FABRIC

Feasibility analysis and development of on-road charging solutions for future electric vehicles

E-road consequences for power grids, vehicle fleets and other technical systems

Hans Bludszuweit
CIRCE, Spain

FABRIC Final Event, Turin 21 June 2018

General remark

1. Grid impact of massive upscale of DWPT for electric transportation has been studied;
2. Three scenarios have been created:
   - motorway (e-Corridor)
   - periurban (e-Launcher)
   - urban bus (e-Trench)
3. Simulations show:
   - daily pattern of eRoad demand is beneficial for solar PV integration;
   - storage for 24-h smoothing provides substantial reduction of grid impact in terms of demand peaks and ramps.

Agenda

1. Methodology
2. DWPT Scenarios
   - Motorway, Periurban, Urban Bus
3. Grid connection architectures
   - Power and Energy requirements
   - Load curves
4. Demand of DWPT – impact on European level
5. Outlook on CO_2 emissions
6. Integration of e-road with Renewables and Storage
7. Conclusions

1. Methodology

Steps followed by the study presented

1. Definition of DWPT scenarios
2. Definition of power and energy requirements
3. Evaluation of energy balances and CO_2 emissions for upscale at European level
4. Study DWPT integration with distributed generation and storage
5. Analysis of economic consequences

2. DWPT Scenarios

Motorway (e-Corridor)

- 25 km stretch of e-road, 50 kW
- Objective: range extension for light and heavy vehicles

Periurban (e-Launcher)

- 10 km stretch of e-road, 100 kW
- Objective: range extension for heavy vehicles

Urban Bus (e-Trench)

- 25 m e-Trench at each bus stop, 100 kW
- Objective: Battery shrink for buses

3. Grid connection architectures

Power requirement

- Charging power per vehicle
- Number of Vehicles per km (for e-road) or km² (for bus)

Energy requirement

- Typical traffic pattern is needed
- Vehicles per km → vehicles per day
- Different for eRoad and bus:
  - eRoad: range-extension → $E = P \times \Delta t$
  - Bus: battery-shrink: $E = kWh/km \times km$

3. Grid connection architectures

Results – Power Requirement

Charging power (per vehicle) P_{ch} $[kW]$	Grid power per 25 km (HV/MV substation rating) P_{25km} $[MW]$	
	$N_{vpk} = 10$	$N_{vpk} = 15$
20	6.3	9.4
50	15.6	23.4
100	31.3	46.9

Motorway: DWPT power requirement for grid supply

3. Grid connection architectures

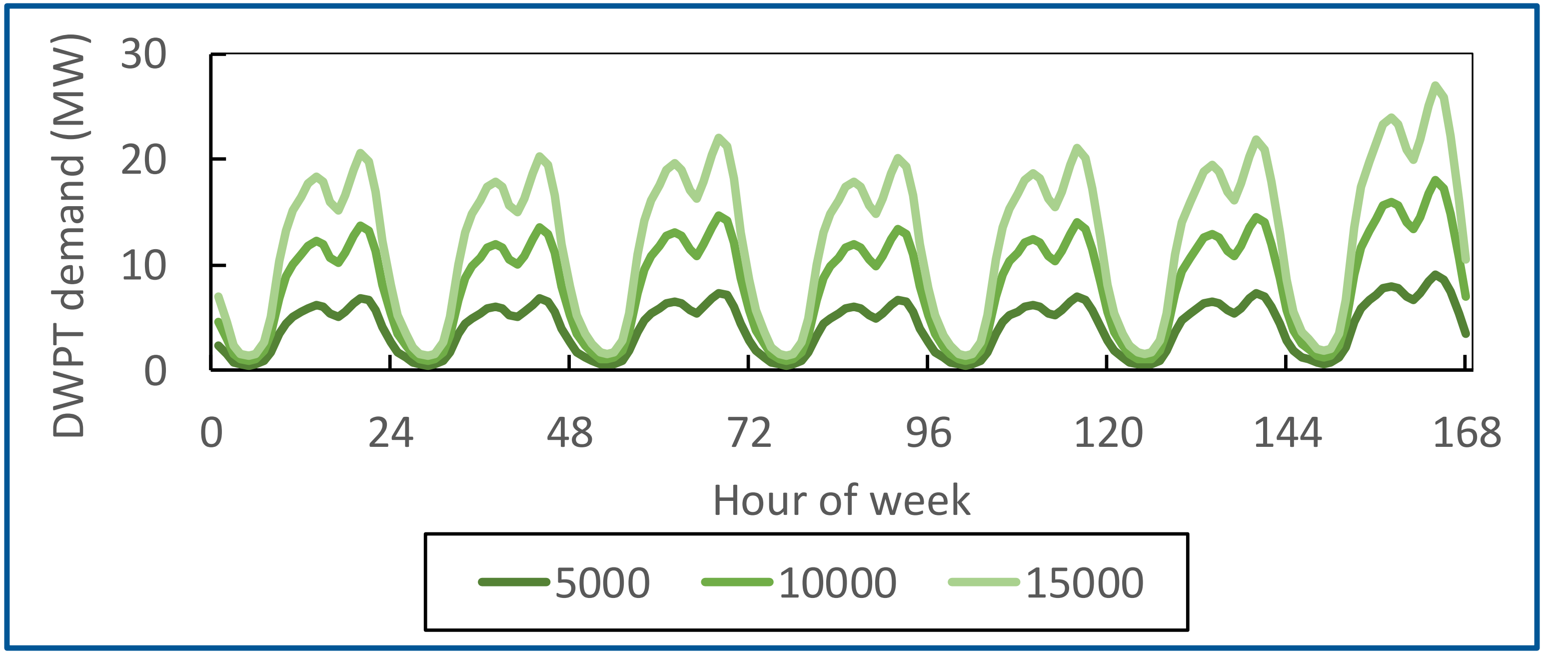
Results – Power Requirement

Charging power (per vehicle) P_{ch} $[kW]$	Grid power per km² P_{sqkm} $[MW]$	
	$N_{vpk} = 1$	$N_{vpk} = 10$
20	0.06	0.63
50	0.13	1.25
100	0.19	1.88

Urban Bus: DWPT power requirement for grid supply

3. Grid connection architectures

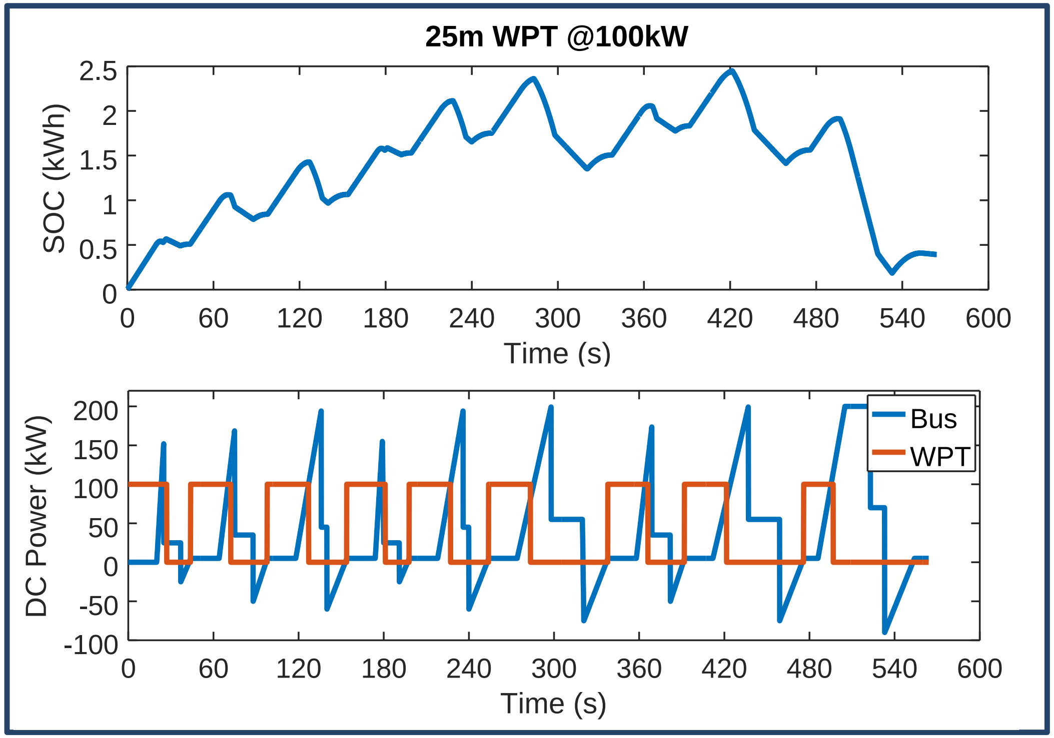
Results – Energy Requirement



Motorway: DWPT demand pattern for different AATD.

3. Grid connection architectures

Results



Urban Bus: Battery SoC and DWPT demand pattern.

4. Demand of DWPT – impact on European level

	Power (GW)			Energy (TWh)		
	2030	2040	2050	2030	2040	2050
Motorway	0.02	0.15	0.62	0.04	0.34	1.4
Periurban	0.44	2.4	8.5	0.3	1.6	5.7
Urban Bus	0.48	1.4	3.2	2.8	7.1	14.2
Total	**0.94**	**4.0**	**12.3**	**3.2**	**9.0**	**21.2**

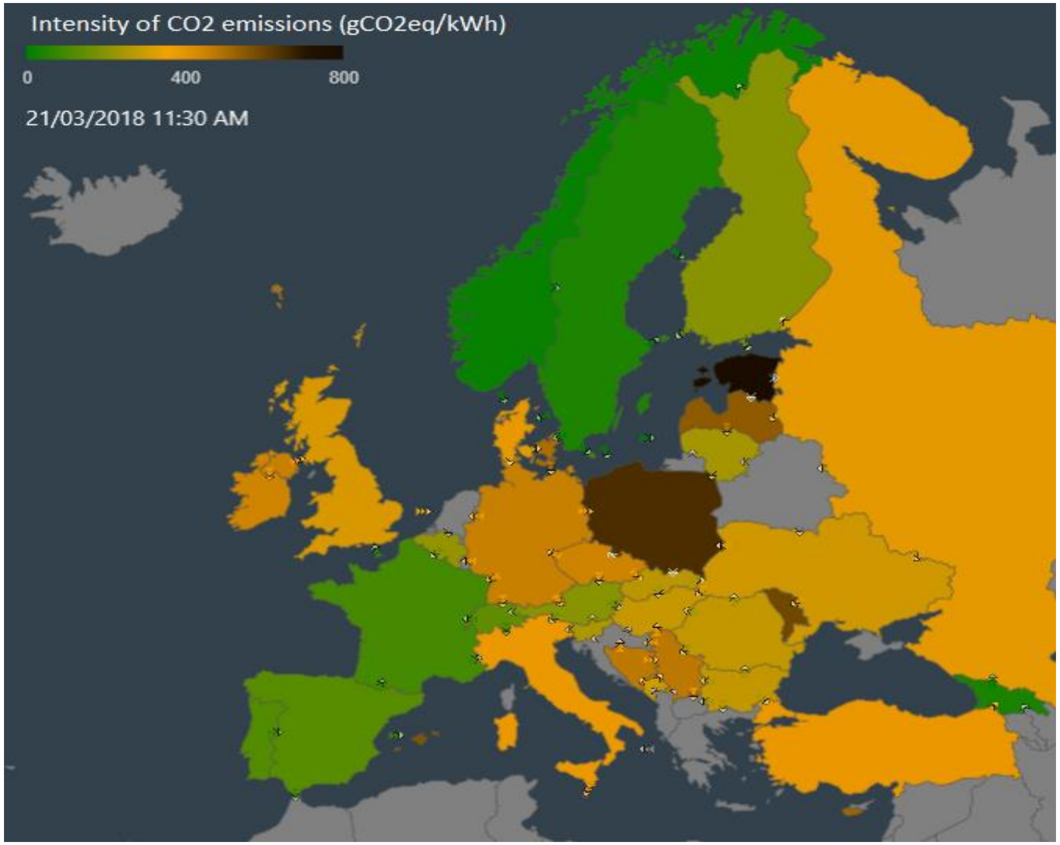
European DWPT upscale, power and energy requirements.

4. Demand of DWPT – impact on European level

	2030	2040	2050
Number of EVs in Europe (millions)	107.4	168.8	189
Expected EV electricity demand (TWh/a)	242	380	425
Percentage of 2015 gross generation	7.5%	11.7%	13.1%
Percentage of DWPT demand vs. EV demand	1.3%	2.4%	5.0%

Projected electricity demand of entire EV fleet in Europe.

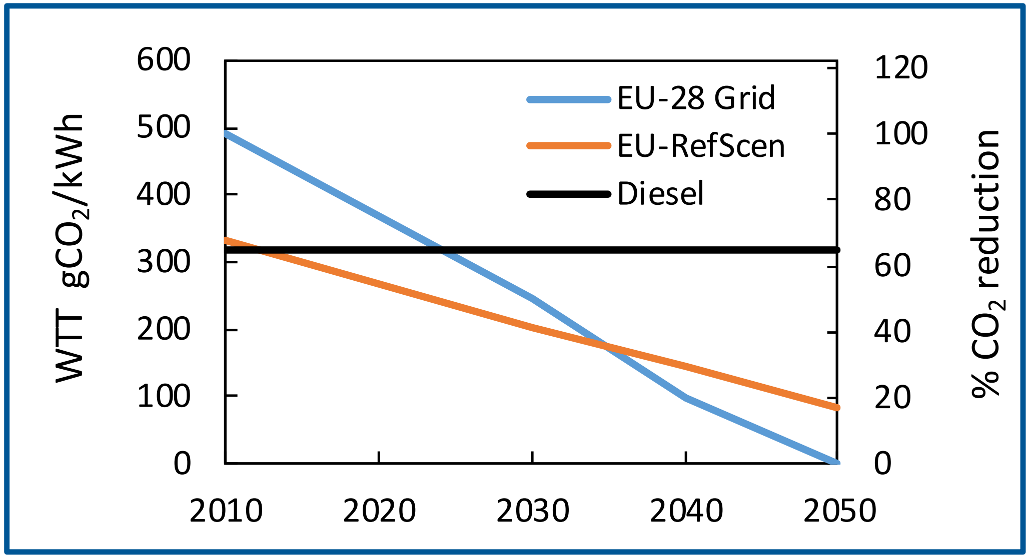
5. Outlook on CO_2 emissions



(Source: www.electricitymap.org)

Snapshot of intensity of CO2 emissions in Europe on 21/03/2018 11:30 AM

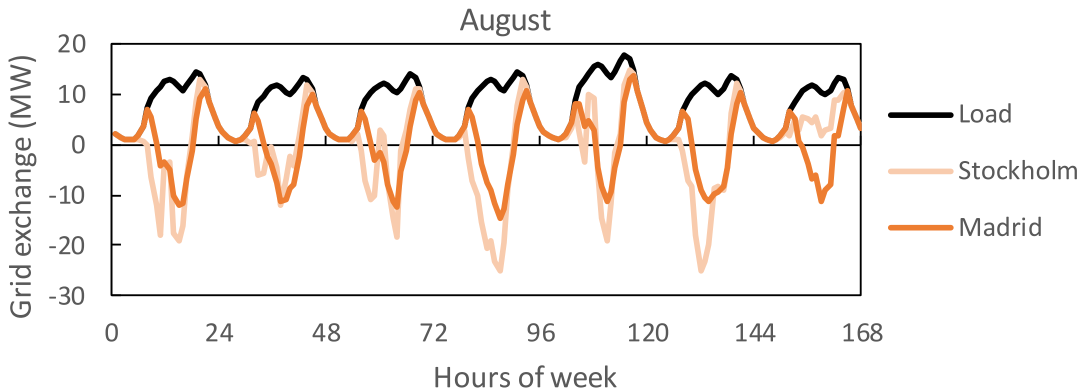
5. Outlook on CO_2 emissions



Electricity WTT CO_2 emissions vs. Diesel fuel.

6. Integration of eRoad with Renewables and Storage

Solar Integration

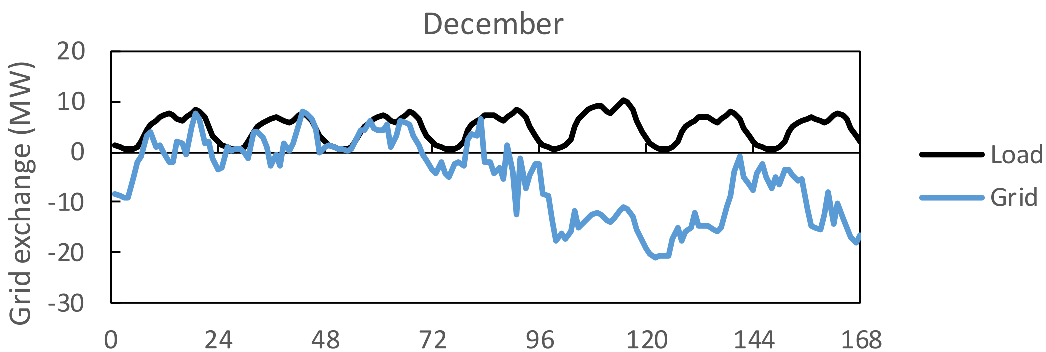


Daily pattern similar to DWPT

46-55% self-consumption

Best option in south EU

Wind Integration



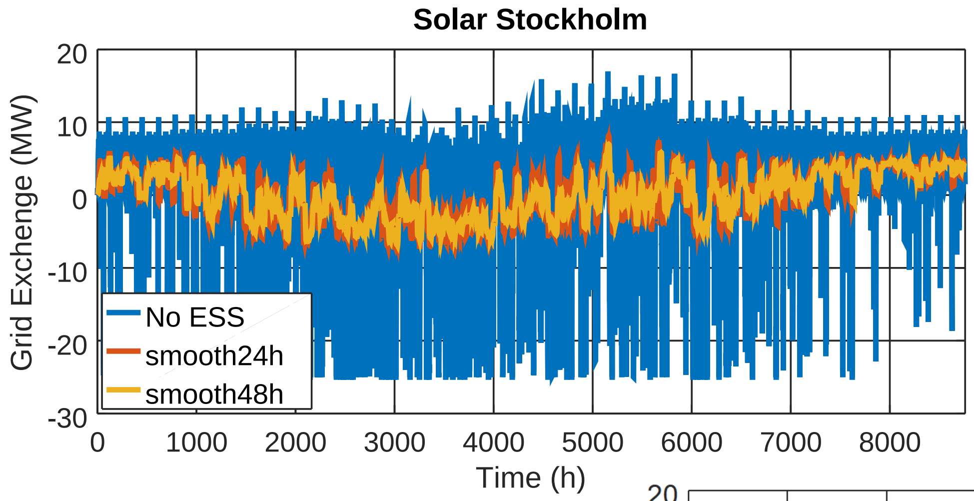
No correlation with DWPT

44% self-consumption

Best option in north EU

6. Integration of eRoad with Renewables and Storage

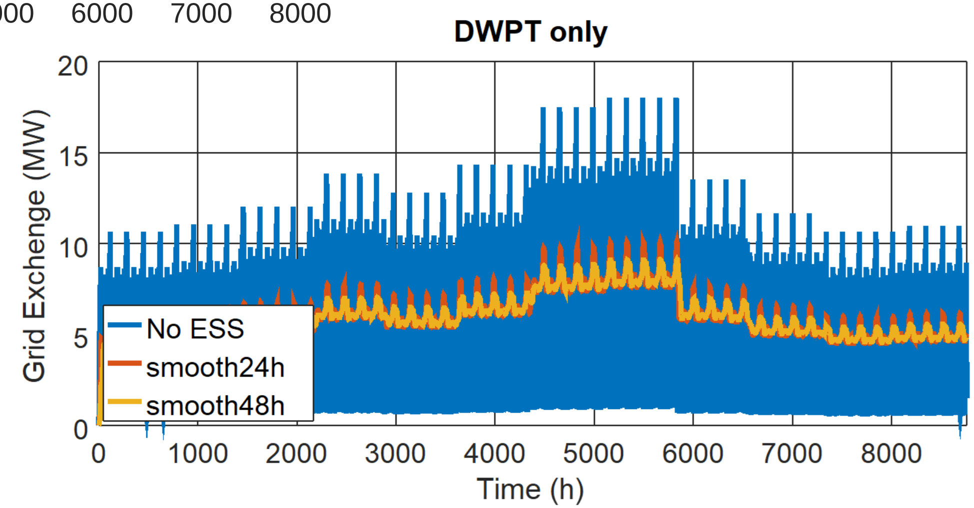
Simulation results – 24h smoothing



Relatively small:
2 days of average demand

Reduction of demand power peaks and ramps

Useful for RES integration, but also for smoothing of DWPT demand peaks



7. Conclusions

- 3 DWPT reference scenarios have been developed;
- eRoad deployment will not be limited by the grid – for both, energy and power requirements;
- Daily patterns are ideal for integration of solar power (55% self-consumption in Spain);
- 24-h storage mitigates intra-daily fluctuations and can reach up to 60-87% self-consumption rates.

FABRIC

Feasibility analysis and development of on-road charging solutions for future electric vehicles

Thank you!

Hans Bludszuweit

hblud@fcirce.es

Technology Expert,

CIRCE, Spain

circe

RESEARCH CENTRE
FOR ENERGY RESOURCES
AND CONSUMPTION