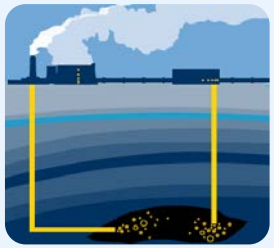








ECF Consumer Roundtable Study – Lithuania Extension

BEUC - ALCO

23/05/2018

Element Energy Ltd

Alex Stewart
Christopher Fernandes
David Garrick

Agenda

Overview of Lithuania-specific input assumptions

Presentation of initial results

Appendices: Input assumption tables

Agenda

Overview of Lithuania-specific input assumptions

- Baseline and OEM announcements scenarios
- Lithuanian taxes and incentives
- Taxes for LPG powertrains
- Slovenian taxes and incentives scenario

Presentation of initial results

Appendices: Input assumption tables

Core Assumptions

This table shows some of the core assumptions used in the model:

Model Input	Value	Source
Ownership Period	- 1st hand: 4 years - 2nd hand: 5 years - 3rd hand: 7 years	European Commission study results presented to Roundtable
Yearly mileage	- 1st hand: 15,000 km - 2nd hand: 12,000 km - 3rd hand: 10,000 km	EU average
Purchase Price	Same as EU-wide study	Element Energy Market analysis
Depreciation	Same as EU-wide study	EE ICE market review
Maintenance	Set value for petrol/diesel ICE and HEV. 50% and 30% discounts for BEVs/FCVs and PHEVs.	EE ICE and EV market reviews

Additional Vehicles Included

LPG

- As requested we have included an LPG vehicle in each segment modelled
- The modelled 2018 prices associated with LPG are[1]:
  - Price (excl. duty + VAT) = 26.97 ¢/l
  - Duty = 16.70 ¢/l
  - VAT = 21%
  - Price (inc. duty + VAT) = 52.83 ¢/l
- The cost of converting a petrol ICE to LPG is 600€
- The LPG price is projected into the future based on the oil price evolution
- The model assumes that for a given segment, LPG fuel consumption is 40% higher than for an equivalent Petrol ICE vehicle

1. Prices are based on actual 2018 LPG prices in Lithuania

Agenda

Overview of Lithuania-specific input assumptions

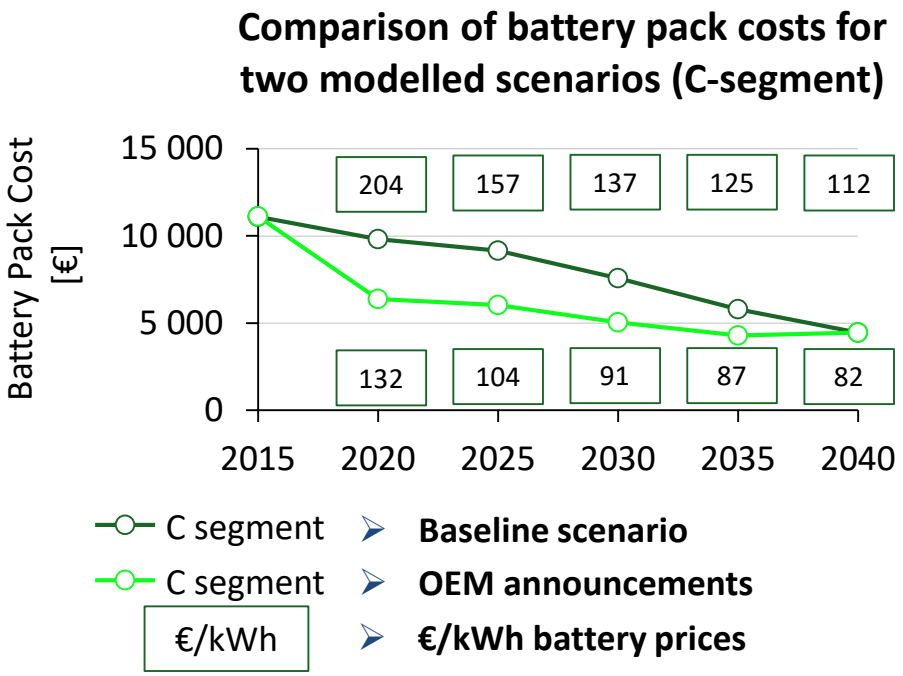
Baseline and OEM announcements scenarios

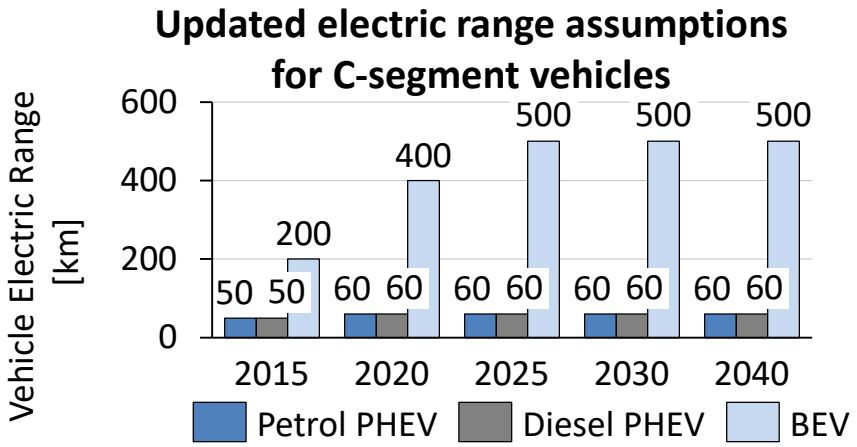
- Lithuanian taxes and incentives
- Taxes for LPG powertrains
- Slovenian taxes and incentives scenario

Presentation of initial results

Appendices: Input assumption tables

Two BEV cost scenarios: Base scenario and low battery cost scenario





- The Element Energy model uses 2 battery cost scenarios. The first is a based on a bottom-up model, which calculates the costs of all materials and labour based on expected changes in battery chemistries and production volumes. This has been validated by battery suppliers and universities.
- The second scenario is a deliberately optimistic scenario based on recent OEM announcements (e.g. from Tesla, LG and GM) about future cell and pack prices. These costs fall more quickly than the baseline in the short term (to 2020), , with more limited falls thereafter.
- The OEM announcements scenario results in lower TCOs, but has been validated by OEMs and University research centres and will be used as the central scenario for this study.
- In reality, OEMs will make a trade-off between battery cost and size/range, to ensure that vehicle prices are in line with what customers are willing to pay

Agenda

Overview of Lithuania-specific input assumptions

Baseline and OEM announcements scenarios

Lithuanian taxes and incentives

Taxes for LPG powertrains

Slovenian taxes and incentives scenario

Presentation of initial results

Appendices: Input assumption tables

Current tax and incentives overview

Registration Tax

- Lithuania has no vehicle registration tax but there are registration fees and roadworthiness testing fees (shown on next slide)

Road Tax

- Lithuania has no road tax for passenger cars

Incentives

- Lithuania has no purchase incentives

Registration Fees

Cost of Registration Procedure

	Registration fee (€)	Vehicle Identity check (€)	Number plates (€)
1st hand	14.48	15.35	15.06
Other	12.45*	15.35	15.06

*The actual fee range is 10.14 – 12.45 but upper bound used in model

Cost of Roadworthiness Test for Passenger Vehicles

Fuel Type	Test Fee (€)
Petrol	14.48
Diesel	18.2
LPG	23.4
Electric	6.62
H2	0
CNG	0

Agenda

Overview of Lithuania-specific input assumptions

- Baseline and OEM announcements scenarios
- Lithuanian taxes and incentives
- **Taxes for LPG powertrains**
- Slovenian taxes and incentives scenario

Presentation of initial results

Appendices: Input assumption tables

LPG vehicles registered as Petrol vehicles before conversion will get taxed as petrol vehicles even though an LPG conversion largely increases emissions

- In Lithuania, only a very small percentage of vehicles are registered as being LPG while nearly 15% of all fuel sold on the market is LPG[1]
- Although LPG has lower emission values than petrol (1557 gCO2/l vs 2557 gCO2/l), the increased fuel consumption assumed in this study (40%) means LPG pollutes more on a gCO2/km basis

LPG taxes in Lithuania vs Slovenia

- Although this is not felt by a 1st hand LPG owner in Lithuania, it would make a significant difference in the Slovenian tax regime (assuming the 1st hand owner pays LPG registration taxes rather than petrol ICE taxes)
- In the rest of the study, it is assumed that an LPG owner retrofits his vehicle with an LPG kit; this means the first owner pays registration taxes for a petrol ICE.
- For completeness, LPG taxes are shown for the Slovenian registration taxes on slide 17.

1. https://enmin.lrv.lt/lt/veiklos-sritys-3/nafta

Agenda

Overview of Lithuania-specific input assumptions

- Baseline and OEM announcements scenarios
- Lithuanian taxes and incentives
- Taxes for LPG powertrains
- **Slovenian taxes and incentives scenario**

Presentation of initial results

Appendices: Input assumption tables

Slovenian tax and incentives overview (1)

Registration tax (1)

In Slovenia, vehicle registration tax is paid at the point of purchase of all new and second-hand vehicles. The tax is a percentage of the vehicle purchase price before tax and the tax rate is a function of CO2 emissions, fuel type and Euro standard:

CO_2 emissions [g/km]	Petrol/Hybrid/ LPG [%]	Diesel [%]
0 – 110	0.5	1
111 – 120	1	2
121 – 130	1.5	3
131 – 150	3	6
151 – 170	6	11
171 – 190	9	15
191 – 210	13	18
211 – 230	18	22
231 – 250	23	26
>250	28	31

Slovenian tax and incentives overview (2)

Registration tax (2)

Additionally, the registration tax rate is adjusted depending on the vehicle's Euro rating, with lower Euro-rated vehicles' taxes being increased by up to 10%:

Euro Standard	Tax rate increase
0	10%
1	10%
2	10%
3	5%
4	2%
5+	No change

NOTE: This part of the registration tax doesn't affect results due to the focus on new vehicles, which will always achieve the highest Euro standard in place at the time of purchase.

Slovenian tax and incentives overview (3)

Road Tax

Road tax is a yearly fixed fee which is based on engine size:

Engine Size [cc]	Tax Rate [€]
≤ 1,350	62
1,350 – 1,800	96
1,801 – 2,500	153
2,501 – 3,000	282
3,001 – 4,000	452
≥ 4,500	565

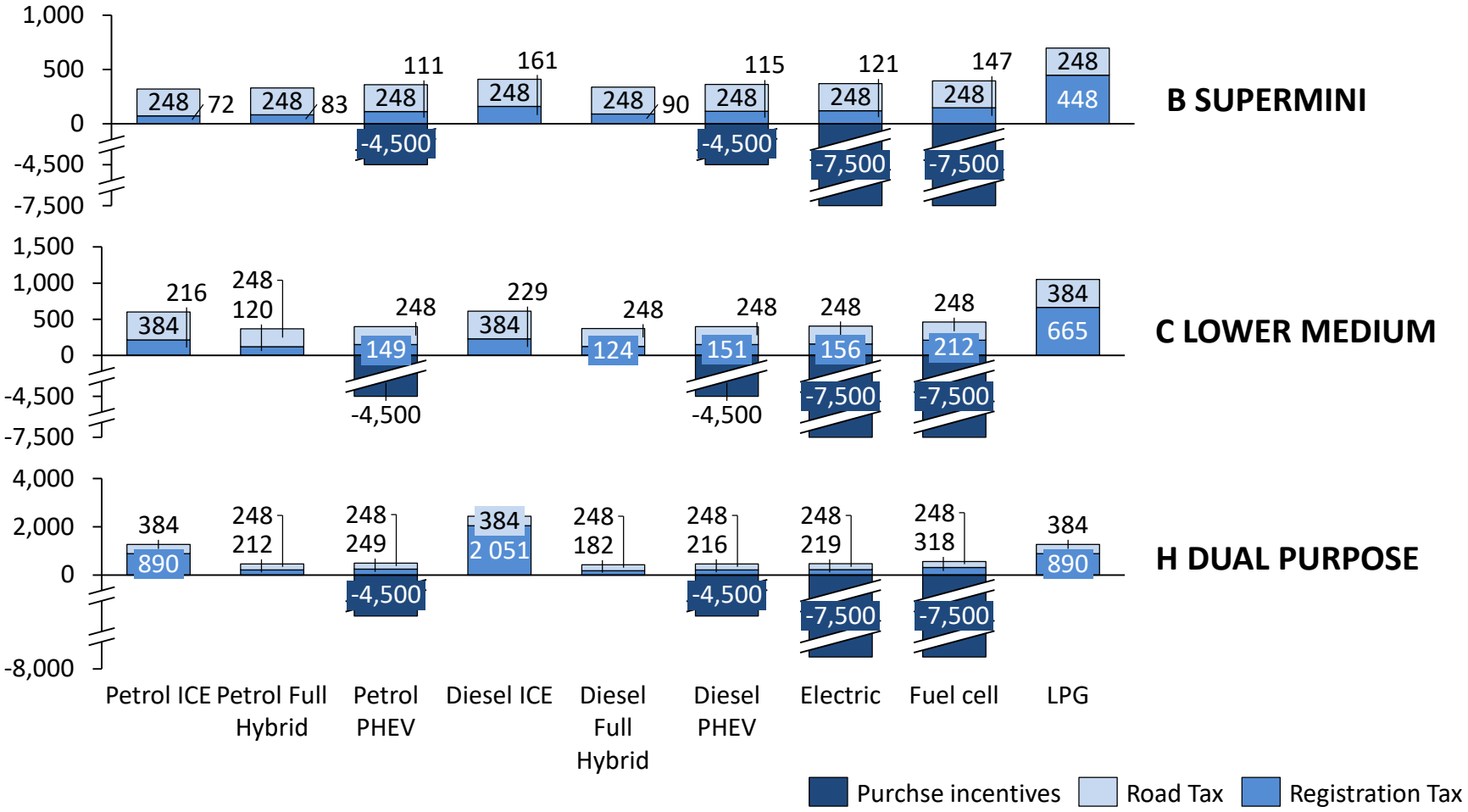
Purchase Incentives

Slovenia offers purchase incentives for BEVs and PHEVs :

- €7,500 for a new BEV
- €4,500 for a new PHEV or a RE-EV with CO_2 emission figure below 50gCO_2/km

Slovenian tax and incentives overview (3)

Overview of taxes and incentives over 1st ownership period for a new vehicle bought in 2018

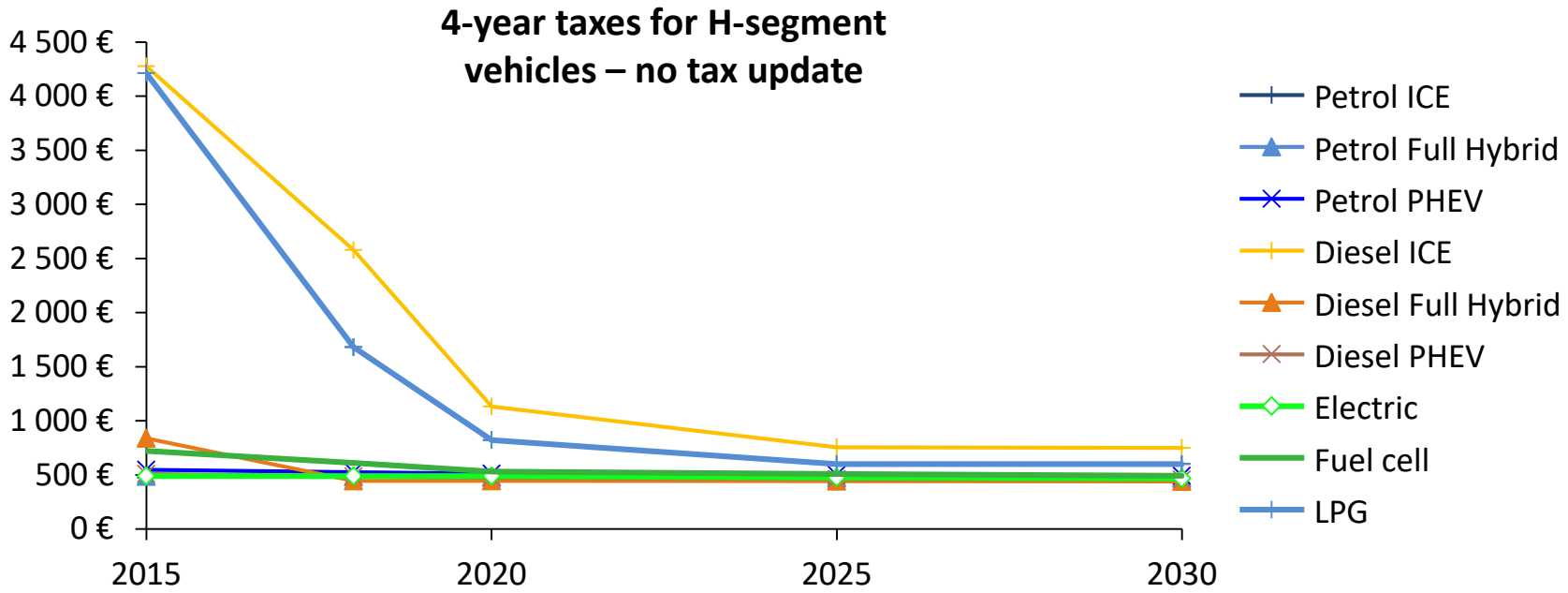


Slovenian tax and incentives overview (4)

Updating tax bands over time

- To make the tax rates more representative in the future, the tax tables used to calculate registration tax and road tax are updated over the time period of the model. For registration tax this means adjusting the CO2 bounds of each tax bracket so that the same proportion of the fleet falls into each tax bracket in each year.
- The Euro standard correction factors are also updated over time. All vehicles initially meet the highest Euro standard. Euro standard correction factor changes from Euro 6 to lower Euro standard correction factors as the vehicle ages (every 4-5 years) to simulate the introduction of new Euro standards. BEVs and FCEVs are exempt from this effect as they will always meet the highest Euro standard.

If tax band are not updated periodically, as the new vehicle CO2 emissions drop, the most polluting vehicles will pay less and less taxes



- As new vehicle emissions drop to comply with European policy, if the tax bands are not adjusted downwards to reflect this, the most polluting vehicles in the fleet reach the lowest tax bands by 2025
- Adjusting the tax bands downwards ensures that the more polluting vehicles remain in the higher tax bands and continue being penalised effectively while incentivising low-emission vehicles.

Agenda

Overview of Lithuania-specific input assumptions

Presentation of initial results

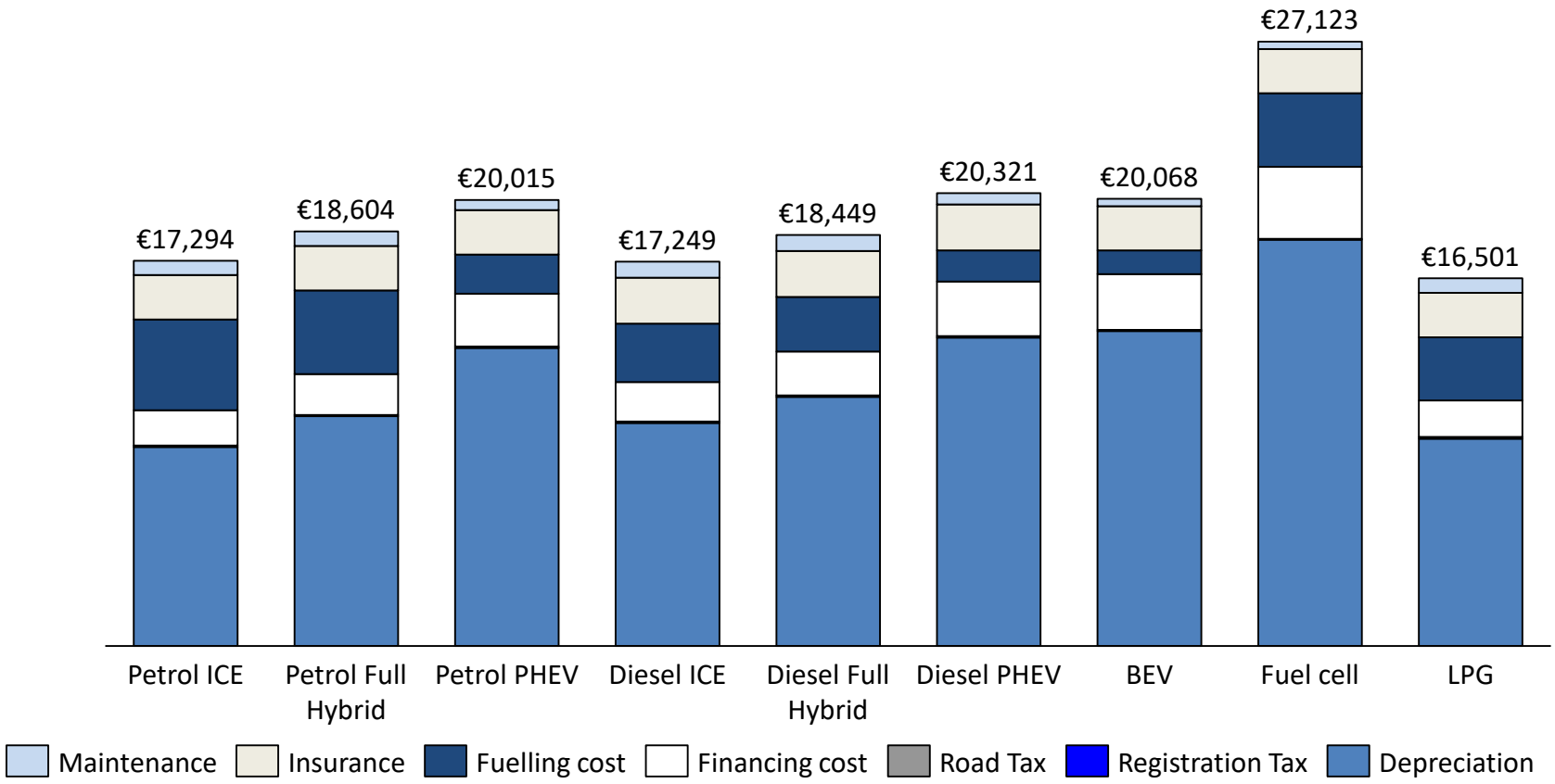
TCO analysis (Central scenario)

Home PV charging scenario

TCO analysis with Slovenian tax regime

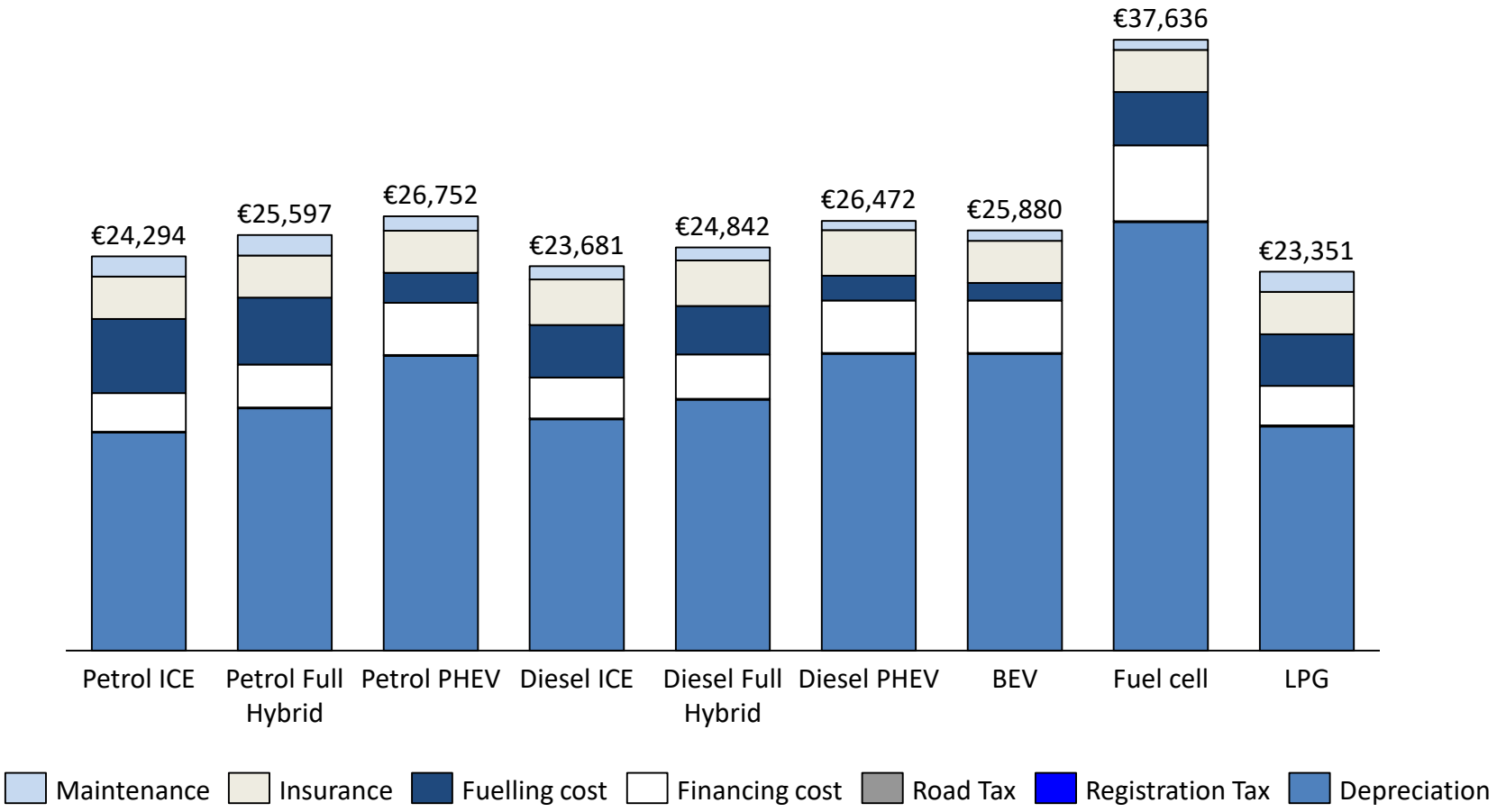
Appendices: Input assumption tables

1st hand B-segment 4 year TCO: 15,000 km per year (bought today)



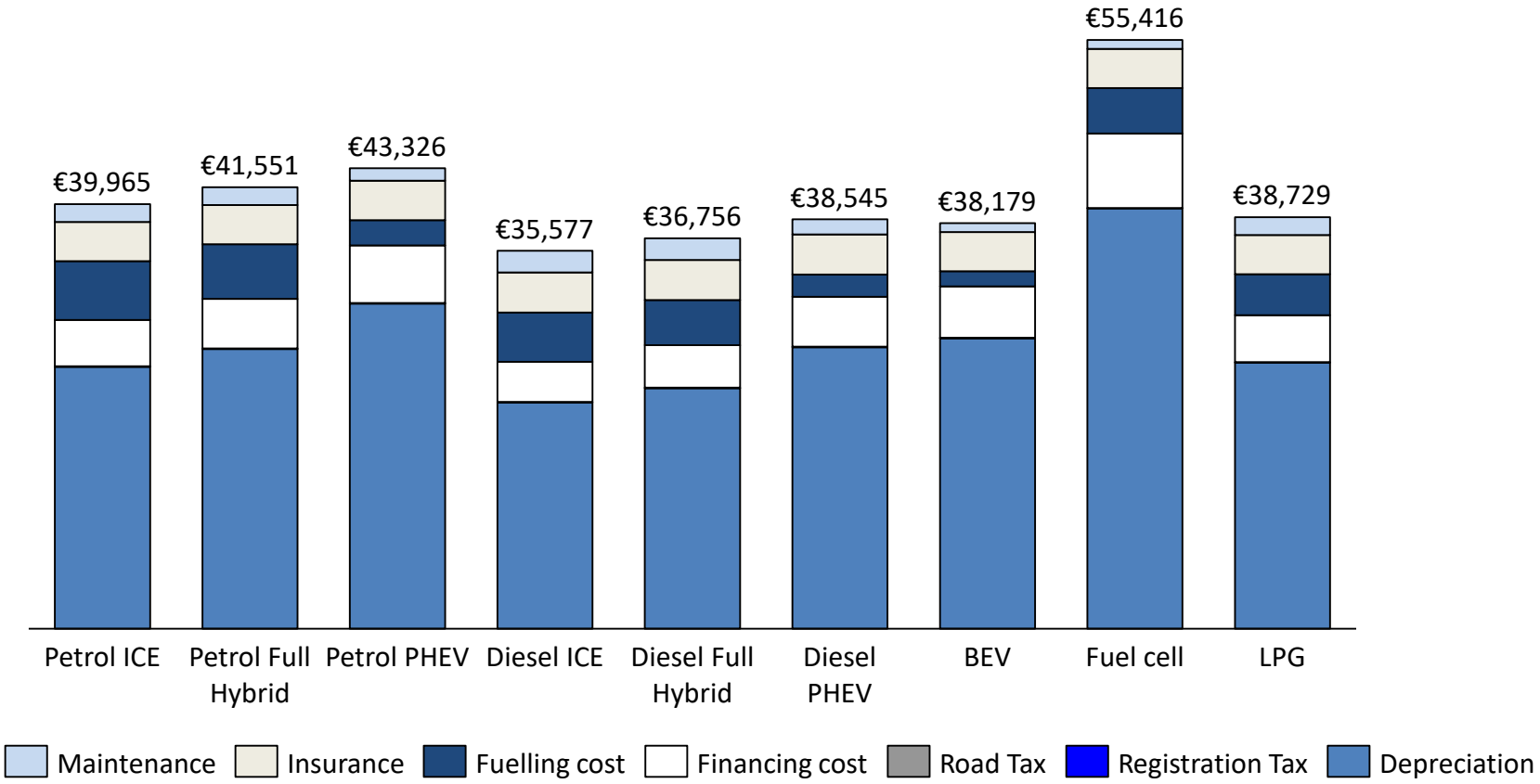
- LPG has lowest TCO in 2018 due to minimal additional purchase cost and high fuel cost savings
- TCO for BEVs is higher than for their petrol and diesel ICE counterparts

1st hand C-segment 4 year TCO: 15,000 km per year (bought today)



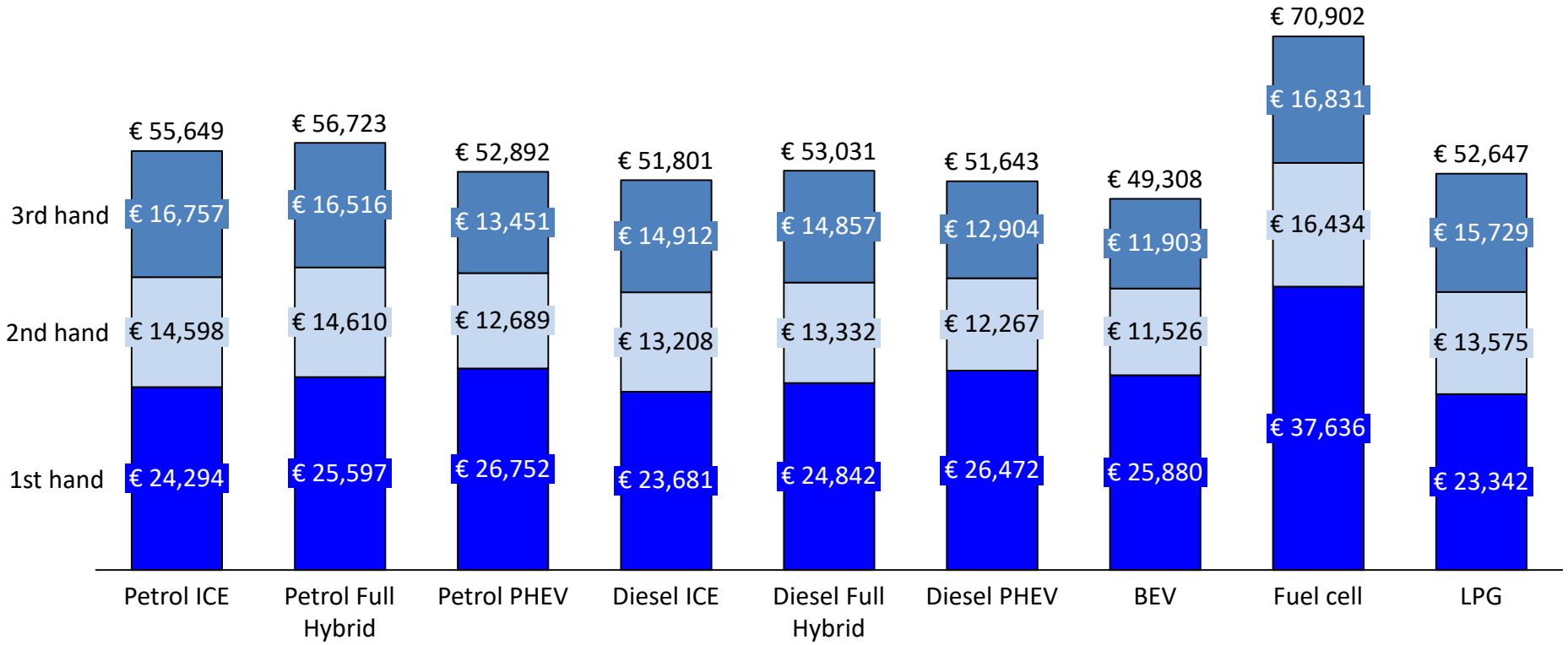
- The results are similar for the C segment, in terms of relative TCOs – LPG has the lowest TCO and BEVs have a higher TCO than petrol and diesel ICEs in 2018

1st hand H-segment 4 year TCO: 15,000 km per year (bought today)



- H-segment diesel ICE vehicles have a lower TCO than H-segment BEVs. However, BEVs have a lower TCO than their petrol ICE counterparts due to high petrol consumption in these large vehicles. This is despite BEVs having a higher cost of depreciation, and can be explained by refuelling costs of under c.€1.5k for BEVs compared to c.€5.5k for petrol ICEs.
- LPG does not have the lowest TCO in segment H due to the high fuel consumption figures

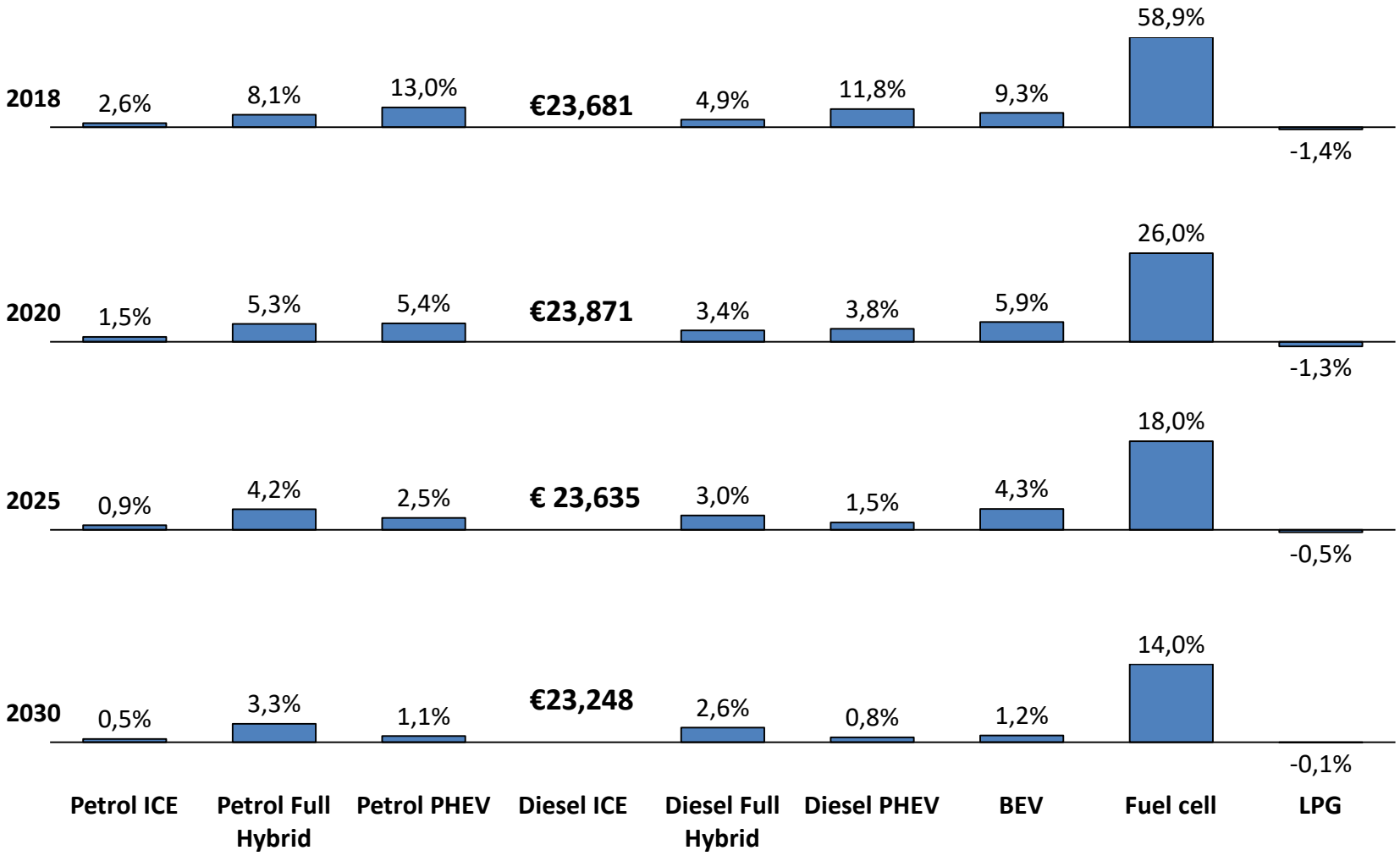
Whole-life cost of a C-segment vehicle bought in 2018



- 3rd hand TCO is higher than 2nd hand TCO for all powertrains – this is due to rising energy prices and due to a longer 3rd ownership period (7 years vs 5 years). This increases maintenance and insurance costs as well as the number of km travelled (fuel costs)
- BEVs are the cheapest for both 2nd and 3rd hand ownership due to fuel costs increasing in importance relative to depreciation (and low relative fuel prices).

Note: Petrol ICE taxes have been used for 1st hand and LPG taxes have been used for subsequent ownership periods as discussed previously

Comparing the TCOs of C-segment vehicles against a C-segment diesel bought 1st hand in 2018, 2020, 2025 and 2030



- By 2030 the 1st hand TCO of a C-segment BEVs is almost at parity with an equivalent Diesel ICE vehicle

Agenda

Overview of Lithuania-specific input assumptions

Presentation of initial results

- TCO analysis (Central scenario)
- **Home PV charging scenario**
- TCO analysis with Slovenian tax regime

Appendices: Input assumption tables

A range of tariffs have recently been introduced for households producing electricity from solar photovoltaic systems, which allow the electricity to be bought and sold to the grid when not used in the home

Overview of tariffs for PV owners

The four different pricing regimes are presented below:

Option	Offtake Price [€/kWh]	Monthly Fixed Cost [€/kWp/month]	Maximum % offtake
1	0.03876	-	-
2	-	2.02191	100%
3	0.01938	1.01156	-
4	-	-	62%

- **Option 1:** PV owner can withdraw the same amount of energy from the grid as he has injected at a price of c.0.0388€ per kWh. The rest of the electricity is bought at the standard price
- **Option 2:** A monthly fee of c.2.02€ per kW peak installed is paid and the PV owner can inject and use as much electricity as they make. The rest of the electricity is priced normally.
- **Option 3:** Combination of Option 1 and Option 2
- **Option 4:** No money is exchanged for the PV electricity. 62% of all electricity injected into the grid can be used by the PV owner free of charge. Above this the normal rate applies.

Solar irradiation data for Kaunas was used to calculate monthly electricity production for several array sizes, ranging from 3 kWp to 10 kWp

Input data for PV panel electricity production in Kaunas, Lithuania

The table below shows approximate solar irradiation values for each month of the year and how many kWh 3 – 5 kWp roof-mounted solar arrays are capable of producing. The 'degradation' column assumes an average panel degradation of 0.7% per year averaged over 20 years. This brings the average system's efficiency down from c. 90% to c. 83% over the assumed 20 years of production. "AC energy" means electricity flowing to the grid as it has been converted with an inverter (DC input/AC output)

	Solar Array Peak Capacity	3 kWp		4 kWp		5 kWp	
Month	**Solar Radiation** *(kWh / m2 / day)*	**AC Energy** *(kWh)*	**AC Energy** (degradation) *(kWh)*	**AC Energy** *(kWh)*	**AC Energy** (degradation) *(kWh)*	**AC Energy** *(kWh)*	**AC Energy** (degradation) *(kWh)*
January	0.68	58	53	77	71	96	88
February	1.37	106	98	142	131	177	163
March	2.53	215	198	287	264	359	330
April	3.91	304	280	406	374	507	467
May	5.36	416	383	554	510	693	638
June	5.65	418	385	557	513	696	641
July	5.37	409	376	546	503	682	628
August	4.89	368	339	491	452	614	565
September	3.16	244	225	325	299	406	374
October	1.73	141	130	189	174	236	217
November	0.79	64	59	85	78	106	98
December	0.37	30	28	40	37	51	47

Source: https://pvwatts.nrel.gov/

A type of Levelized Cost Of Electricity (LCOE) methodology was implemented to find the cost per kWh for the electricity produced by the PV panels

Several assumptions were made in order to find the average electricity price that a PV owner would receive for charging his BEV, with different panel sizes, while subscribing to the various tariff regime options:

- The solar panels' output is measured over 20 years so the capital cost is amortised over those 20 years
- Only the premium+ panels are considered due to space-saving requirements
- They lose c.0.7% system efficiency per year on average[1,2]
- The LCOEs calculated here are an upper-bound to the actual cost of electricity as it is assumed that all electricity produced during the day is sent to the grid and taken off the grid for charging rather than being used directly from the solar panels (due to the difficulty in estimating the percentage of production that's used as its being produced). The average price per kWh will drop when PV electricity is used directly by the household

PV array turn-key prices offered by Lithuanian DSO

Panel Peak Output kWp	Standard €	Premium €	Premium + €
3	4100	4360	4760
4	4890	5250	5700
5	5820	6330	6710
6	7320	8200	8860
7	7970	9030	9820
8	9080	9980	10740
9	10000	10820	11830
10	10835	11750	12800

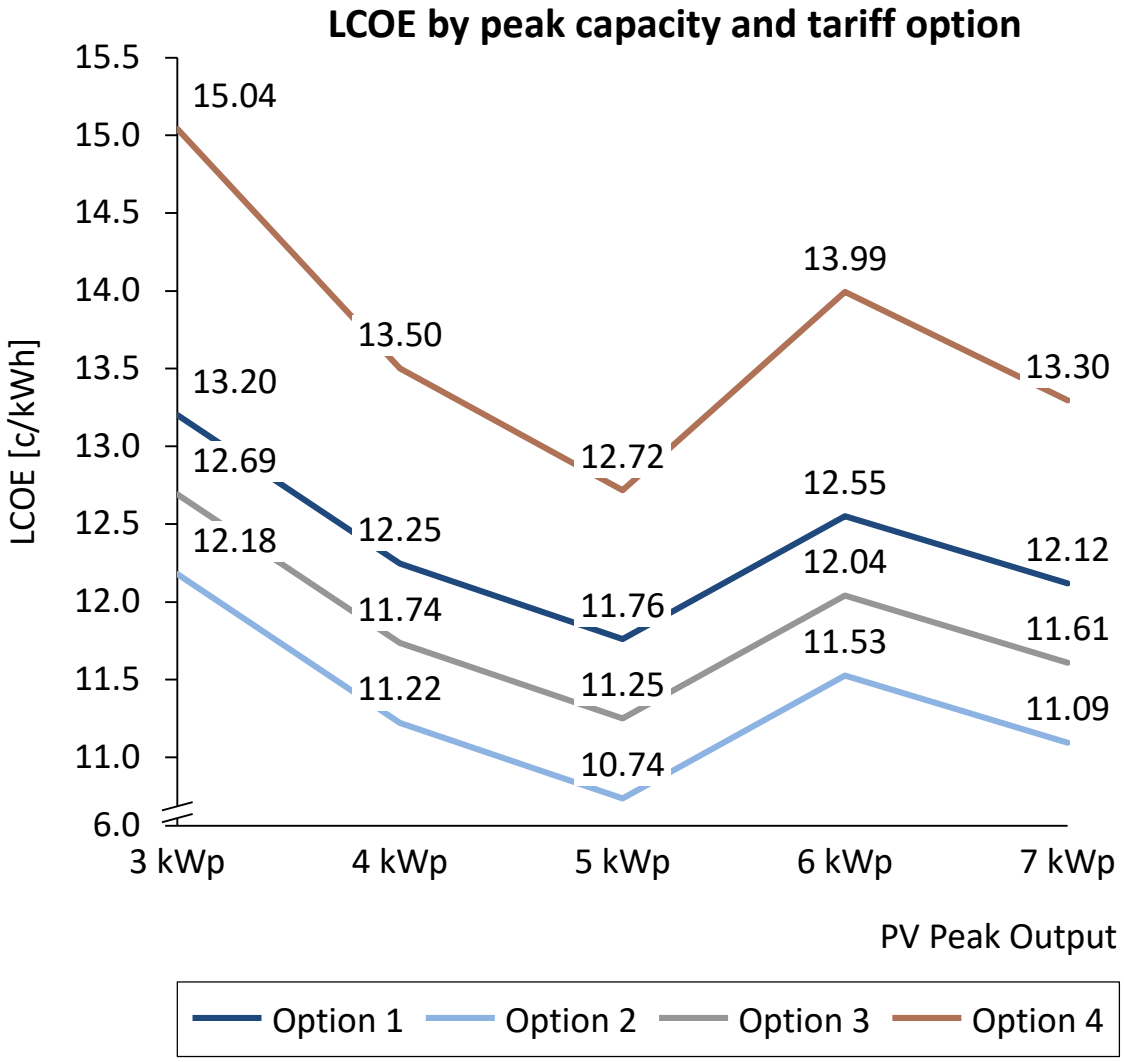
The cost of electricity (€/kWh) was found by calculating how many kWh would be produced over the array's lifetime and how much the owner would be paying for each kWh produced over the 20 years (based on the different options presented previously). Additionally, it is assumed the tariffs shown on Slide 33 increase year-by-year in accordance with our electricity price projections.

Option 1 only has variable costs dependent on number of kWh produced plus a fraction of the capital cost
Option 2 only has monthly fixed costs and a fraction of the capital cost
Option 3 has variable costs dependent on kWh produced, monthly fixed costs and a fraction of the capital cost
Option 4 depends only on the capital cost of the panel

1. Photovoltaic Degradation Rate – An Analytical Review (NREL 2012)
2. Annual degradation rates of recent crystalline silicon photovoltaic modules (I. Tetsuyuki, M. Atsushi 2017)

The cheapest option on an LCOE basis is a 5kWp panel, assuming space is relatively limited and going over 7kWp is unfeasible

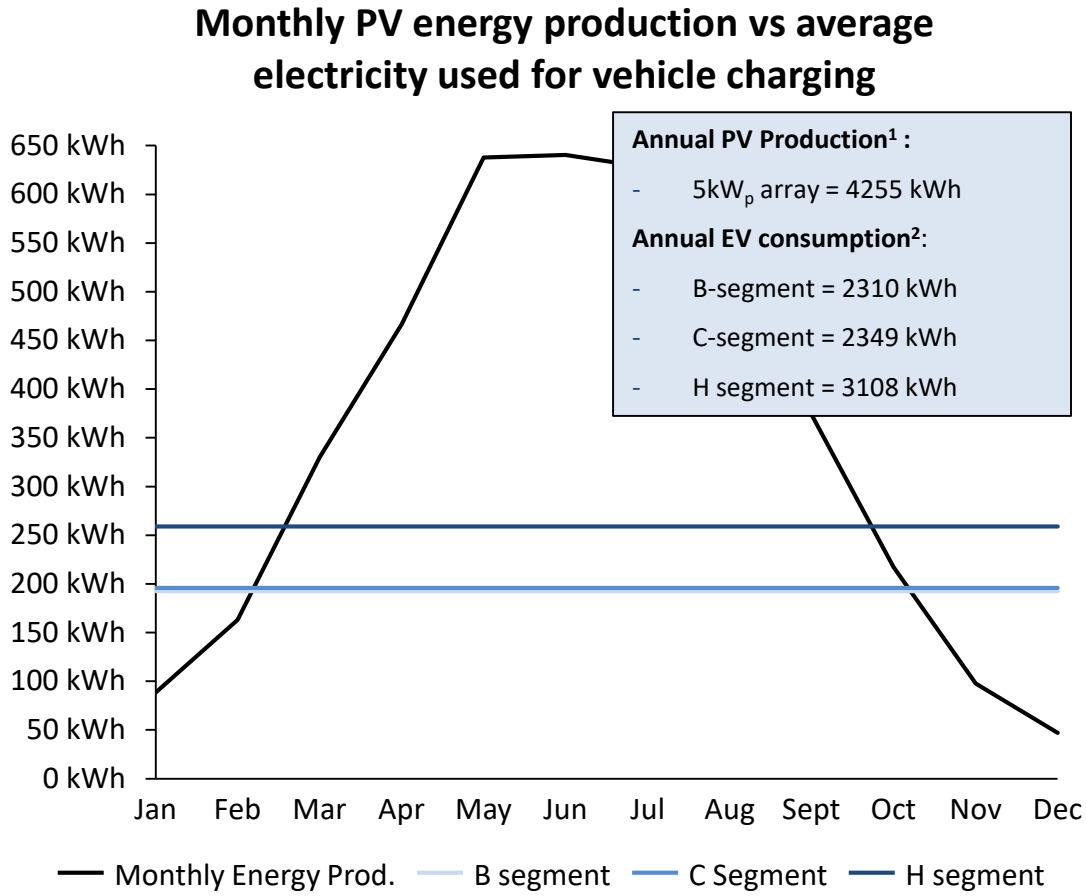
- In every case, the lowest LCOE was for Option 2, where the owner pays a fixed monthly fee and can effectively use the grid as a battery.
- There is a jump in price between 5kWp and 6kWp due to administrative barriers which make permitting and installation more difficult above the 5kWp threshold.
- The graph on the right shows that for a 5kWp panel, the LCOE is lower than domestic electricity price for options 2 and 3 (<11.4 c/kWh)
- In further calculations, it is assumed that the owner has enough space and chooses to install a 5kWp array.



A 5 kWp array not only gives the optimal price but will produce enough energy to cover a large share of an average household's usage.

Comparison of PV system output and EV electricity assumption

- One of the advantages of the Lithuanian tariff regime is that it allows PV owners to use the grid as a form of energy storage, exporting PV energy when on-site consumption is low (e.g. when the car is not charging) and re-importing it when it is needed (as for overnight charging) at favourable prices
- In addition to this intra-day pattern, any excess electricity produced in the summer months can be used in the winter months when PV generation is low, at the same price as when the electricity was produced, without the need to invest in household battery-storage technologies.

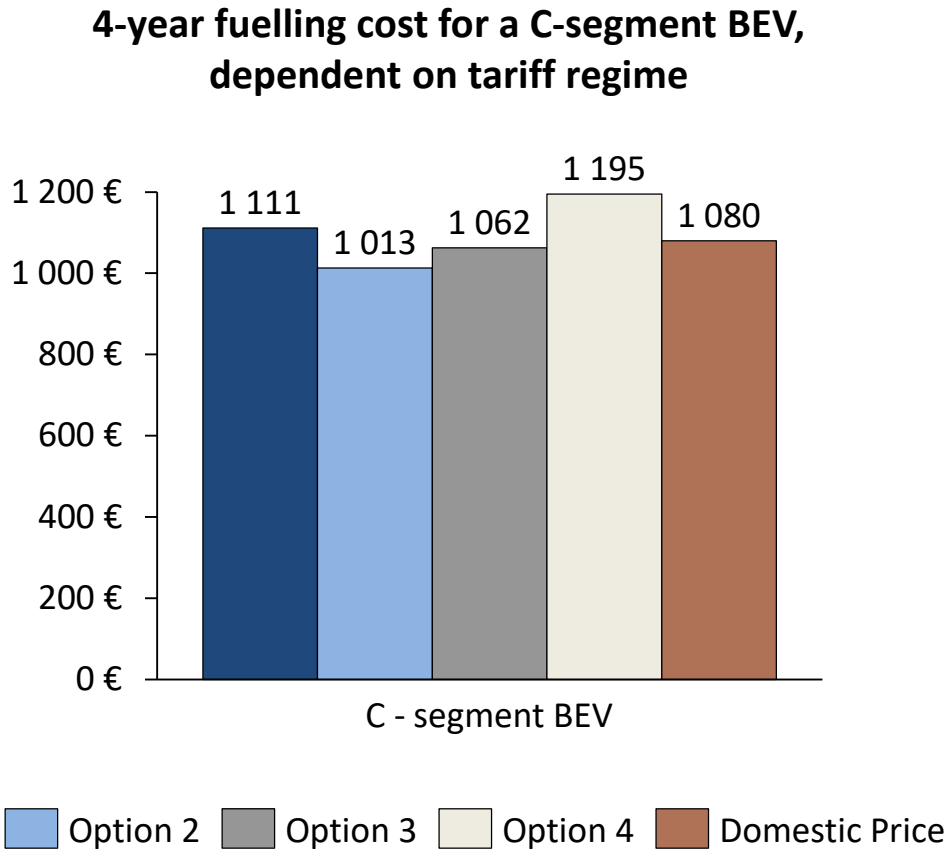


1. https://pvwatts.nrel.gov/
2. Element Energy proprietary cost and performance model

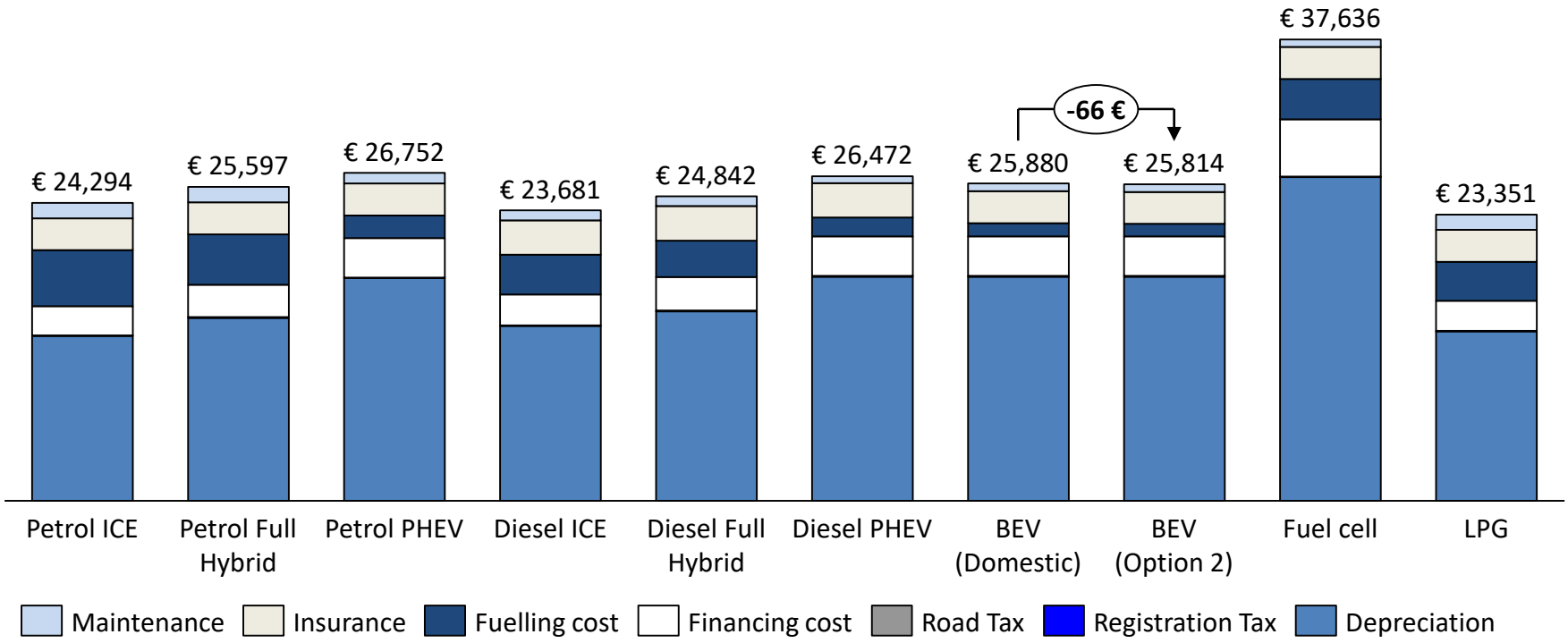
Our analysis shows that fuel costs for a 1st hand BEV are similar with home PV production but the majority of the electricity used is renewable

In calculating the new TCOs, it is assumed that any reduction in electricity price is used to cover BEV needs first and other household needs second

- For the purpose of this calculation, we assume that the PV output (or re-imported grid energy) is used to charge the PV owner's BEV. In reality, PV production will be used to power other domestic appliances, lighting etc.
- Hence, other electrical loads in the house are assumed to use grid electricity at the normal domestic price unless there is overproduction which the BEV doesn't need.
- This overproduction (and use by electrical loads other than the BEV) is beneficial on an LCOE basis as it allows the installation of a larger PV array and accompanying lower LCOE
- A 5kWp array will not produce enough every month but will cover all BEV energy needs over a whole year, easily making up for winter underproduction



1st hand C-segment 4 year TCO: 15,000 km per year (bought today) comparing TCO with and without PV installation



- The graph above demonstrates the effect that solar panels would have on the TCO of a C-segment BEV.
- Due to the fact that fuelling plays such a small part in a BEVs overall TCO, especially in Lithuania where the base electricity price is low, even a large price reduction makes little difference compared to the other costs. The PV system does bring other advantages which are not quantified in the graph above though:
  - Effectively running your BEV on 100% renewable electricity at a lower cost than only using the grid.
  - Reduced household bills due to the oversized panels which produce more than enough to cover vehicle charging needs and a good share of the other household energy needs.

Agenda

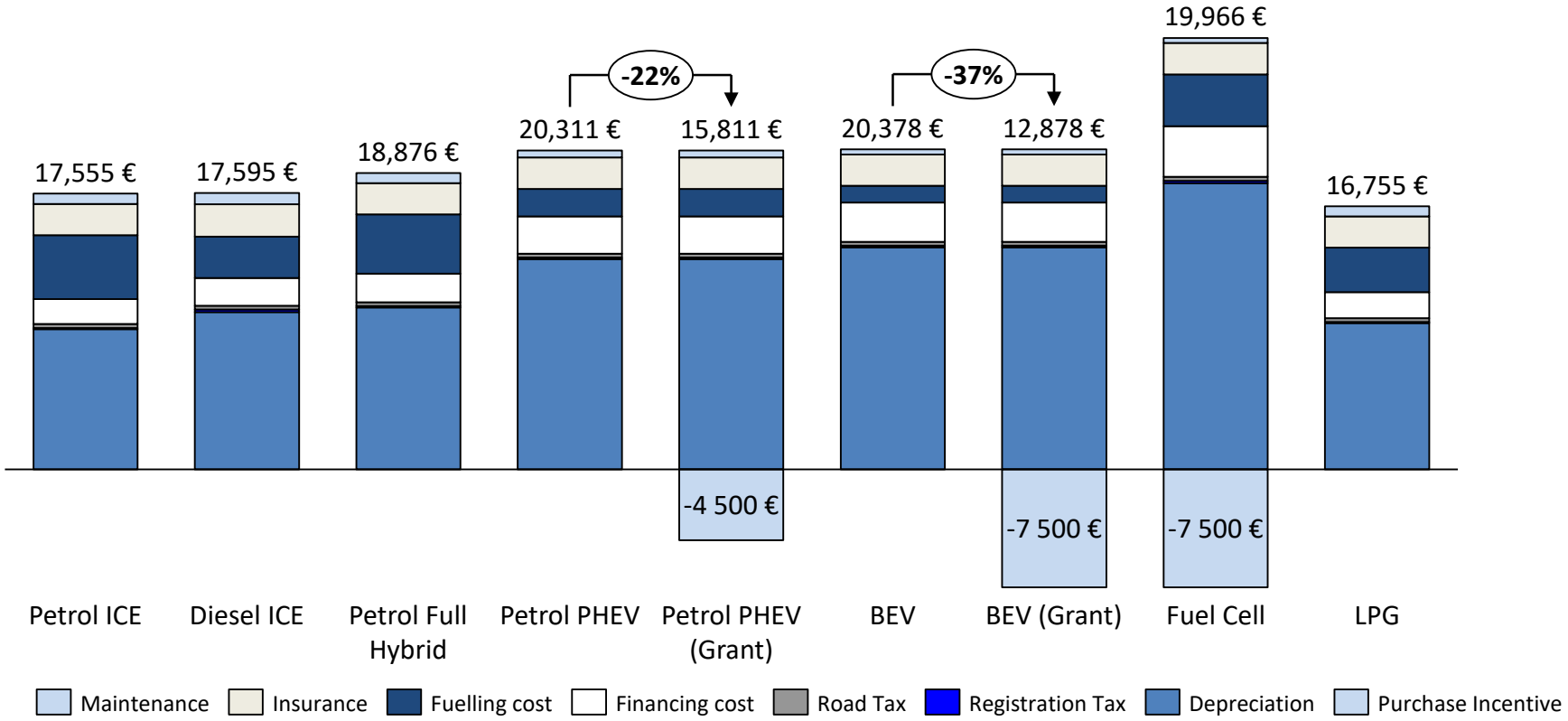
Overview of Lithuania-specific input assumptions

Presentation of initial results

- TCO analysis (Central scenario)
- Home PV charging scenario
- **TCO analysis with Slovenian tax regime**

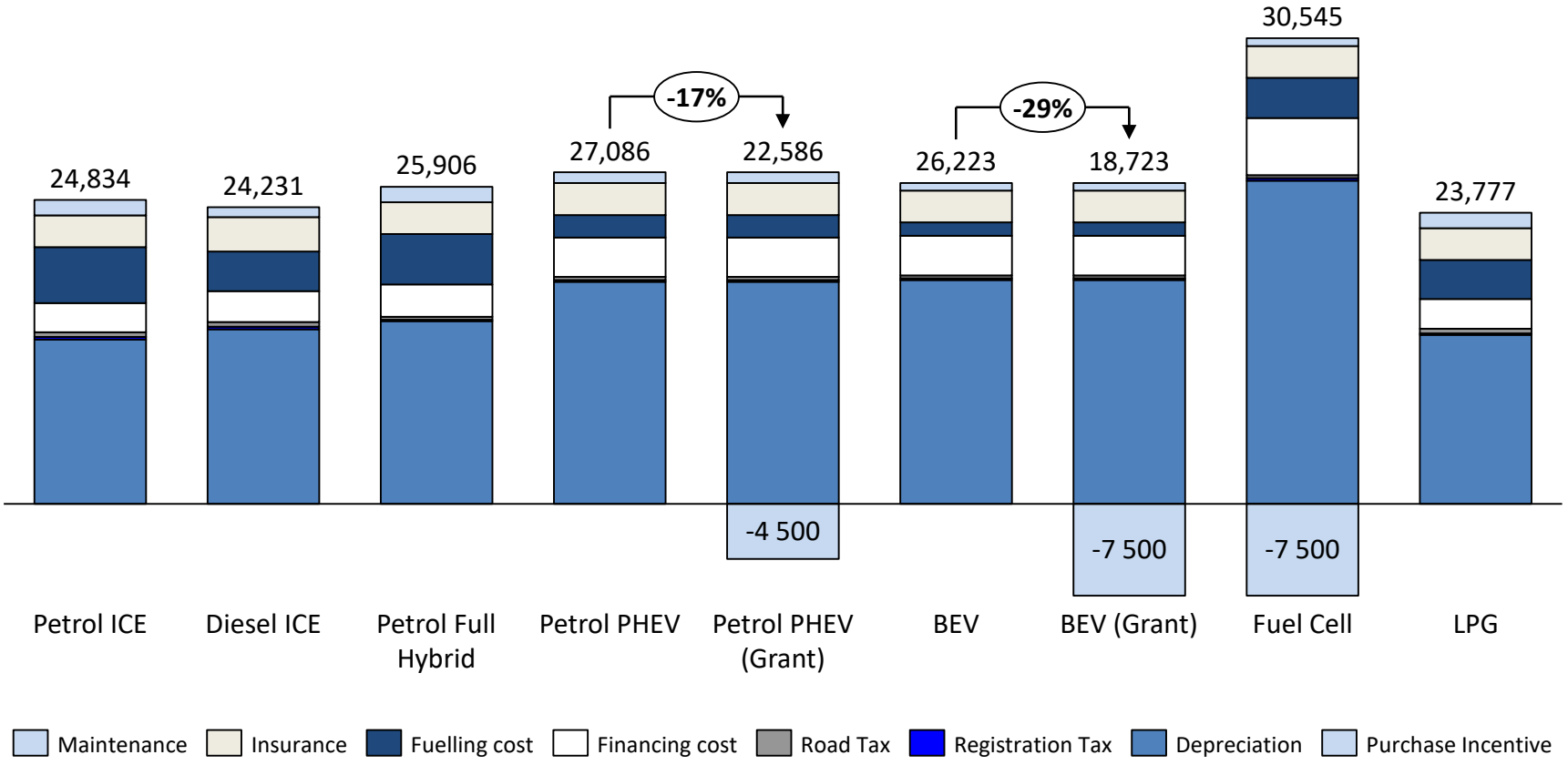
Appendices: Input assumption tables

1st hand B-segment 4 year TCO: 15,000 km per year (bought today)



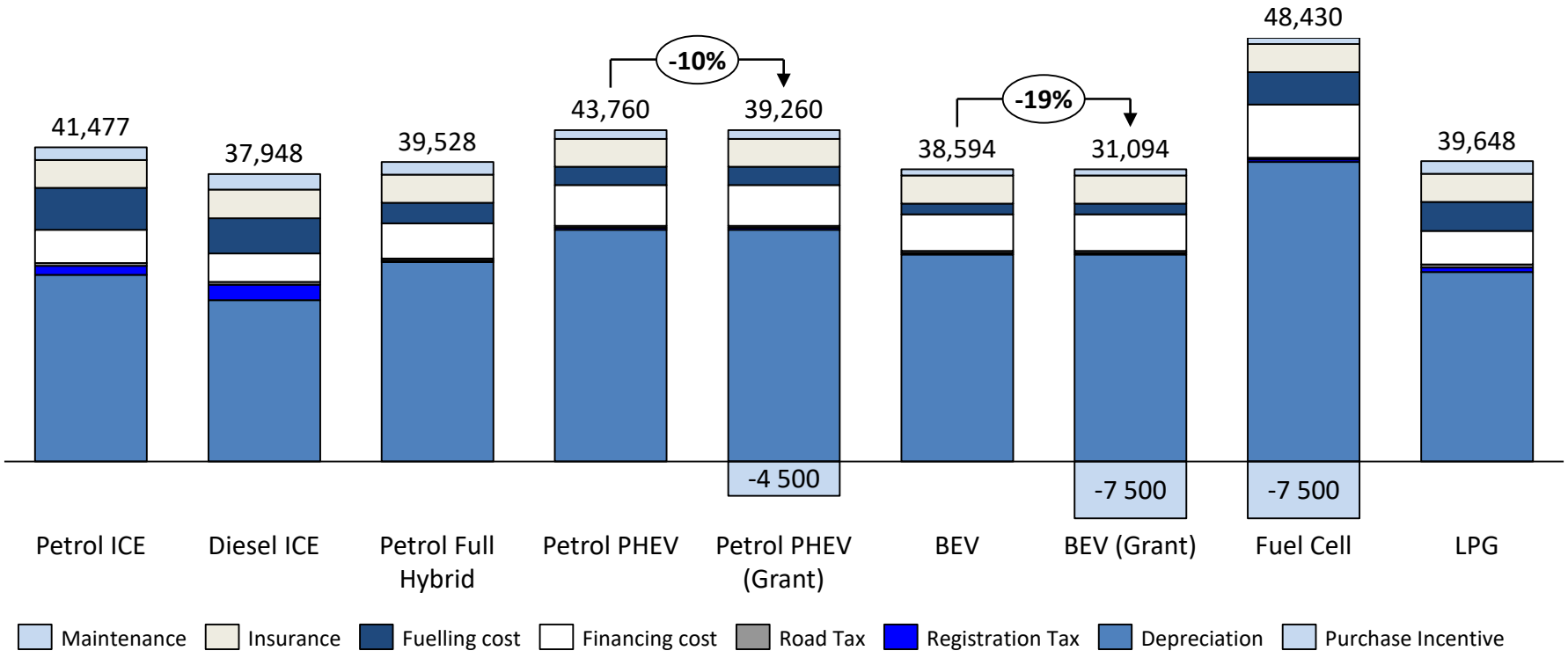
- With the Slovenian tax regime, lower segment (relatively low emission) vehicles are not penalised very much compared to larger segments so the TCO differences seen in the Lithuanian tax regime remain relatively unchanged.
- Adding the Slovenian purchase incentives easily closes the TCO gap between BEVs / PHEVs and their ICE counter-parts, with BEVs becoming cheapest powertrain on a TCO basis for a 1st hand B-segment vehicle owner(€12,878 BEV vs €16,755 LPG)

1st hand C-segment 4 year TCO: 15,000 km per year (bought today)



- The purchase incentive makes less of a difference in terms of percentages for more expensive vehicles but still puts BEVs far below the other powertrains in terms of TCO

1st hand H-segment 4 year TCO: 15,000 km per year (bought today)



- The Slovenian taxes effectively make enough of a difference for BEVs to have a lower TCO than diesel and petrol ICEs.
- All electrified vehicles benefit from the Slovenian tax, with PHEV and full hybrids also becoming cheaper than their non-electrified models.
- In the higher segments, the Slovenian tax regime penalises more polluting vehicles far more than the lower segments, this is seen by the increased gap between pure fossil fuel powertrain TCOs and electrified powertrains.

Agenda

Overview of Lithuania-specific input assumptions

Presentation of initial results

Appendices: Input assumption tables

Input Assumptions (2/5) – to be updated

Model Input	Value	Source
Fuel price	Fuel Duty: • Petrol: 43.4 ¢/l • Diesel: 34.7 ¢/l • LPG: 16.7 ¢/l Price projections to 2050 based on IEA World Energy Outlook 2017 projections	ACEA Tax Guide IEA World Energy Outlook 2017
Electricity Price	- Normal tariff: 11.30 ¢/kWh - Night tariff: 9.1 ¢/kWh (currently not applied)	ALCO
Hydrogen Price	Calculated from Italy coal, oil and electricity prices: 1000 – 700 ¢/kg (2018-2025) then constant at 700 ¢/kg	Coal and gas price from DECC updated energy and emissions projection's
Financing Rate	3%	ALCO

Input Assumptions (3/4) – to be updated

Model Input	Value	Source
Insurance	EU-average	EE Market analysis
Vehicle registration tax	No registration tax, but includes a registration fee and the cost of a roadworthiness test	ACEA Tax Guide 2018
Road Tax	No road tax	ACEA Tax Guide 2018
Technology-specific reductions	No technology-specific reductions	ACEA Tax Guide 2018

Input Assumptions (4/4)

Model Input	Value	Source
Purchase Incentives	No incentives for purchase in Lithuania Slovenian incentives: - €7,500 for a BEV or FCEV - €4,500 for a PHEV	ALCO ACEA Tax guide 2018 for Slovenian incentives
Newly registered vehicle fleet composition	Not used	
Bestselling vehicles within each vehicle segment	Not used	