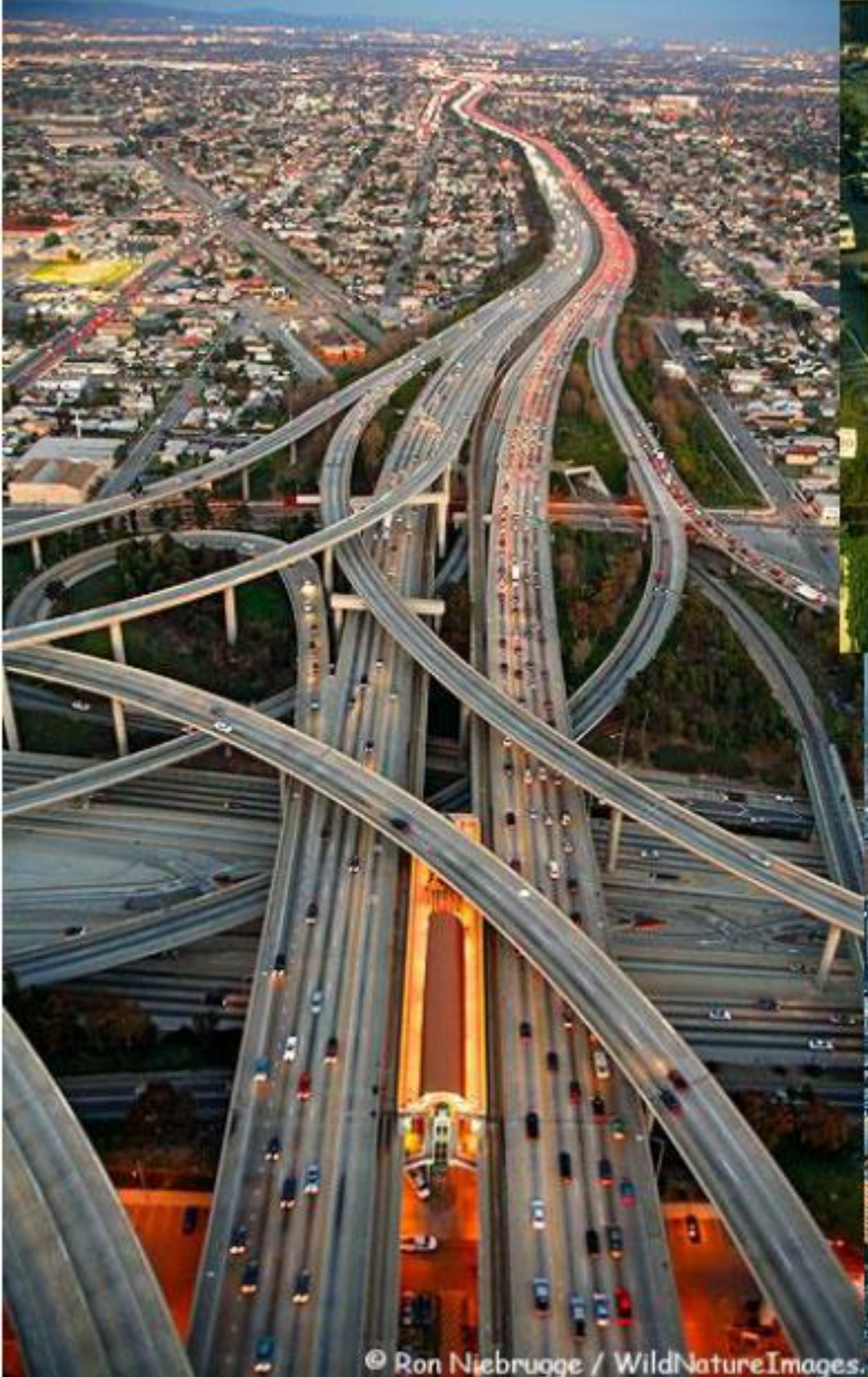
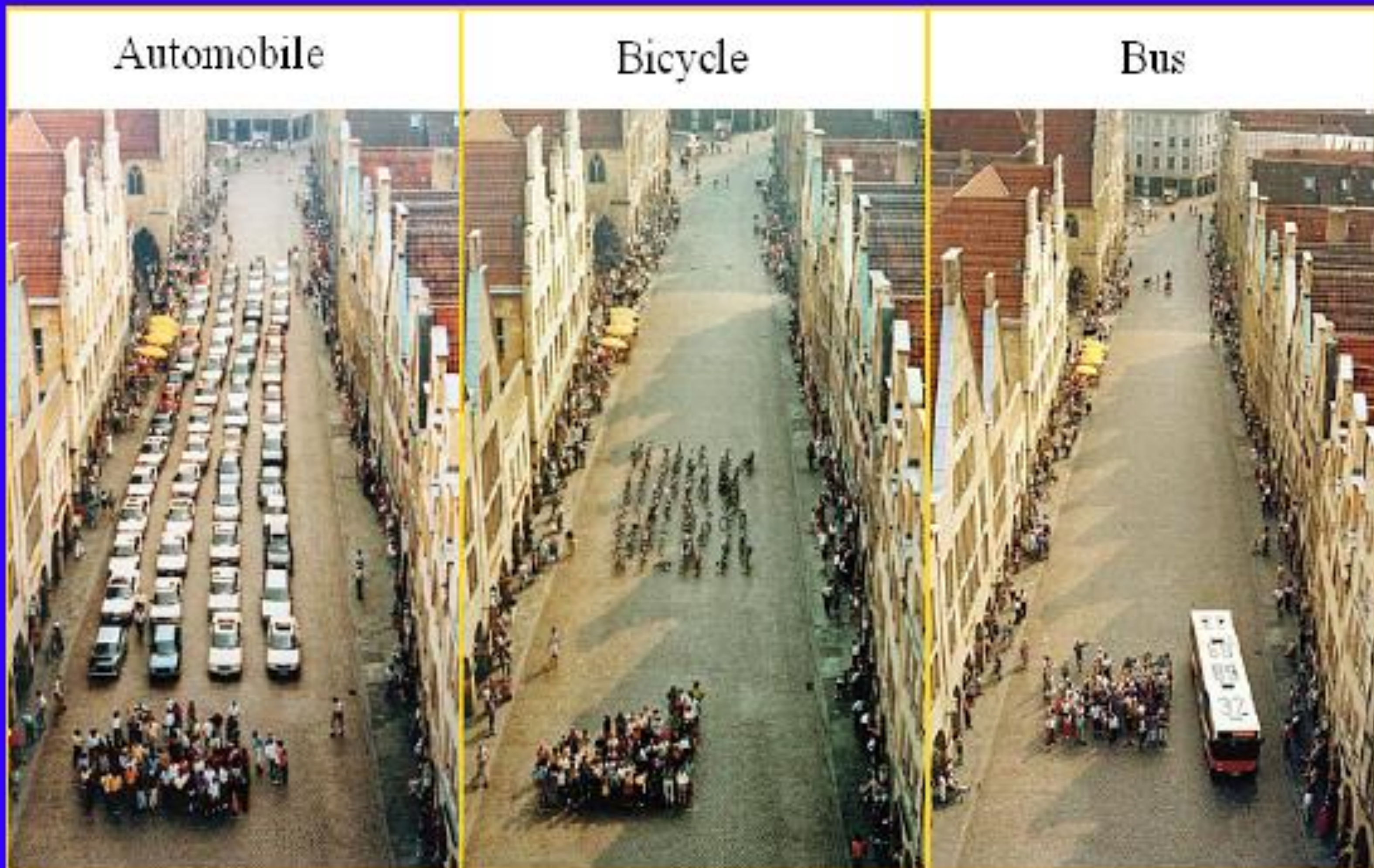
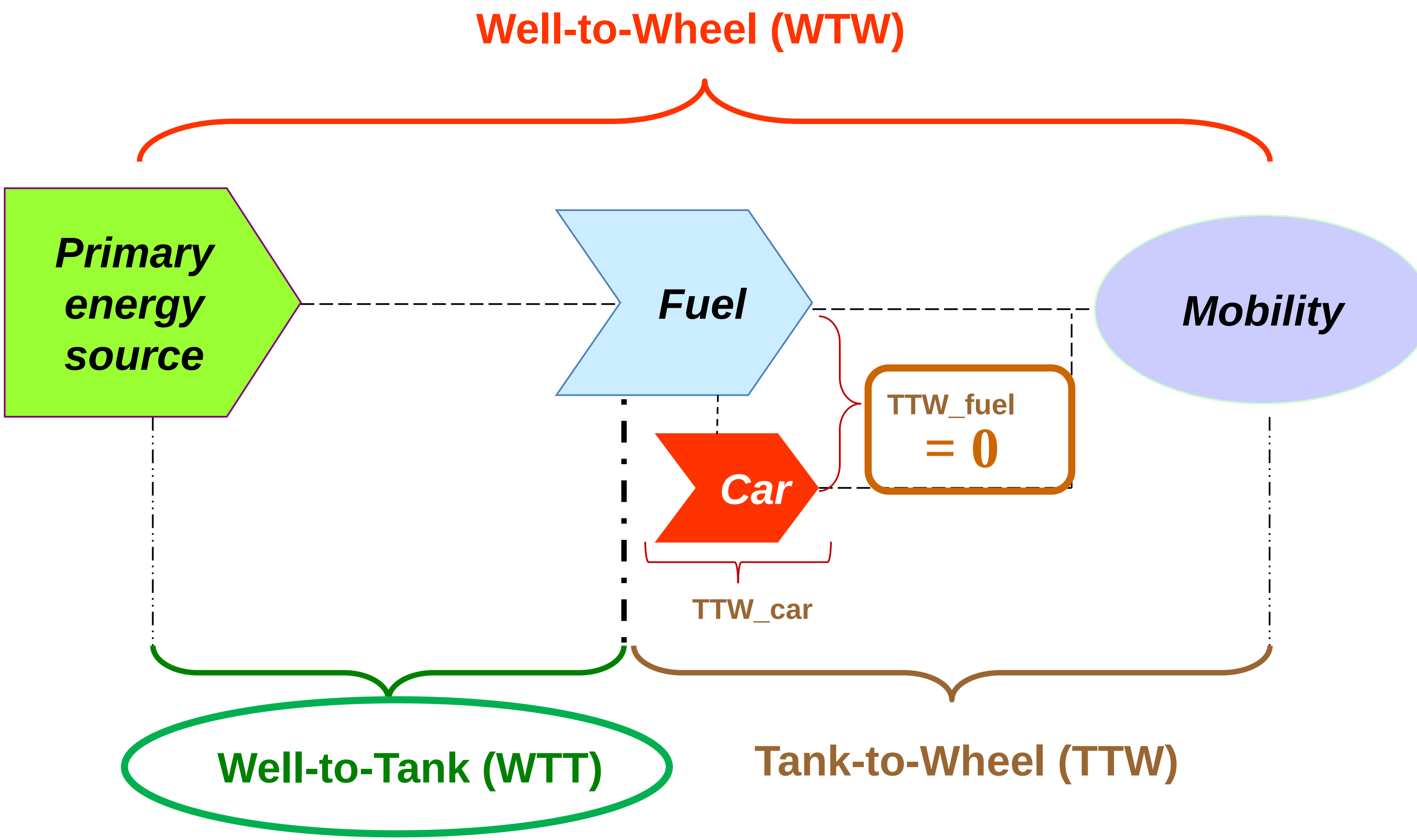
ELECTRIC VEHICLES: CLEAN SOLUTION OR CREATION OF NEW PROBLEMS ?


© Ron Niebrugge / WildNatureImages.

Area Occupied by Various Transport Modes

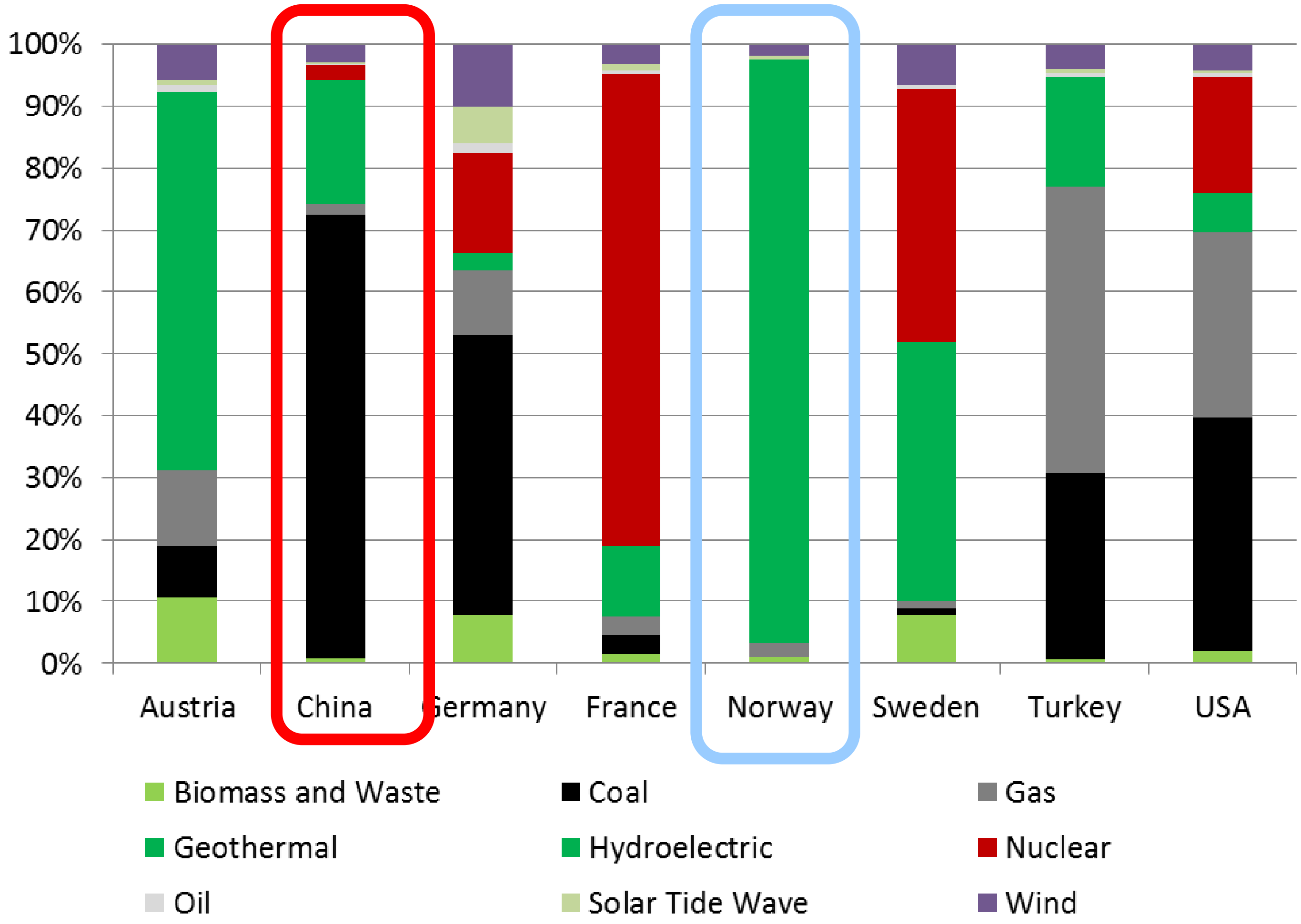


Environmental assessment



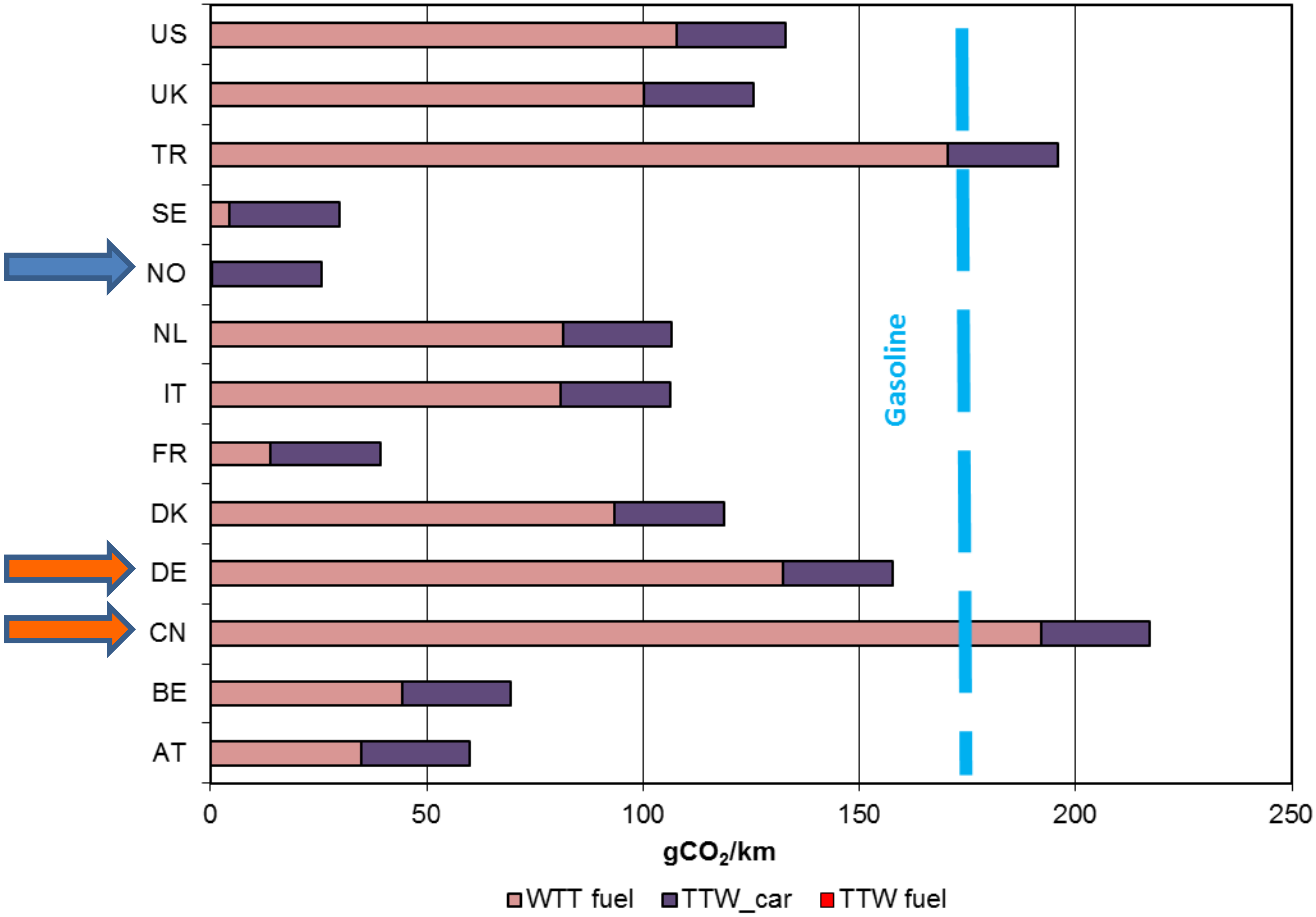
Electric vehicles reduce local pollution!

Electricity mix (2016)



→ **From mix to margin!**

Environmental assessment



The problems of the battery

Where do the materials come from?

- **New dependancies ? From south America …**
- **Children work in Congo to mine scarce materials …**

SOME CONCLUSIONS

- EVs can provide important contribution but we will not solve the transport problems just by changing the technology;
- It is important to conduct a comprehensive assessment from graddle to grave;
- Currently electricity mainly from fossile plants → marginal generation → need for certified green electricity!
- Fair trade for Electric vehicles‘ batteries?

Sustainable energy systems with focus on personal transport electrification

Multi-criteria analysis of sustainability criteria

Aleksandar Janjić

sdewes

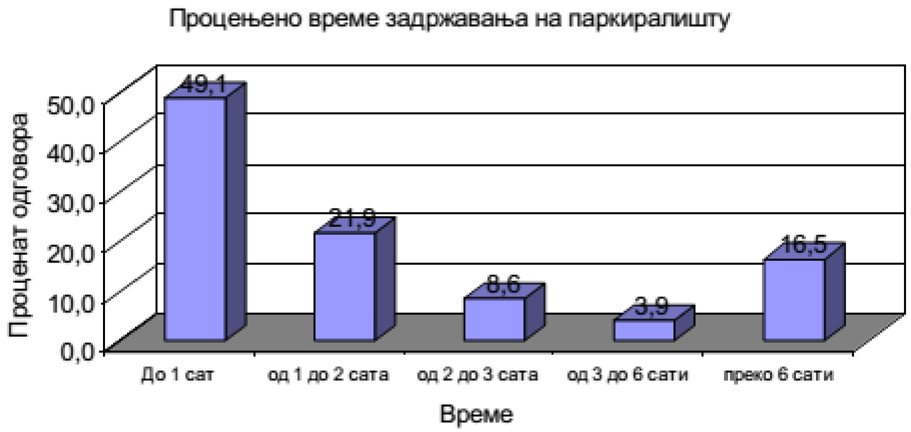
3rd SOUTH EAST EUROPEAN CONFERENCE ON SUSTAINABLE DEVELOPMENT OF ENERGY, WATER AND ENVIRONMENT SYSTEMS

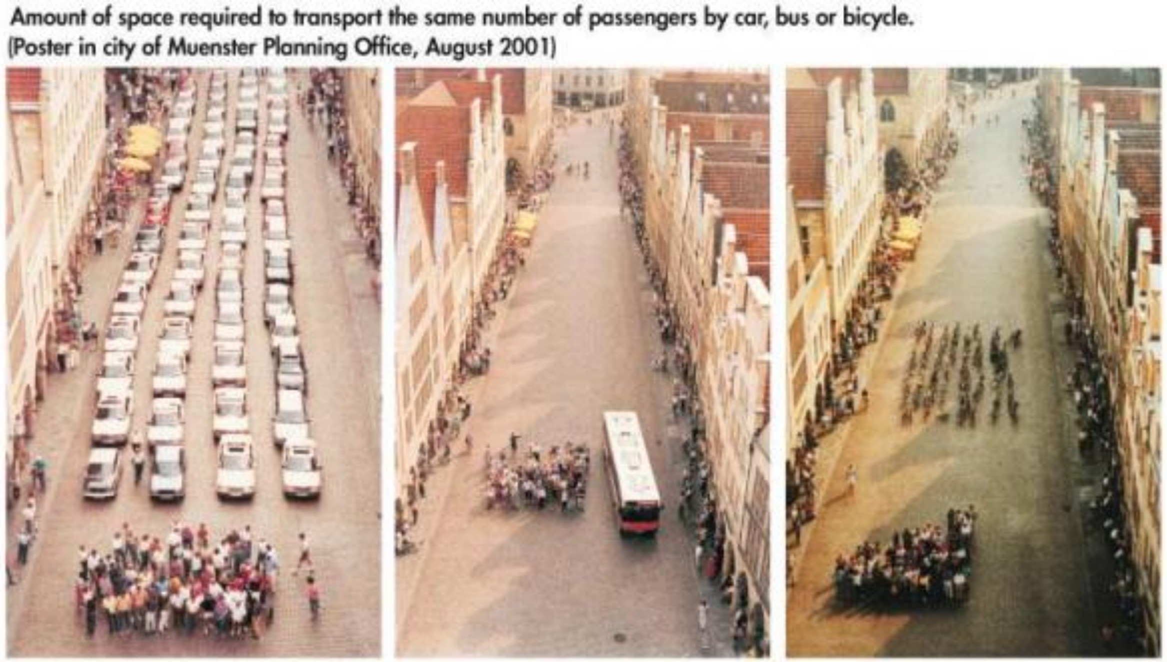
What is the Smart Grid?

EC Smart Grid Task Force

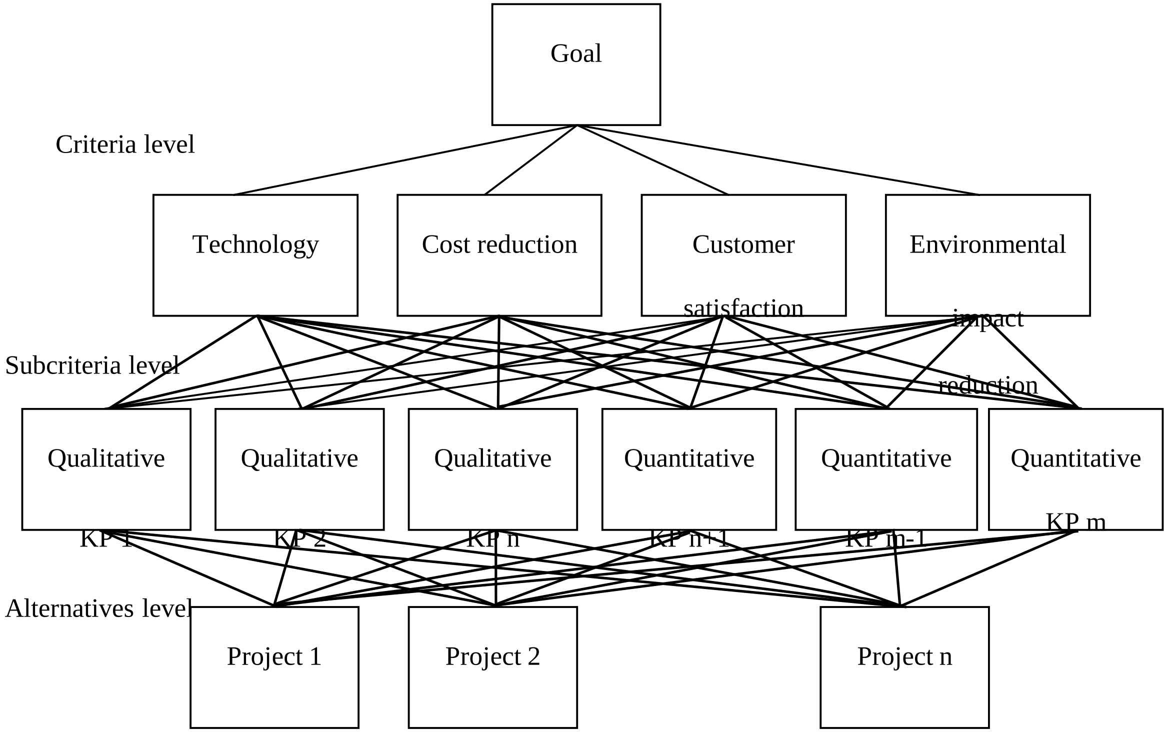
- Increased sustainability;
- Adequate capacity of transmission and distribution grids for ‘collecting’ and bringing electricity to the consumers;
- Adequate grid connection and access for all kinds of grid users;
- Satisfactory levels of security and quality of supply;
- Enhanced efficiency and better service in electricity supply and grid operation;
- Effective support of transnational electricity markets by load flow control to alleviate loop flows and increased interconnection capacities;
- Coordinated grid development through common European, regional and local grid planning to optimise transmission grid infrastructure;
- Enhanced consumer awareness and participation in the market by new players;
- Enable consumers to make informed decisions related to their energy to meet the EU Energy Efficiency targets;
- Create a market mechanism for new energy services such as energy efficiency or energy consulting for customers;
- Consumer bills are either reduced or upward pressure on them is mitigated.

Existing parking system





Multi Criteria Decision Making



Charger location methodologies

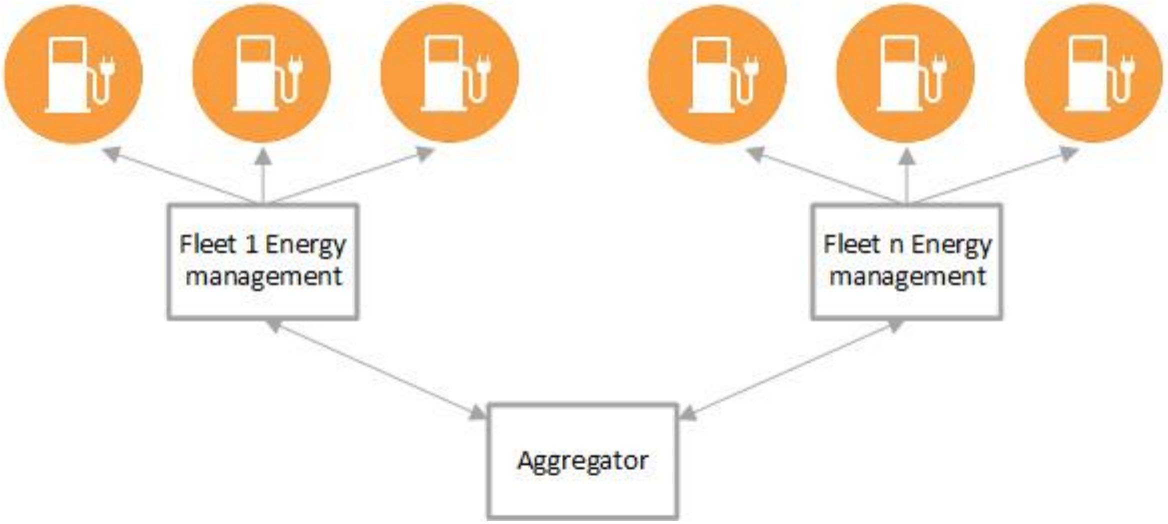
Criteria: construction cost and running cost, traffic status, impact on power grid, impacts on ecology and urban development, user's comfort

- Multiple Objective Decision Making
- Multiple Criteria Decision Making

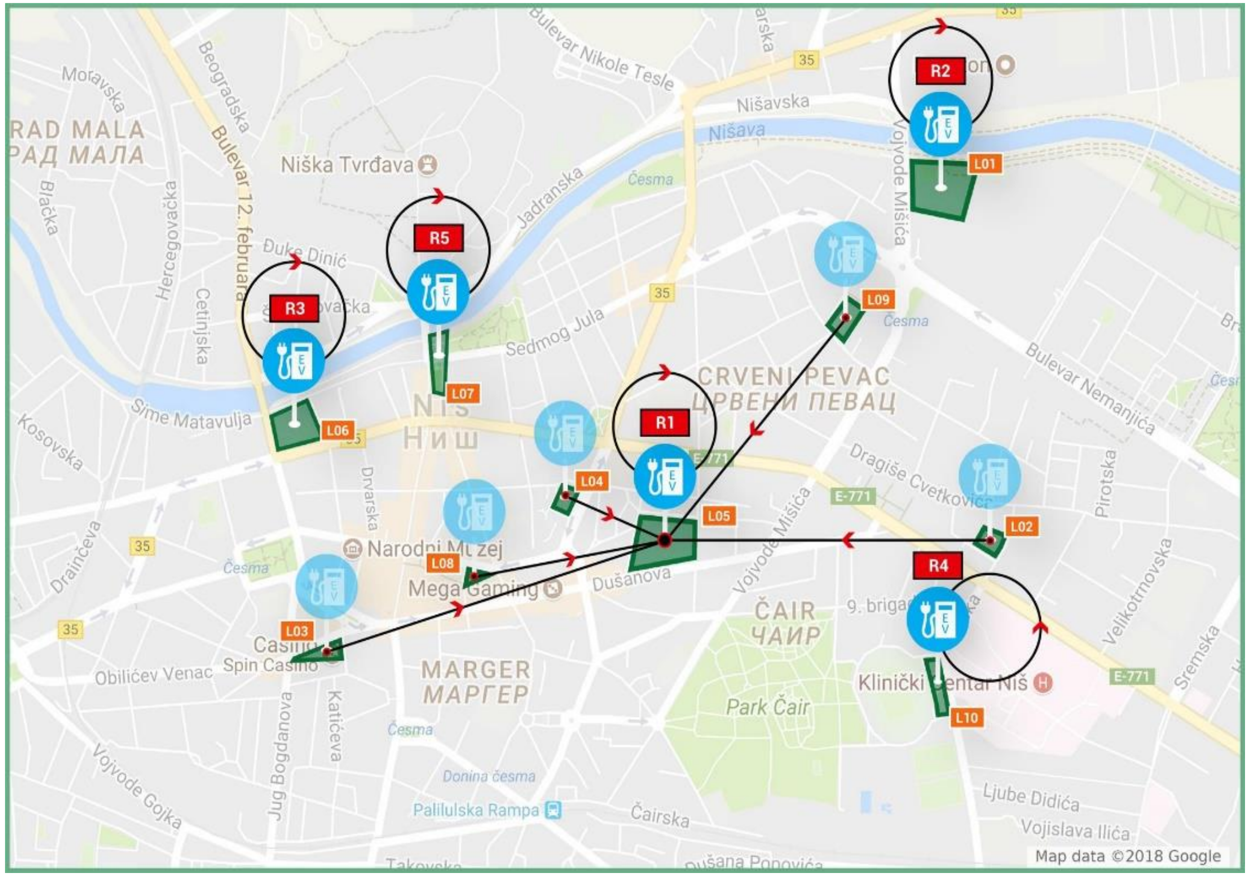
Existing studies, which are based on the application of MODM methodology, for the selection of optimal locations use models such as:

- Linear/ nonlinear programming
- Mixed integer programming
- Stochastic programming
- Genetic algorithm (GA)
- Particle Swarm optimization (PSO)

V2G scheduling



City of Niš Case Study



UNIVERSITY OF ZAGREB
FACULTY OF MECHANICAL ENGINEERING AND NAVAL ARCHITECTURE
DEPARTMENT OF ENERGY, POWER AND ENVIRONMENTAL ENGINEERING

“Impacts of transport sector digitalization and electrification on medium and long term energy planning”

doc. dr. sc. Goran Krajačić, dipl. ing.

Sustainable energy systems with focus on personal transport electrification

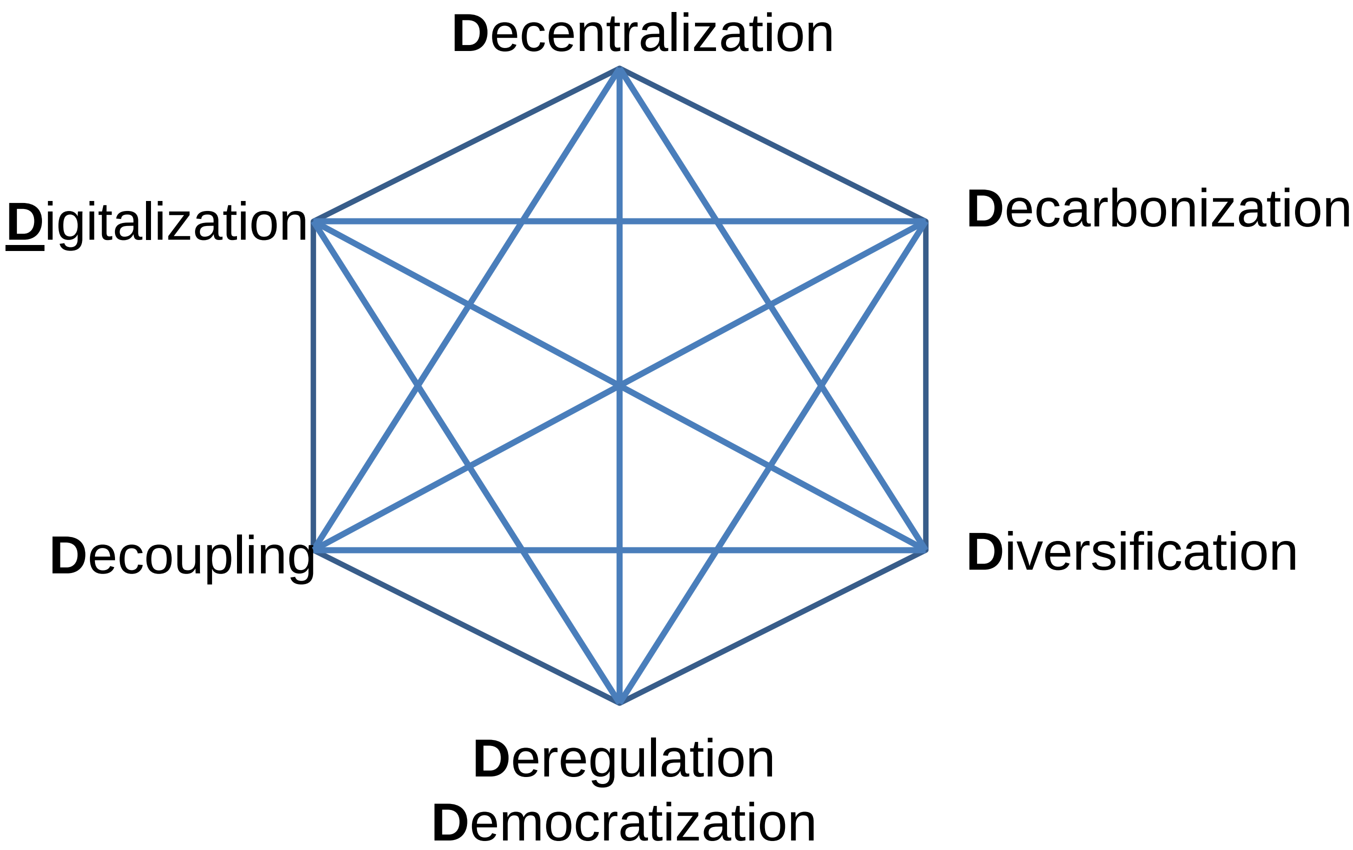
3rd SEE SDEWES Conference

Novi Sad, Serbia

01/07/2018

3rd SEE sdewes Conference Novi Sad 2018

ENERGY TRANSITION



UNIVERSITY OF ZAGREB

FACULTY OF MECHANICAL ENGINEERING AND NAVAL ARCHITECTURE

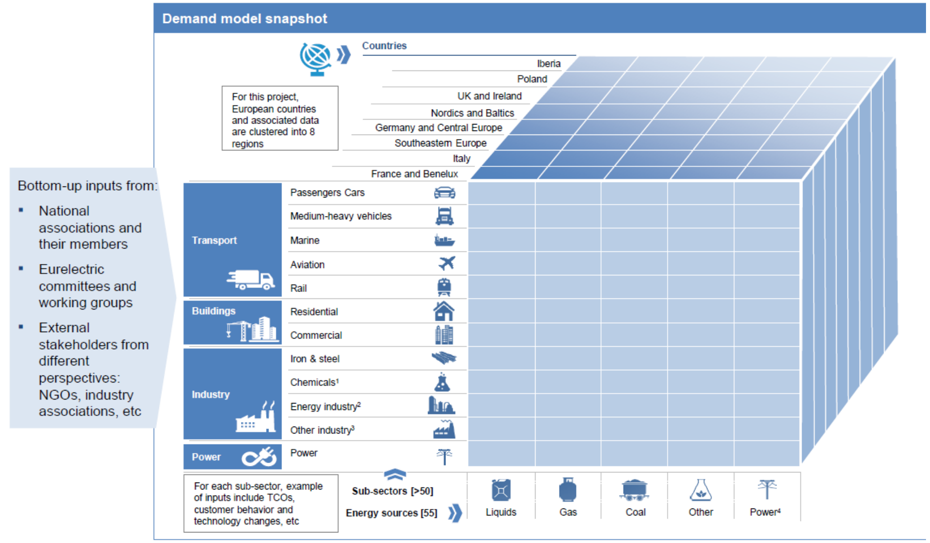
DEPARTMENT OF ENERGY, POWER AND ENVIRONMENTAL ENGINEERING

eurelectric powering people

Decarbonization pathways

European economy

EU electrification and decarbonization scenario modelling
Synthesis of key findings
May 2018

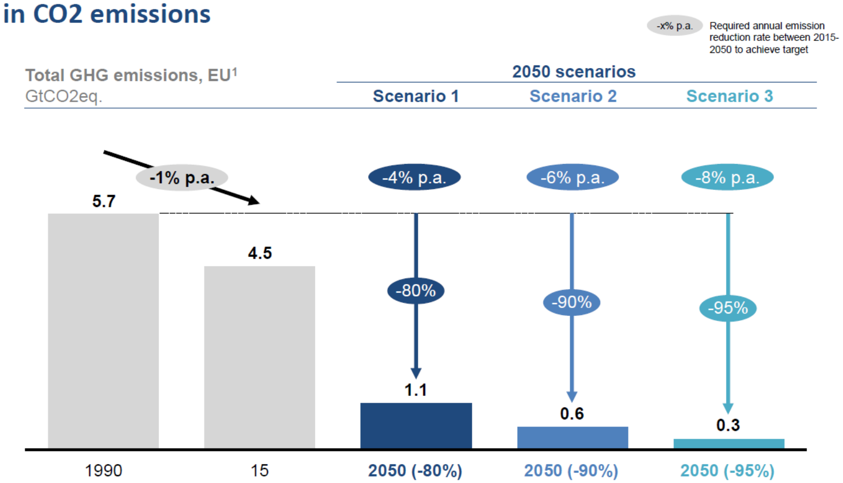


1. Organic, Ammonia, Other; 2. Oil & Gas, Own use, Other 3. Construction, Food & Agriculture, Manufacturing, Materials, Mining, Non-Energy, Other; 4. Separate global granular model
SOURCE: Energy Insights, a McKinsey Solution – Global Energy Perspective

OVERALL ELECTRIFICATION SCENARIOS

eurelectric

The 3 scenarios deliver unprecedented but necessary reductions in CO2 emissions



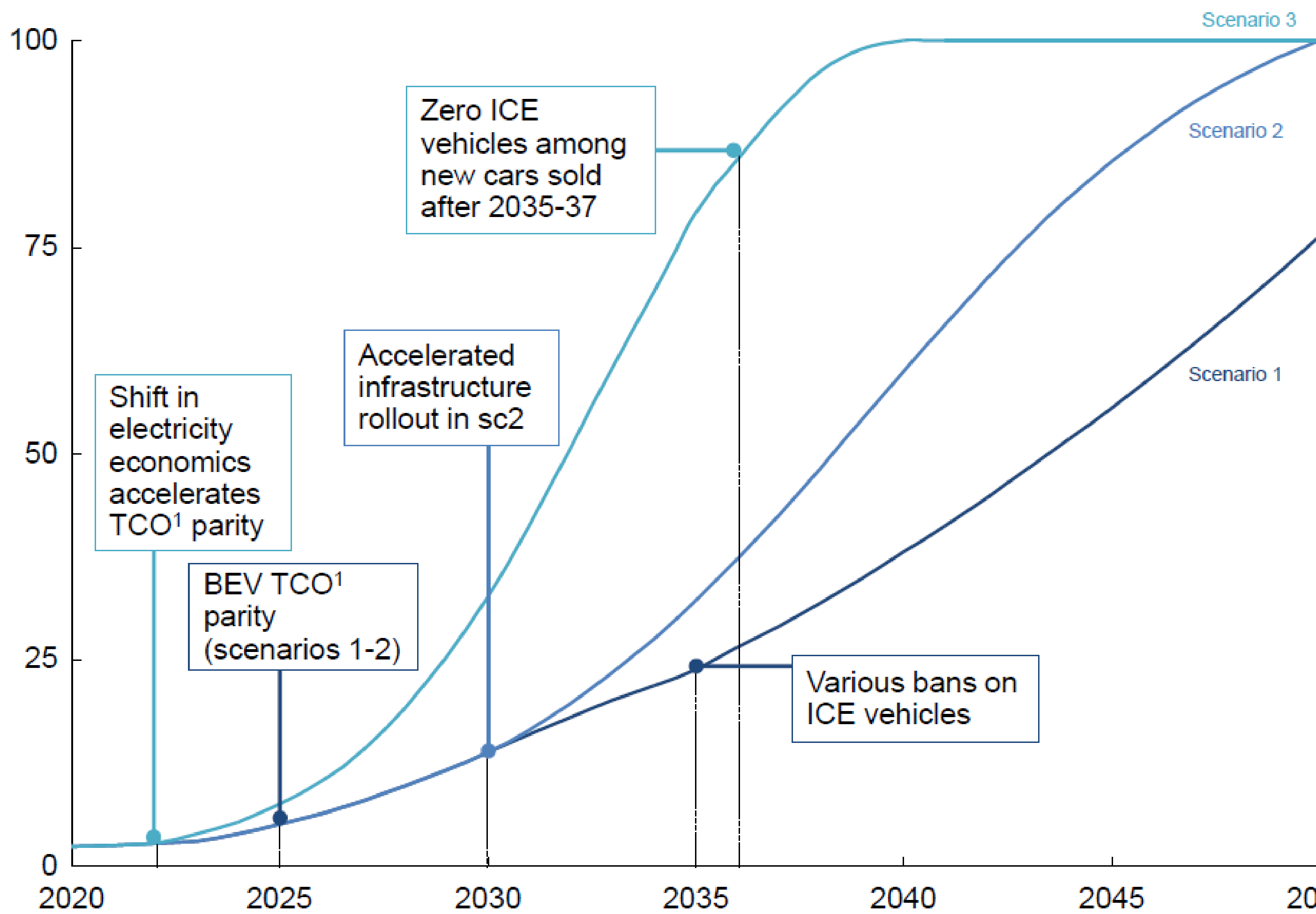
Direct electrification results by scenario

		2015 Baseline	2050 Scenario 1	2050 Scenario 2	2050 Scenario 3
Total EU economy	EU economy decarbonization vs 1990	22%	80%	90%	95%
	Direct electrification rate	22%	38%	48%	60%
Total transport	Direct electrification rate	1%	29%	43%	63%
Total buildings	Direct electrification rate	34%	45%	54%	63%
Total industries	Direct electrification rate	33%	38%	44%	50%

source: eurelectric

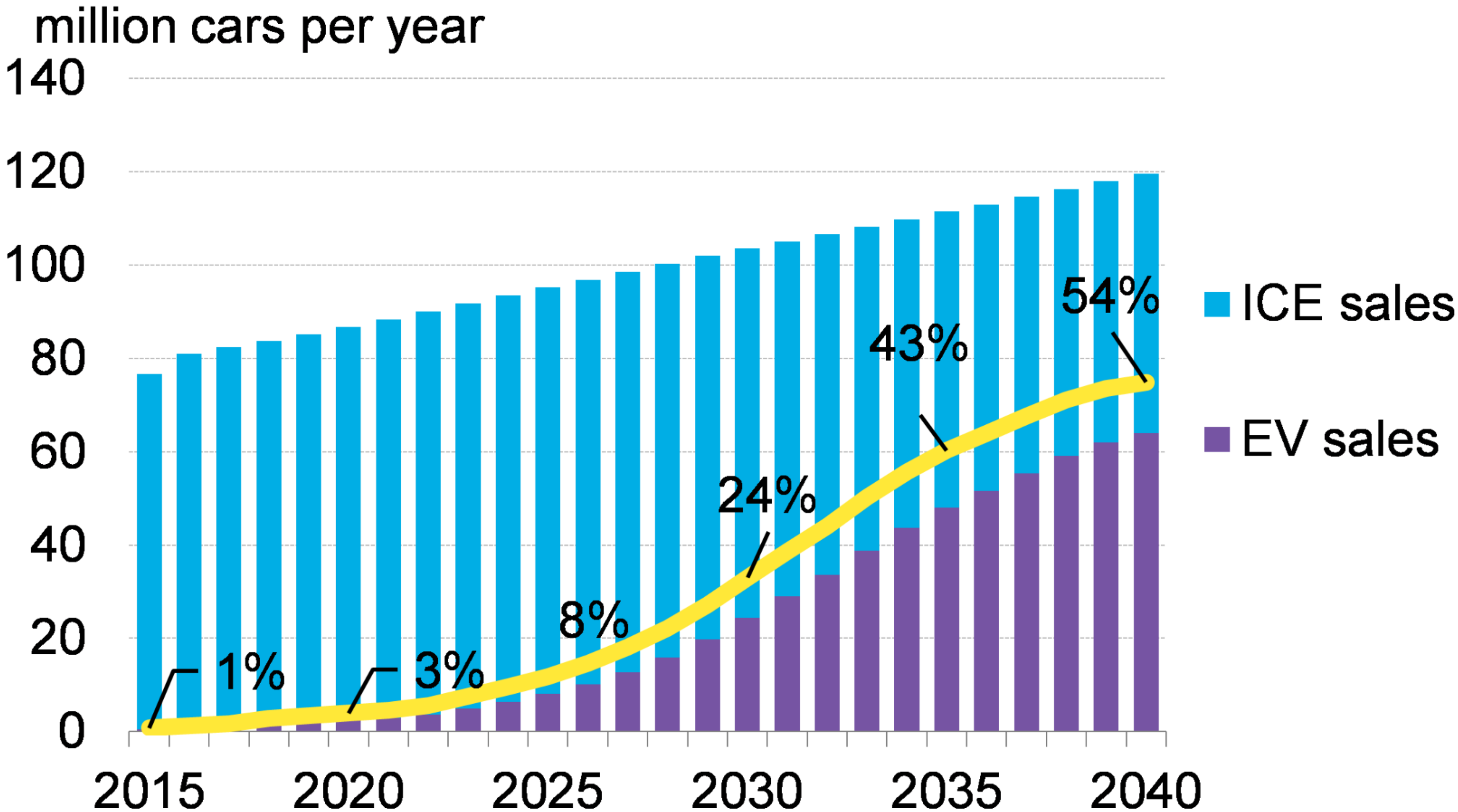
Share of battery electric vehicles (BEVs) in new sales in the EU

Percent



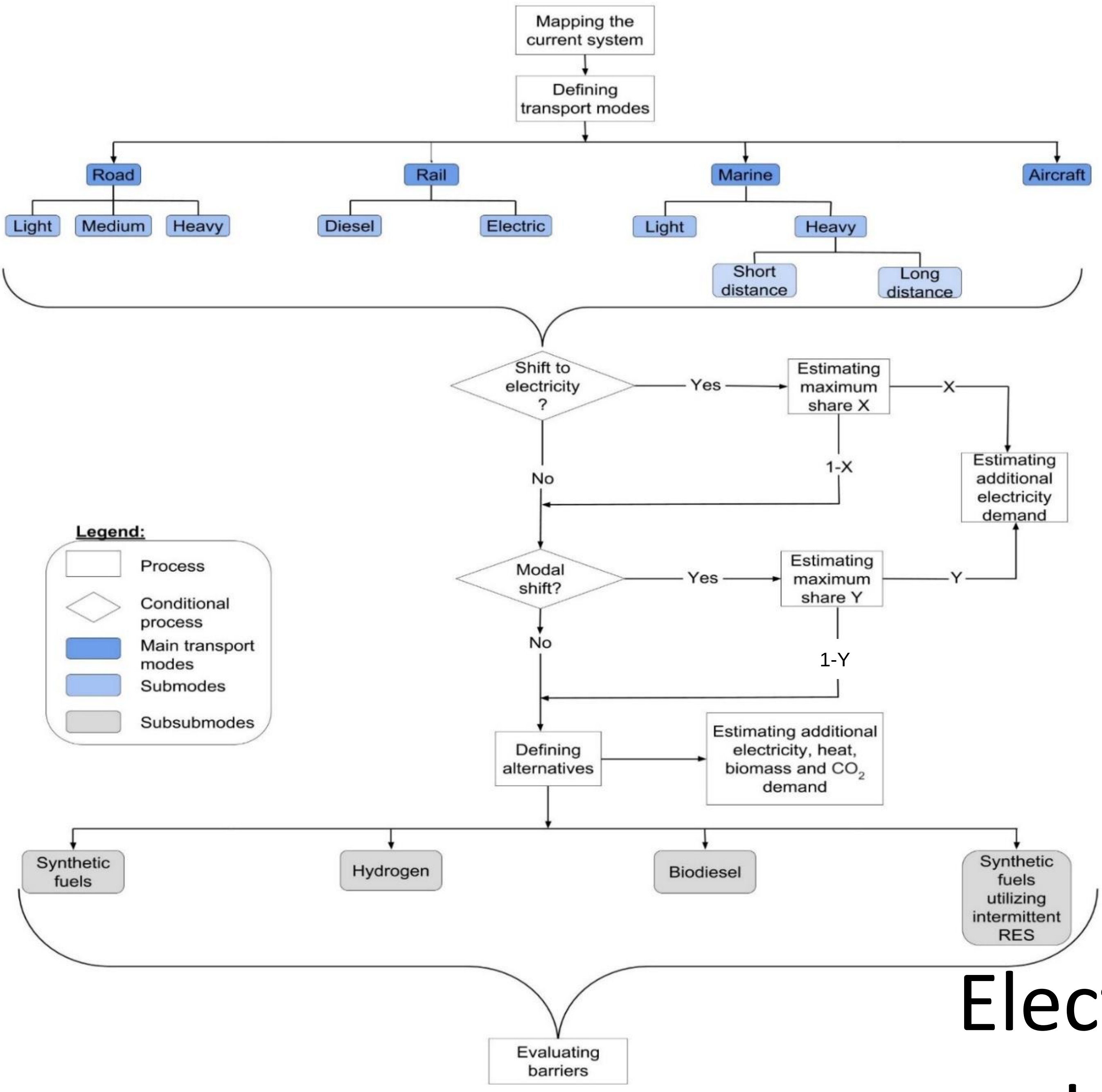
Key drivers of BEVs sales

- Current fleet
- Macro-economic drivers: GDP, population growth
- Scrap rates, especially of internal-combustion-engine (ICE) vehicles
- TCO of BEVs relative to other competing technologies, driven by decreasing battery cost
- Demand for shared mobility and autonomous driving
- Infrastructure deployment and innovation *(i.e. wireless charging)*
- Non-economic drivers for BEV acquisition *(i.e. regulation, environmental awareness)*



source: Bloomberg New Energy Finance

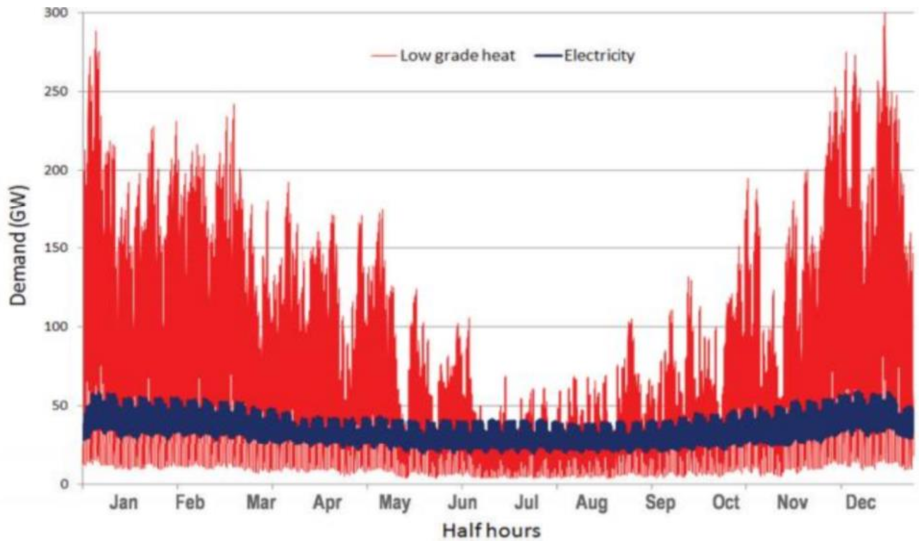
Electrification of transport?



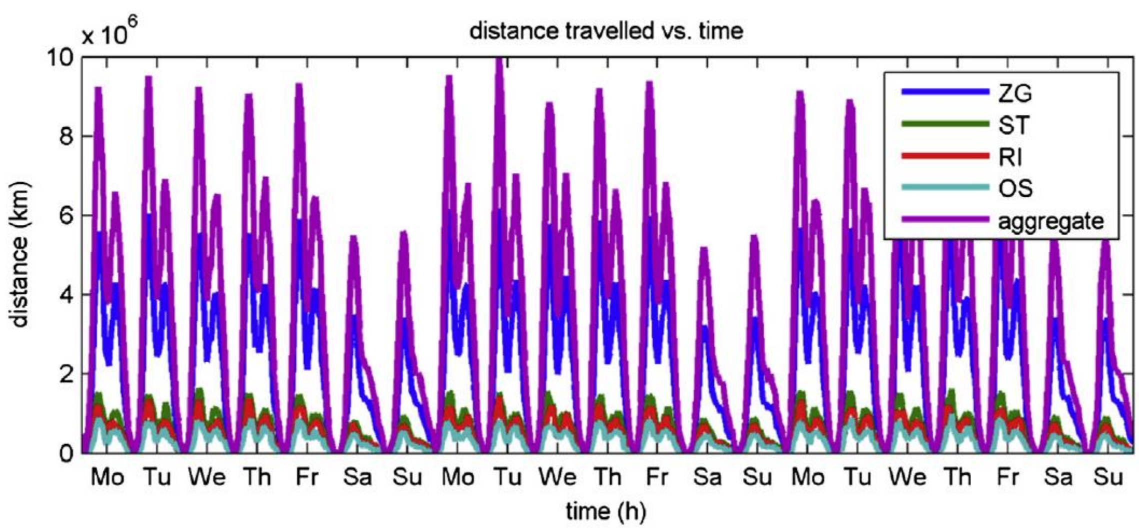
ELSEVIER
Renewable and Sustainable Energy Reviews
Available online 5 July 2017
In Press, Corrected Proof

The future of transportation in sustainable energy systems: Opportunities and barriers in a clean energy transition

D.F. Dominković [a], I. Bačeković [b], A.S. Pedersen [a], G. Krajačić [c]



Source: Robert Sansom (Imperial College), Winter Peak Heat Demand



Contents lists available at ScienceDirect

Energy

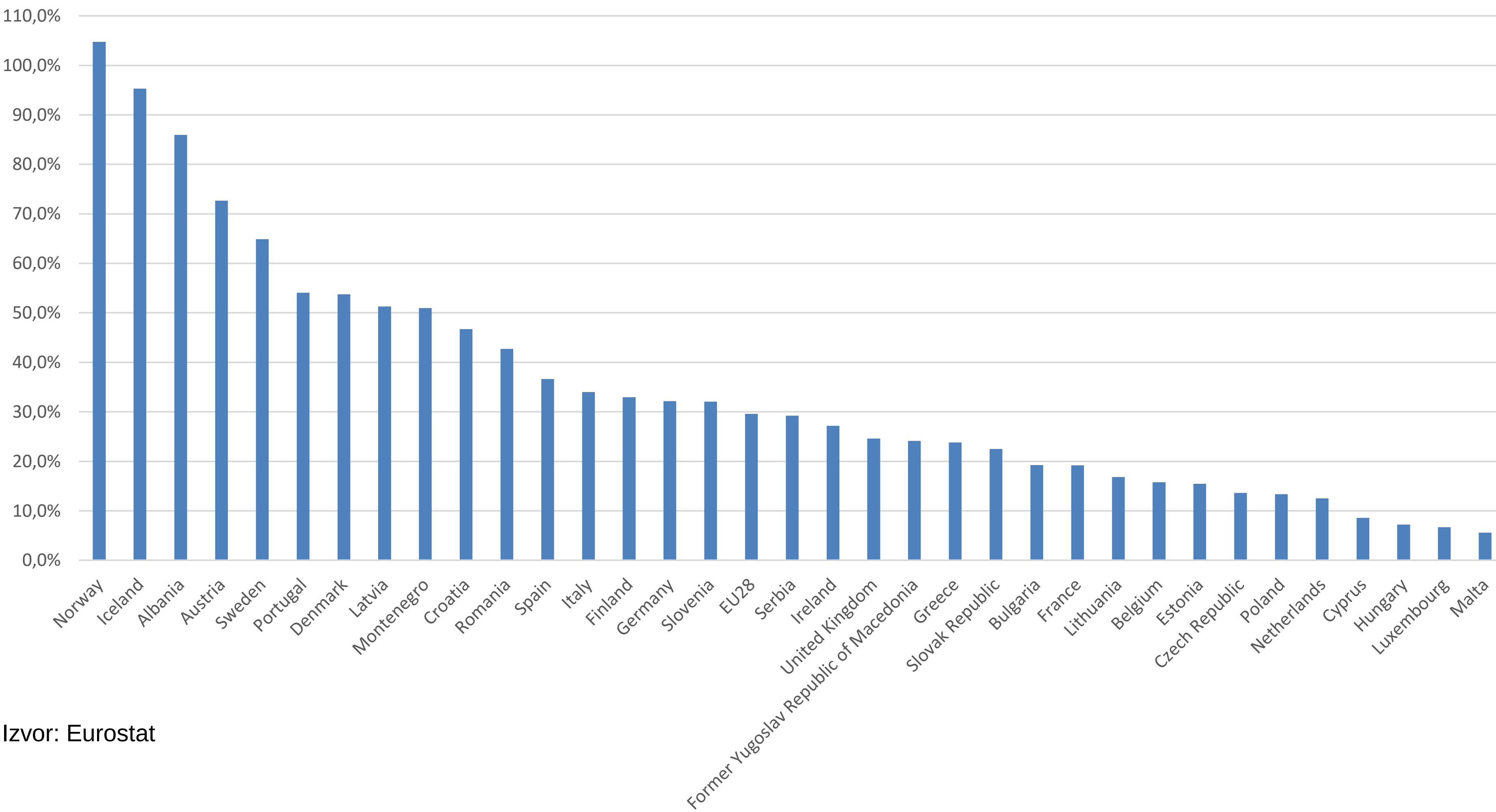
journal homepage: www.elsevier.com/locate/energy

Agent based modelling and energy planning – Utilization of MATSim for transport energy demand modelling

T. Novosel [a,*], L. Perković [a], M. Ban [a], H. Keko [b], T. Pukšec [a], G. Krajačić [a], N. Duić [a]

[a] University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Department of Energy, Power Engineering and Environment, Ivana Lučića 5, 10002 Zagreb, Croatia
[b] Energy Institute Hrvoje Požar, Department for Energy Generation and Transformation, Savska 163, 10001 Zagreb, Croatia

100% RES electricity supply ?

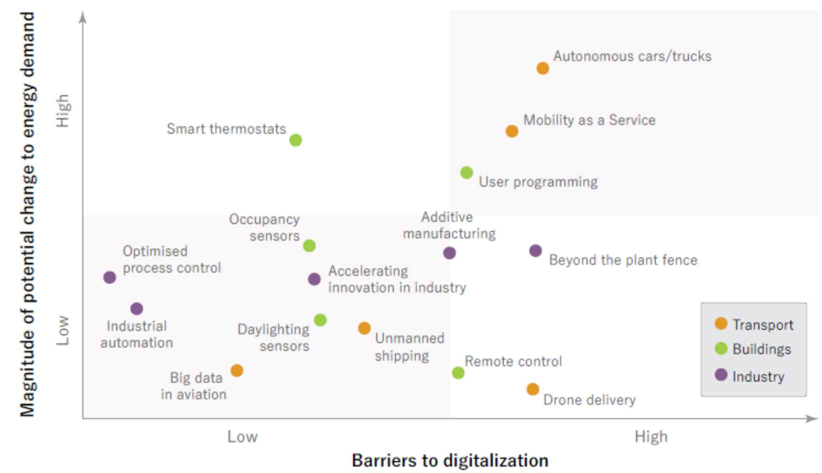


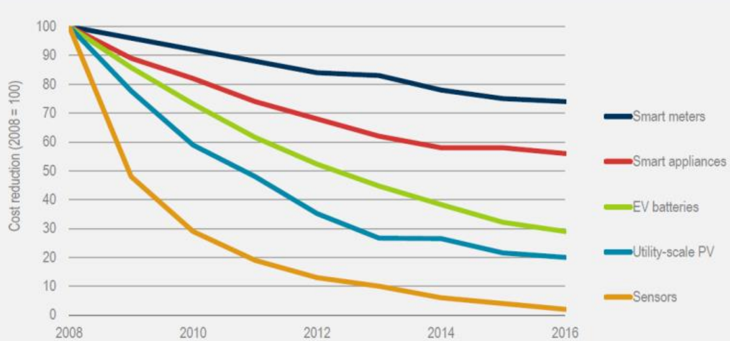
Izvor: Eurostat

Digitalization – market capitalization

Key message: Digital technology companies have become global leaders by market capitalisation, though energy companies still lead in revenues.

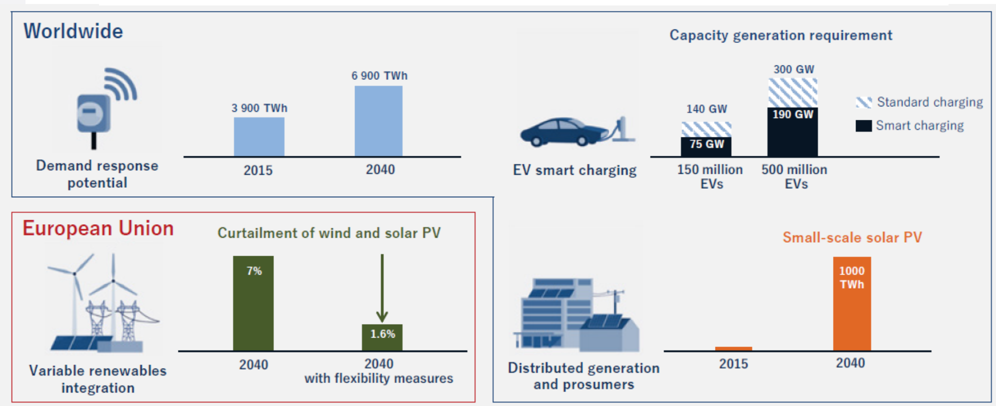
Notes: Rankings are for publicly traded companies; market capitalisations calculated at the end of Q2; circle sizes are relative to market capitalisation.





Key message: Technology cost reduction is a key driver enhancing connectivity throughout the electricity sector.

Sources: IEA analysis based on Bloomberg New Energy Finance (2017); Holdowsky et al. (2015); IEA (2017a; 2017b; 2017c); Navigant Research (2017).

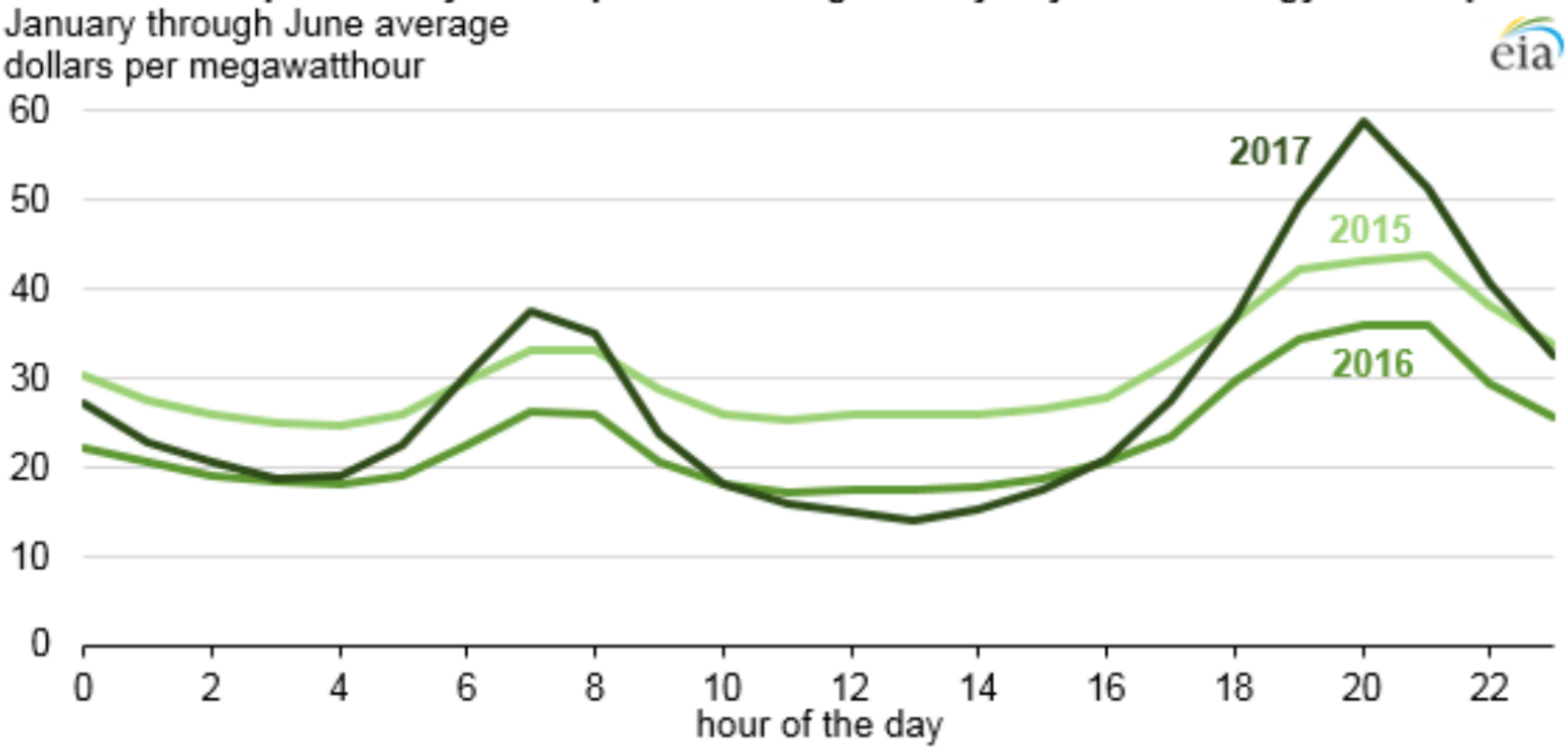


Key message: Digitalization is set to greatly enhance demand flexibility, the integration of variable renewables, smart changing for EVs and distributed generation.

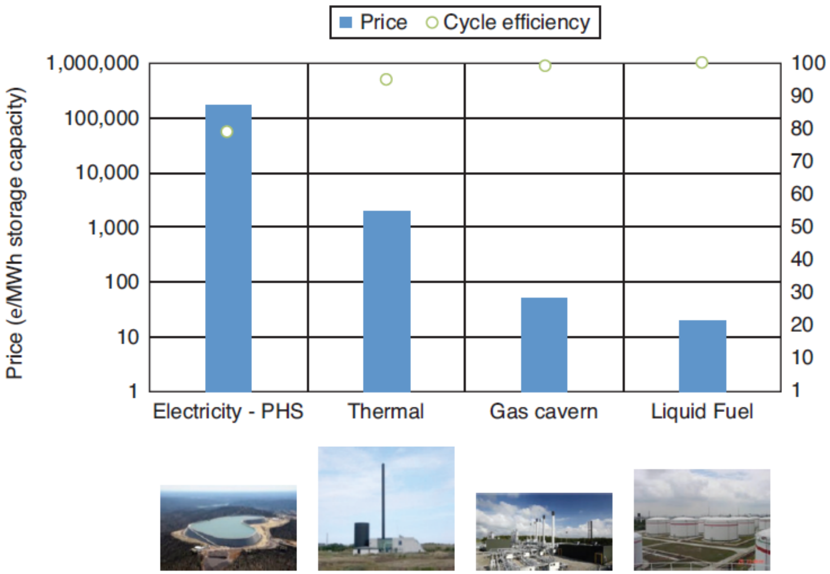
Sources: Analysis based IEA (2016; 2017d).

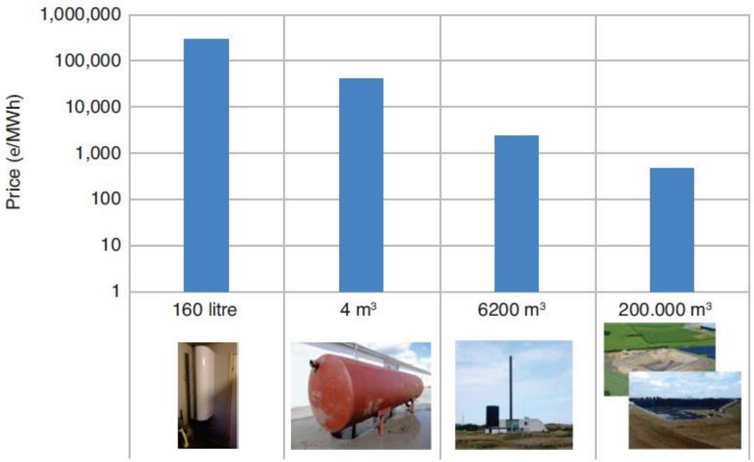
Market response to solarization

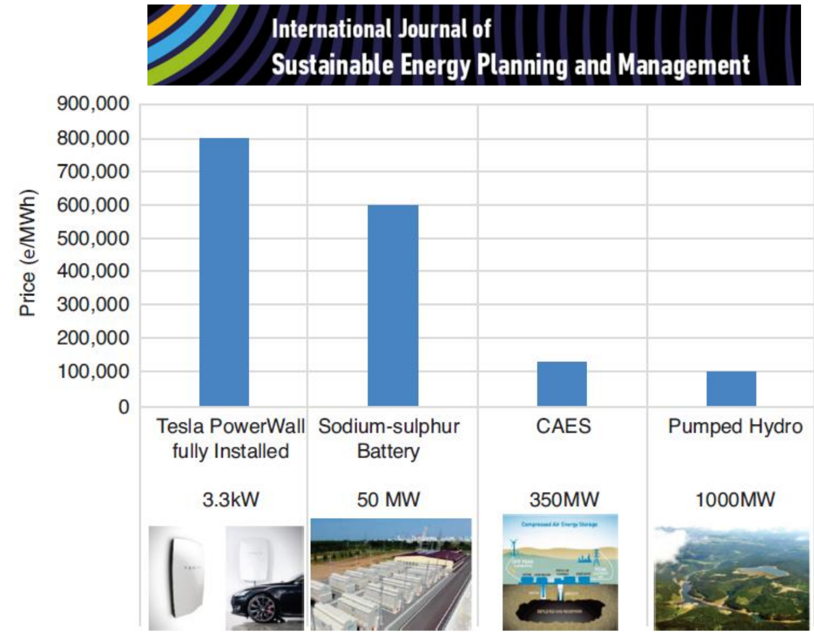
California Independent System Operator average hourly day-ahead energy market prices
January through June average
dollars per megawatthour



Source: U.S. Energy Information Administration, based on ABB Energy Velocity
Note: Prices are simple averages of CAISO trading hubs ZP26, NP15, and SP15 from January 1 through June 30 of each year.







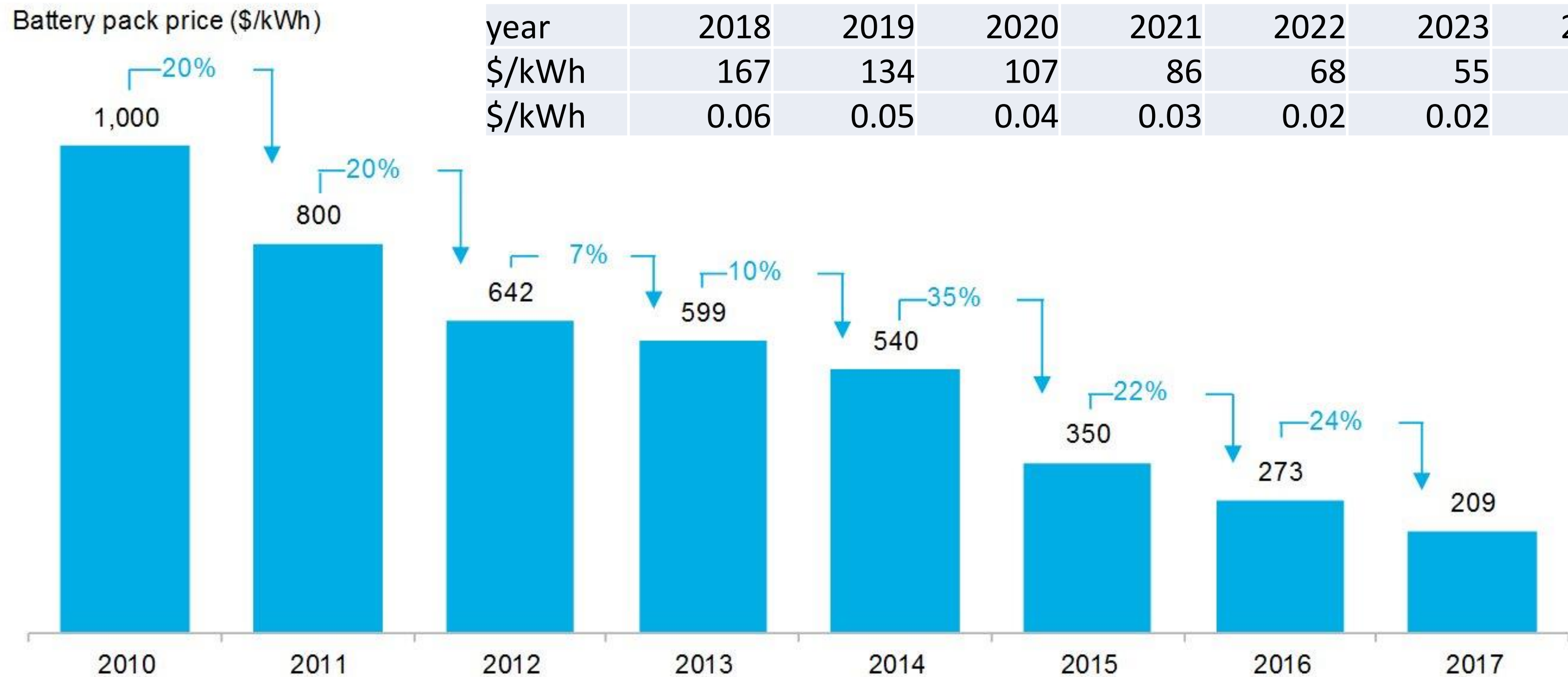
Energy storage?

Source: Energy Storage and Smart Energy Systems
Henrik Lund, Poul Alberg Østergaard, David Connolly, Iva Ridjan, Brian Vad Mathiesen, Frede Hvelplund, Jakob Zinck Thellufsen, Peter Sorknæs

Capacity	1	kWh
Cost	209	$/kW
Lifetime	10	year
Capital cost	5%	
Yearly cost	27.07	$
Daily 1 kWh	365	kWh
LCOE for 1 kWh	0.07	$/kWh

BNEF EV lithium-ion battery pack price survey results

year	2018	2019	2020	2021	2022	2023	2024	2025
$/kWh	167	134	107	86	68	55	44	35
$/kWh	0.06	0.05	0.04	0.03	0.02	0.02	0.02	0.01



Source: Bloomberg New Energy Finance. Pack level pricing. Weighted average of BEV and PHEV packs

Bloomberg New Energy Finance

CLEAN ENERGY FOR ALL EUROPEANS

THANK YOU FOR YOUR ATTENTION!

goran.krajacic@fsb.hr

- Energy Technology Perspectives 2012,2014,2015,2016, 2017 IEA
- Digitalization and Energy 2017, IEA, 2017
- Harnessing Variable Renewables, IEA, 2011
- Lund, H. Renewable Energy Systems, The Choice and Modeling of 100% Renewable Solutions, Elsevier, 2010
- D. F. Dominković, I. Bačeković, A. S. Pedersen, and G. Krajačić, "The future of transportation in sustainable energy systems: Opportunities and barriers in a clean energy transition," *Renewable and Sustainable Energy Reviews*, vol. 82. pp. 1823–1838, 2018.

The development of the power transmission system of electric vehicles.

Huseyin Ayhan Yavasoglu, Ph.D.

TÜBİTAK

TUBITAK

ENERGY INSTITUTE

Automotive Center for Excellence

July 2018

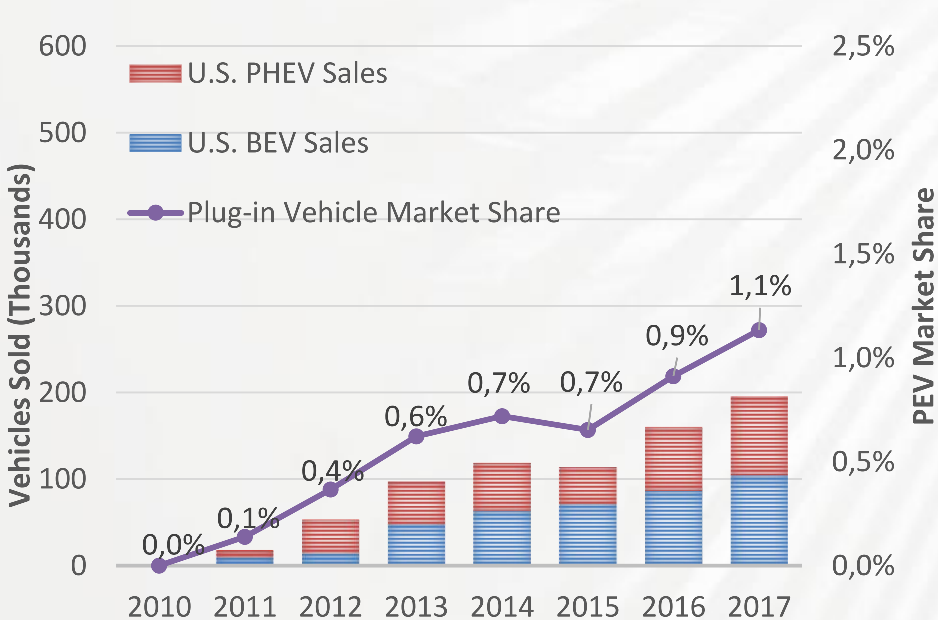
Electric Vehicles

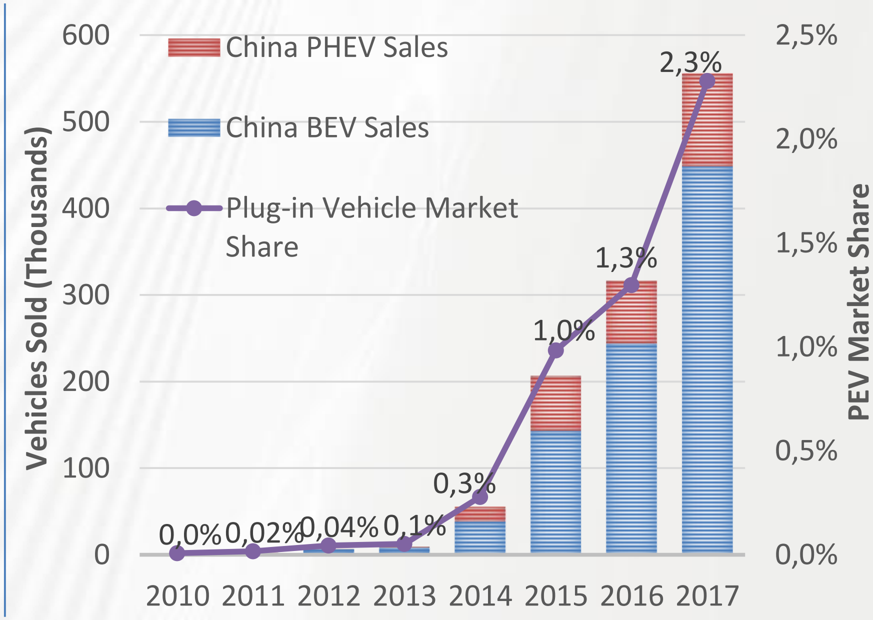
TÜBİTAK

Why EV?

- To reduce petroleum dependency.
- Environmental concerns.
- To have more efficient and quiet transportation.

PEV Market Share





http://www.anl.gov/

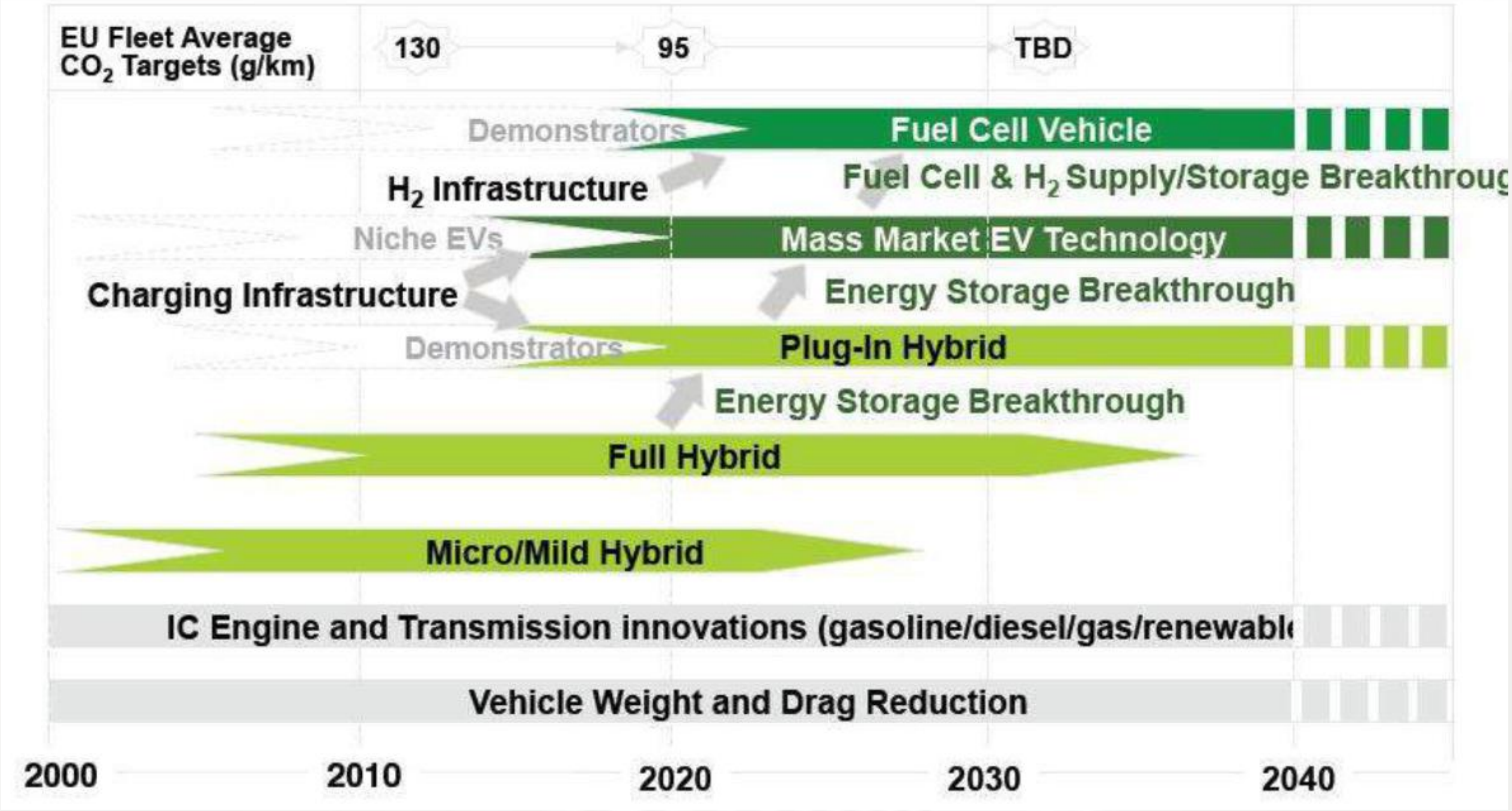
PEV Market share in EU is : 0.8% PEV and 0.64%BEV with total 1.44%

http://www.eafo.eu/eu

Degrees of Electrification

	Engine	Motor	"Battery"
Conventional	100kW Full transient	Starter motor Stop/start	12V 3kW, 1kWh
Mild Hybrid	90-100kW Full transient	3-13kW Torque boost / re-gen	12-48V 5-15kW, 1kWh
Full Hybrid	60-80kW Less transient	20-40kW Limited EV mode	100-300V 20-40kW, 2kWh
PHEV	40-60kW Less transient	40-60kW Stronger EV mode	300-600V 40-60kW, 5-20kWh
REEV	30-50kW No transient	100kW Full EV mode	300-600V 100kW, 10-30kWh
EV	No Engine	100kW Full EV mode	300-600V 100kW, 20-60kWh

Powertrain Road Map



www.warwick.ac.uk

Announcements from major auto makers

- 400 models and estimated global sales of 25 million by 2025.
- Porsche aims at making 50% of its cars electric by 2023.
- JLR has announced it will shift entirely towards electric and hybrid vehicles by 2020.
- General Motors, Toyota and Volvo have all declared a target of 1 million in EV sales by 2025.
- By 2030, Aston Martin expects that EVs will account for 25% of its sales, with the rest of its line up comprising hybrids.
- By 2025, BMW has stated it will offer 25 electrified vehicles, of which 12 will be fully electric.
- The Renault Nissan & Mitsubishi alliance intends to offer 12 new EVs by 2022.

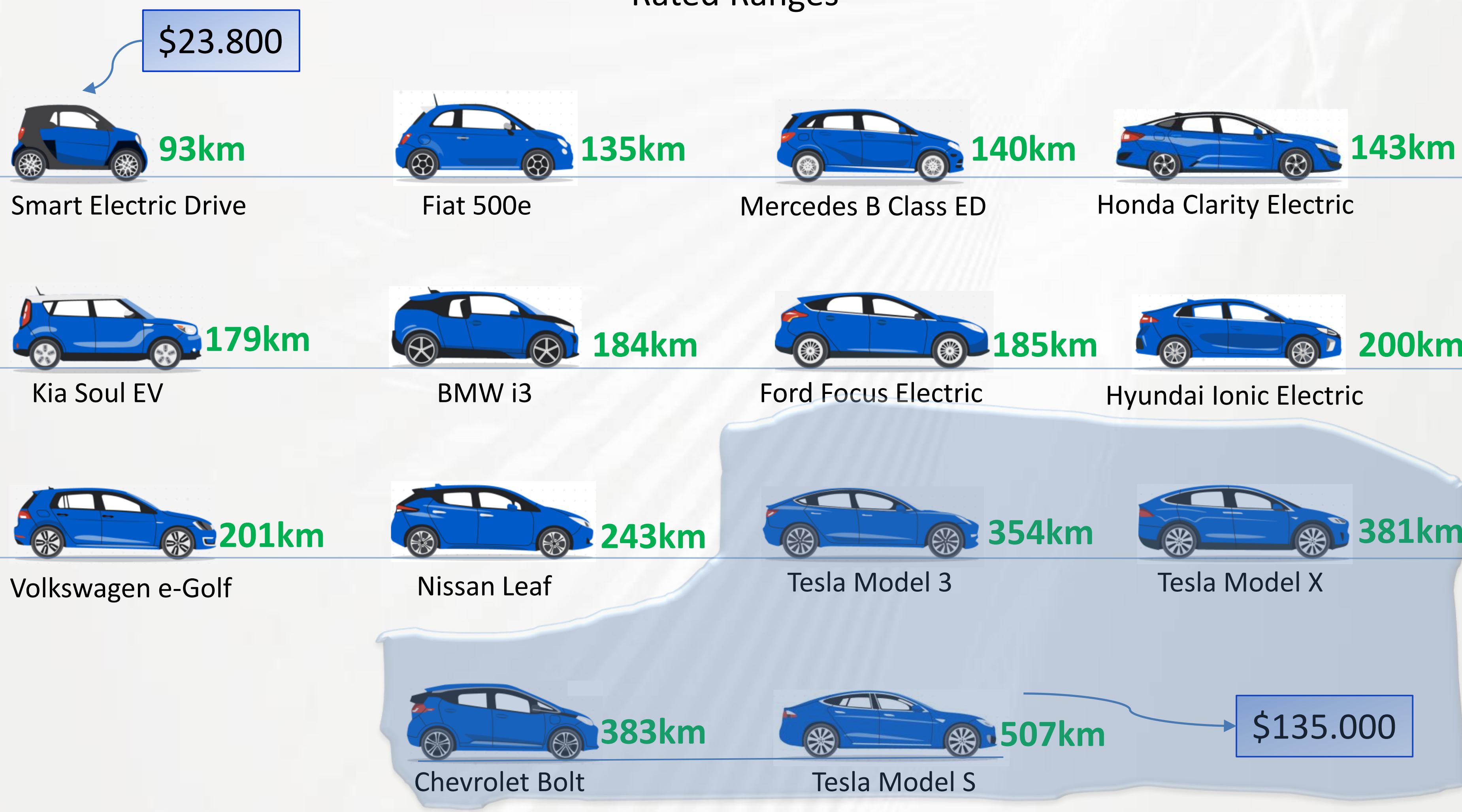
https://www.forbes.com/sites/sarwantsingh/2018/04/03/global-electric-vehicle-market-looks-to-fire-on-all-motors-in-2018/#2ece8f62927f

BEV Range Comparison

TÜBİTAK

2018 US BEV Models

Rated Ranges



https://www.fleetcarma.com

Energy Storage System

Fuel Cell Vehicles (FCV)

By year-end 2017, a total of **6,475** hydrogen fuel cell vehicles have been sold globally since 2013 when the vehicles first became available commercially.

"Global Market for Hydrogen Fuel Cell Vehicles, 2018."

Production FCV

- 2007 - Honda FCX Clarity
- 2010 - Mercedes-Benz F-Cell
- 2014 - Hyundai Tucson FCEV[2]
- 2015 - Toyota Mirai
- 2016 - Riversimple Rasa
- 2016 - Honda Clarity Fuel Cell
- 2018 - Hyundai Nexo

Firms tie up to drive demand for hydrogen vehicles

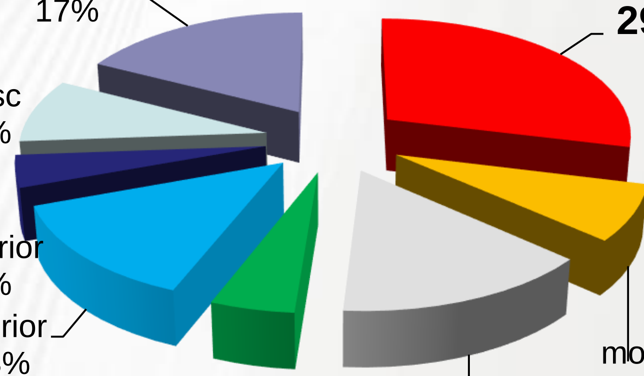
March 2017

Battery Electric Vehicles

TÜBİTAK

Tesla Model S

Tesla Model S Weight Proportion.



Almost %40 of the Cost is battery!

http://teslararti.com

Battery Electric Vehicles

TÜBİTAK

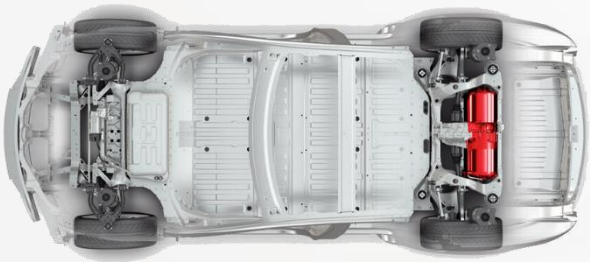
Current BEVs

Current EV in the Market									
	Brand	Model	Region	Price	Range [km]	Battery [kWh]	Powertrain	Year	Motor Type
1	BMW	i3	EU & US	$44,450	183	33	RWD	2018	AC induction
2	Chevrolet	Bolt	US	$36,620	383	60	FWD	2017	AC PMSM
3	Fiat	500e	US	$32,995	135	24	FWD	2017	AC induction
4	Ford	Focus E	EU & US	$29,120	185	33.5	FWD	2018	AC PMSM
5	Honda	Clarity E	US	$37,510	143	25.5	FWD	2018	AC PMSM
6	Hyundai	Ioniq E	EU & US	$29,500	200	28	FWD	2018	AC PMSM
7	Jaguar	I-Pace	EU & US	$76,500	386	90	FRWD	2018	AC PMSM
8	Kia	Soul EV	EU & US	$33,950	179	30	FWD	2018	AC PMSM
9	Mitsubishi	MiEV	US	$22,995	160	16	FWD	2017	AC PMSM
10	Nissan	Leaf (2nd Gen)	EU & US	$29,990	243	40	FWD	2018	AC PMSM
11	Renault	Zoe	EU	$31,000	299	41	FWD	2017	AC PMSM
12	Smart	ED	EU & US	$23,800	161	17.6	FWD	2017	AC SM
13	Tesla	Model 3 (Long Range)	EU & US	$50,000	499	75	RWD	2018	AC PMSM
14	Tesla	Model S 100D	EU & US	$94,000	539	100	FRWD	2017	AC induction
15	Tesla	Model S 75D	EU & US	$74,500	417	75	FRWD	2017	AC induction
16	Tesla	Model S P100D	EU & US	$135,000	507	100	FRWD	2017	AC induction
17	Tesla	Model X 100D	EU & US	$96,000	475	100	FRWD	2017	AC induction
18	Tesla	Model X 75D	EU & US	$79,500	381	75	FRWD	2017	AC induction
19	Tesla	Model X P100D	EU & US	$140,000	465	100	FRWD	2017	AC induction
20	Wolkswagen	e-Golf	EU & US	$30,495	192	35.8	FWD	2017	AC PMSM
21	Wolkswagen	e-Up!	EU	$30,495	159	35.8	FWD	2017	AC PMSM

On target production BEVs

Upcoming EV							
	Brand	Model	Region	Range [km]	Battery [kWh]	Powertrain	Year
1	Audi	e-tron Quattro	SUV	426	95	FRWD	2018
2	Hyundai	Kona E	crossover	402	64	FWD	2018
3	Kia	Niro EV	crossover	380	64	FWD	2018
4	Mercedes- Benz	EQC	SUV	410	70	FRWD	2019
5	Nissan	Leaf (Long Range)	hatchback	362	64	FWD	2019
6	Porsche	Taycan		418	90	FRWD	2019
7	WV	ID	hatchback	370	60	RWD	2019

Utilizing two propulsion Machines



Tesla.com

Only one propulsion machine

- ✓ Simple
- ✗ Limited high efficient operation map

Tesla.com

Two propulsion machines

- ✓ Powertrain efficiency could be improved
- ✗ More complicated

The load power could be effectively split between the two propulsion machines to obtain the highest powertrain efficiency

The powertrain efficiency could be improved up to 10% .

Utilizing two propulsion Machines

IDENTICAL MOTORS

GENOVATION
THE GREEN CAR COMPANY

The World's First Street Legal Electric Car to Exceed 350km/h


SPEED CERTIFICATE

IMRA

NEW Top Speed World Record

AWARDED TO

Genovation Cars GXE

in the category of

Top Speed Street Legal All Electric Car

Driven by Johnny Bohmer w/Passenger Robert Simpson

set this 23rd day of February, 2016 at the Kennedy Space Center, Cocoa Beach, FL.

witnessed by:

Rusty Durham

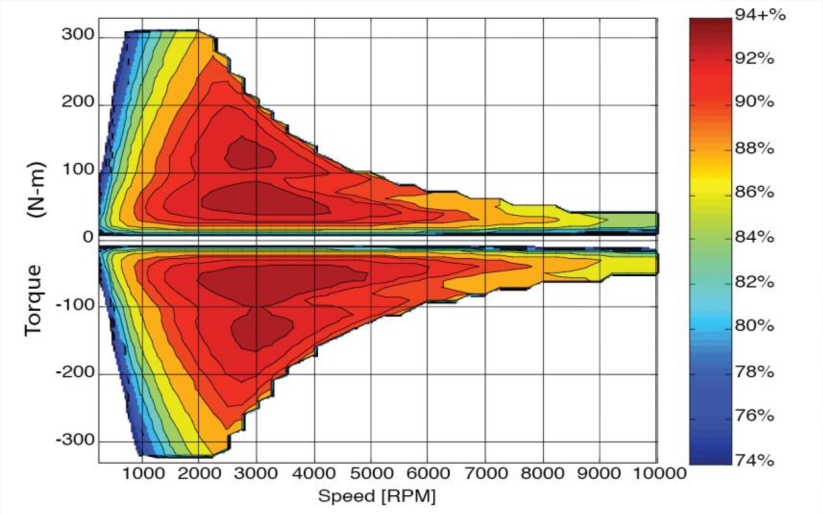
330 km/h
(205.6 mph)

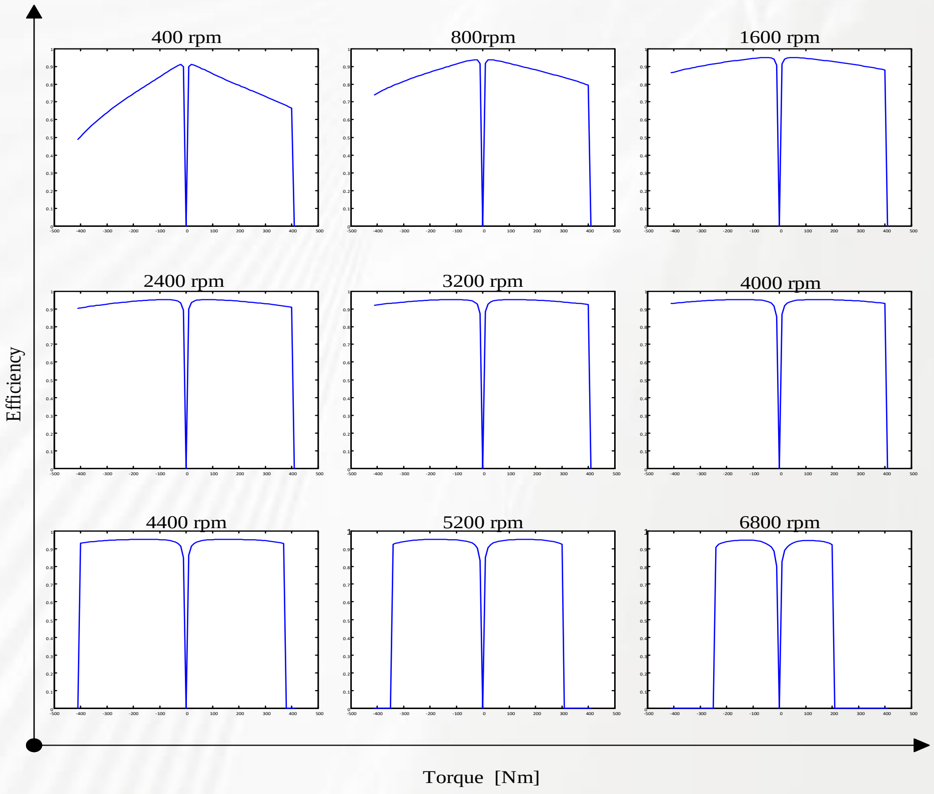
354 km/h
(220 mph)

https://genovationcars.com/

Utilizing two propulsion Machines

Remy Electric Motor Efficiency Map





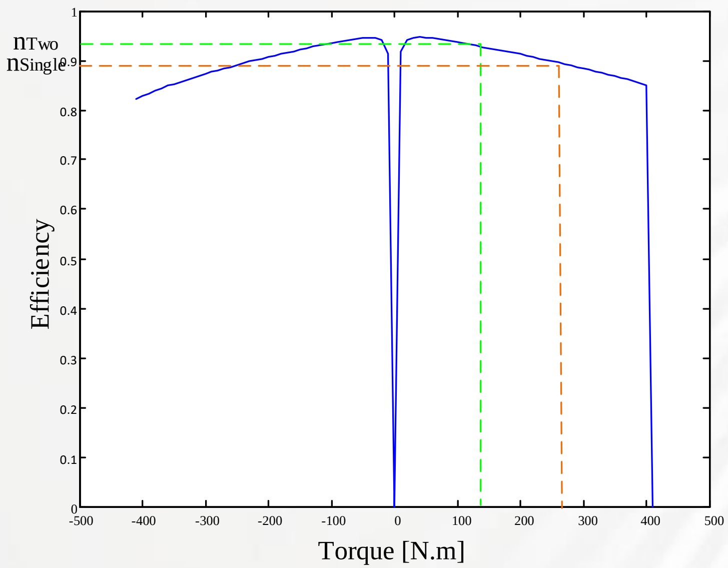
Remy Inc., 2010

Utilizing two propulsion Machines

IDENTICAL MOTORS

For Low Speeds

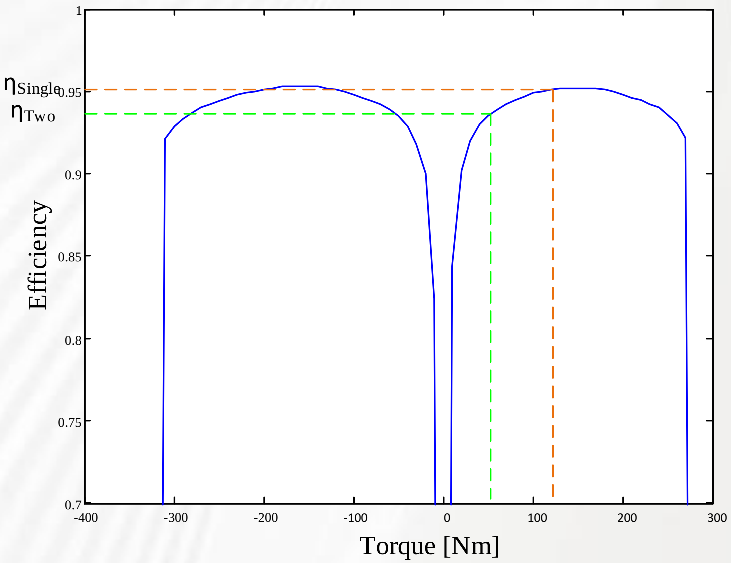
800 rpm



$\eta_{Two} > \eta_{Single}$

For High Speeds

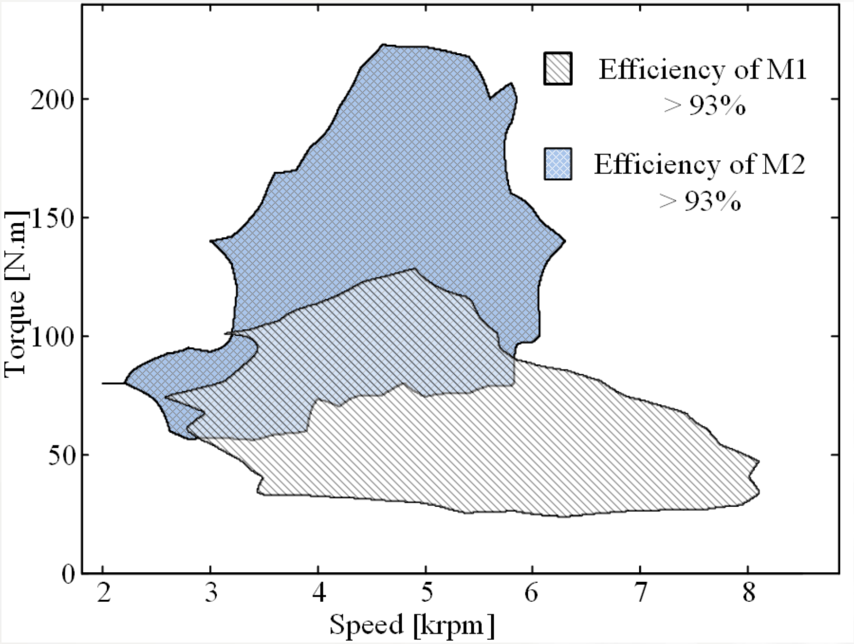
6800 rpm



$\eta_{Two} < \eta_{Single}$

Utilizing two propulsion Machines

Efficiency map of Complementary motor couple



Upcoming high capacity BEVs

- Audi e-tron Quattro SUV (95kWh)
- Mercedes- Benz EQC SUV (70kWh)
- Porsche Taycan (90kWh)

The properties of this two permanent magnet propulsion machines are provided by Argonne National Laboratory (ANL)'s Autonomie software library and detailed specifications are given in.

Potential of having better powertrain efficiency

Conclusion

- Currently PEV are the goal for CO_2 regulations,
  Zero-emission vehicles would be mandatory wish upcoming regulations.

- Powertrain of the EVs is still improving.

- Li-ion batteries are major ESS unit currently,
  Technological improvement and cost reduction are required.

- What kind of new propulsion technologies are likely to make sense ?
  * PMSM is the major propulsion machine for the BEVs.
    Tesla is also going to use PMSM in 4WD Model 3
  * Current and upcoming almost all EVs with +65kWh battery capacity
    utilizes two propulsion machines.
  * Using two complementary propulsion machines instead of double identical
    or single large one make more sense in terms of placing and efficiency.

Thank You!

TÜBİTAK

TUBITAK

ENERGY INSTITUTE

Automotive Center for Excellence

June 2017