid	Lithium-ion
Batteries required per truck (integer)	2	1
	€	€
Total battery cost	7,000.00	20,000.00
Charger cost	1,000.00	3,000.00
Charging room and equipment cost	0.00	0.00
Total	8,000.00	23,000.00

Annual Costs per truck

	Lead Acid	Lithium-ion
	€	€
Energy cost	2,471.94	1,574.01
Battery handling cost	5,079.18	756.00
Battery maintenance cost	725.38	50.00
Total	8,276.50	2,380.01

The last part of the outputs is about the savings and payback period, if the customer chooses Li-ion.
The savings are cumulative and it is possible to convert them into a currency different from Euro. The currency desired can be selected in the drop down menu.
Payback in appropriate applications is as low as 2-3 years.
Also the savings in terms of carbon emissions are estimated due to the higher Li-ion efficiency and are calculated using the standard EN 16796, based on a mix of the German different electricity generation systems.

Savings per truck

	Costs		Cumulative Savings (Lithium-ion vs Lead Acid)	
	Lead Acid	Lithium-ion		
	€	€	€	Select Currency (EU
y1	16,277	25,380	-9,104	-9,104
y2	8,277	2,380	-3,207	-3,207
y3	8,277	2,380	2,689	2,689
y4	8,277	2,380	8,586	8,586
y5	8,277	2,380	14,482	14,482

Payback Time	2.5 years

Estimated CO_2 emissions savings p.a.	4.0 Tonnes

Moving to the next sheet of the tool, the outputs are ready to be printed in 2 pages and presented to your customer to complement the discussion about the best power choice for that specific application.

Lithium-ion Battery Calculator Tool Output Page 16-Nov-17

Truck type	ERP16-20VT_MWB
Start Time	07:00
End Time	22:00
Operating time per day (hh:mm)	14:05
Idle time (hh:mm)	02:57
Number of breaks per day	6
Break time during shift per day (hh:mm)	01:55
Operator hourly rate (€)	30.00
Electricity cost (€/kWh)	0.12

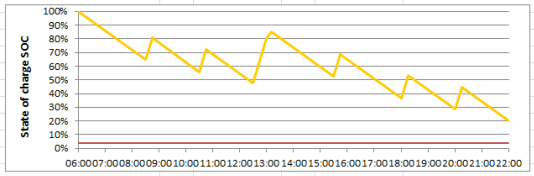
Energy	Lead Acid	Lithium-ion
Voltage (V)	48	51
Capacity (Ah)	575	450
Charge rate (kWh/hour)	n/a	12.80
Useable energy per battery (kWh)	22.08	18.80
Used energy per day (kWh)	38.94	38.94
Energy consumption rate (kWh/h)	3.50	3.50
Mains Energy per day (kWh)	71.53	45.54
Energy cost p.a. (€)	**2,471.94**	**1,574.01**
Estimated CO_2 emmisions savings p.a. (tonnes)		**4.04**

Battery Handling	Lead Acid	Lithium-ion
Number of batteries per truck (integer)	**2**	**1**
Number of battery cycles per day	**1.76**	**7**
Driver recharging time per annum (hours)	169	25
Battery attendant time per annum (hours)	0	0
Battery handling cost p.a. (€)	**5,079.18**	**756.00**

Battery Maintenance	Lead Acid	Lithium-ion
Water cost p.a. (€)	111.03	0
Water top up time p.a. (mins)	1129	0
Top up labour cost p.a. (€)	564.35	0
Annual inspection cost (€)	50.00	50.00
Battery maintenance cost p.a. (€)	**725.38**	**50**

Infrastructure	Lead Acid	Lithium-ion
Charging room and charging equipment (€)	0.00	0.00

Lithium-ion Daily State of Charge Profile



Investment Costs per truck

	Lead Acid €	Lithium-ion €	
Total battery cost	7,000	20,000	
Charger cost	1,000	3,000	
Charging room & equipment cost	0	0	Difference
Total	8,000	23,000	-15,000

Annual Costs per truck

	Lead Acid €	Lithium-ion €	
Energy cost	2,472	1,574	
Battery Handling charge	5,079	756	
Battery maintainance	725	50	Difference
Total	8,277	2,380	5,896

Savings per truck

	Costs Lead Acid €	Costs Lithium-ion €	Cumulative Savings Lithium-ion vs Lead Acid Select Currency (EUR)
y1	16,277	25,380	-9,104
y2	8,277	2,380	-3,207
y3	8,277	2,380	**2,689**
y4	8,277	2,380	**8,586**
y5	8,277	2,380	**14,482**

Payback Time **2.5 years**

Estimated CO_2 emissions savings p.a. **4.0 Tonnes**