Westsächsische Hochschule Zwickau
University of Applied Sciences

„Integration of renewable energies in the development of modern transport infrastructure“

Leupold Institut für angewandte Naturwissenschaften

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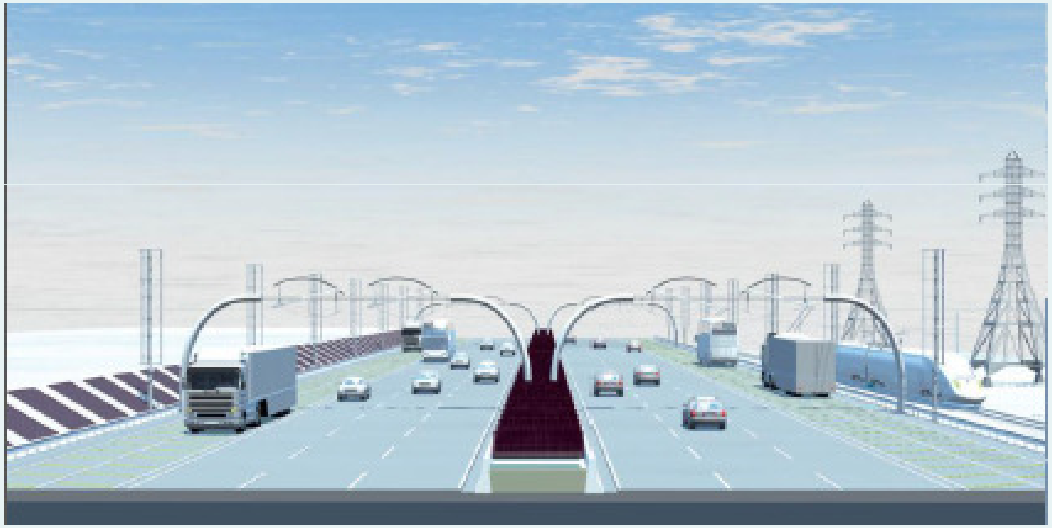
Structure

1 The project “behind“

- part of the feasibility study: “Intelligent infrastructure systems –
  basis for road-oriented e-mobility“
- duration: 01.01.2012 – 31.12.2012



Reference: Prof. Dr.-Ing. habil. W. Kühn

- promoted by: Sächsischen Staatsministerium für Wissenschaft und Kultur (SMWK)

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1.1 Motivation

- extensive development in e-mobility sector

→ german car industry announced to launch electric vehicles with a pure electric drive in the next years

- present infrastructure is not conform to the requirements of e-mobility

→ usage of the electric vehicles is limited

1.2 Targets

• Adaption of the existing and newly constructed roads to the new requirements

Developing a lane-attended energy providing system

1. energy consumption → driving drag: speed, route, type of the vehicle

2. energy providing system → on board: • exchange of energy storage

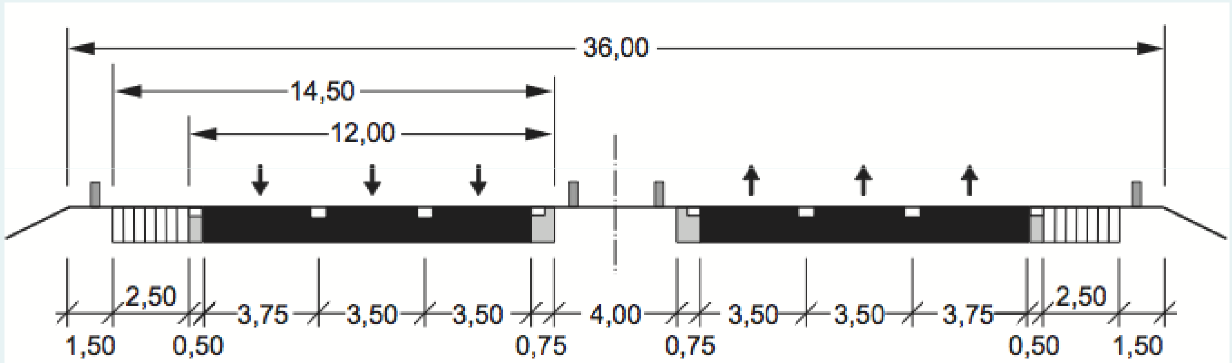
→ external: • loading lane
• filling station

renewable energies along the highway → energy supply

2 Energy consumption

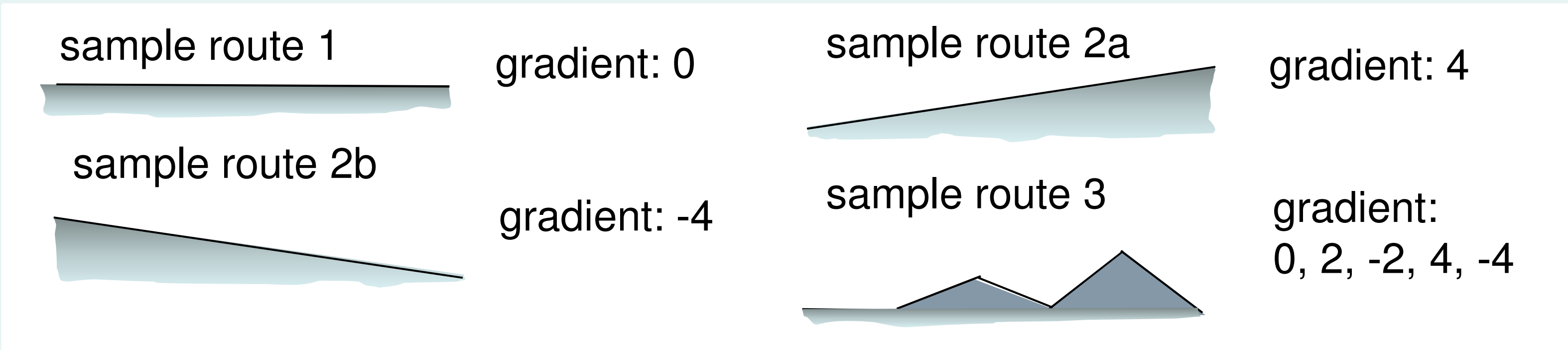
2.1 Sample route

- highway with 3 lanes and 1 hard shoulder for each direction
- distance: about 10 km



Reference: RAA 2008

- simplified structure and limited conditionens for the theoretical calculation



2.2 Selection of sample vehicles

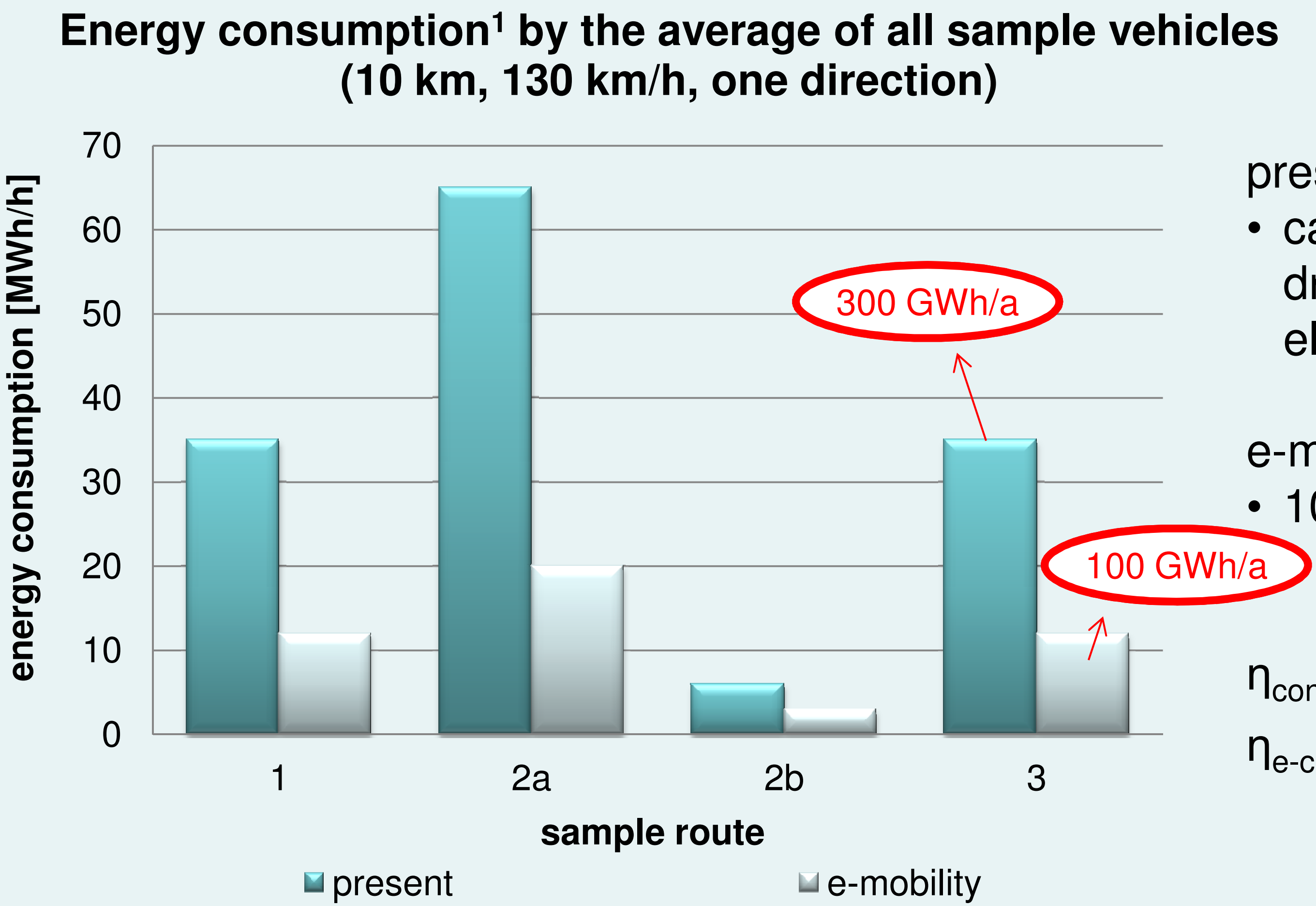
- only passenger cars

drive	conventional (diesel)	electric
minicar	-	Twike
small car	VW Polo	Mitsubishi iMiev
Compact car	VW-Golf	VW E-Golf
mid-range car	VW Passat	-
top-of-the-range car	Porsche Panamera	-

Reference: www.importrpm.com/all-electric-mitsubishi-i-miev-heads-to-the-u-s, 06/2012

Reference: www.autofluence.com/events/geneva-motor-show/electric-vw-golf-in-2013/attachment/electric-golf, 06/2012

2.3 First results for the energy consumption



present:

- cars with conventional drive and few cars with electric drive[2]

e-mobility:

- 100% electric cars

$\eta_{convential}$: 0,28

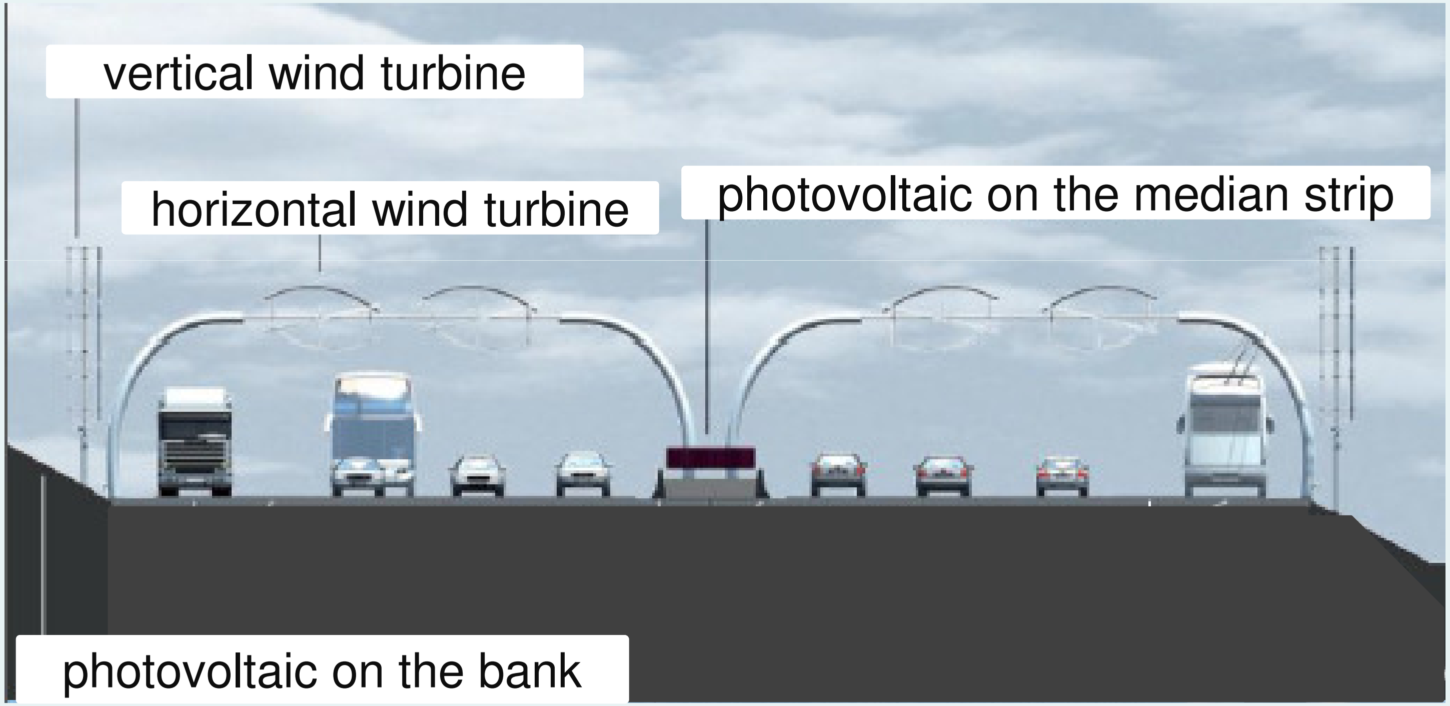
$\eta_{e\text{-}car}$: 0,84

[1] only to get over the driving drag

[2] for calculation: only VW E-Golf

3 Production of energy along the highway

3.1 Opportunities of integrating renewable energies



Reference: Prof. Dr.-Ing. habil. W. Kühn

3.2 Szenarios

usable area around the highway

on/above the highway

roadway | median strip

variant A1:

(small wind turbine)	+	photovoltaic

variant A2:

solar road (small wind turbine)	+	photovoltaic

variant A3:

roof with photovoltaic

next to the highway

open space | noise barrier

variant B1:

photovoltaic, (small wind turbine)	+	additional or integrated photovoltaic

variant B2:

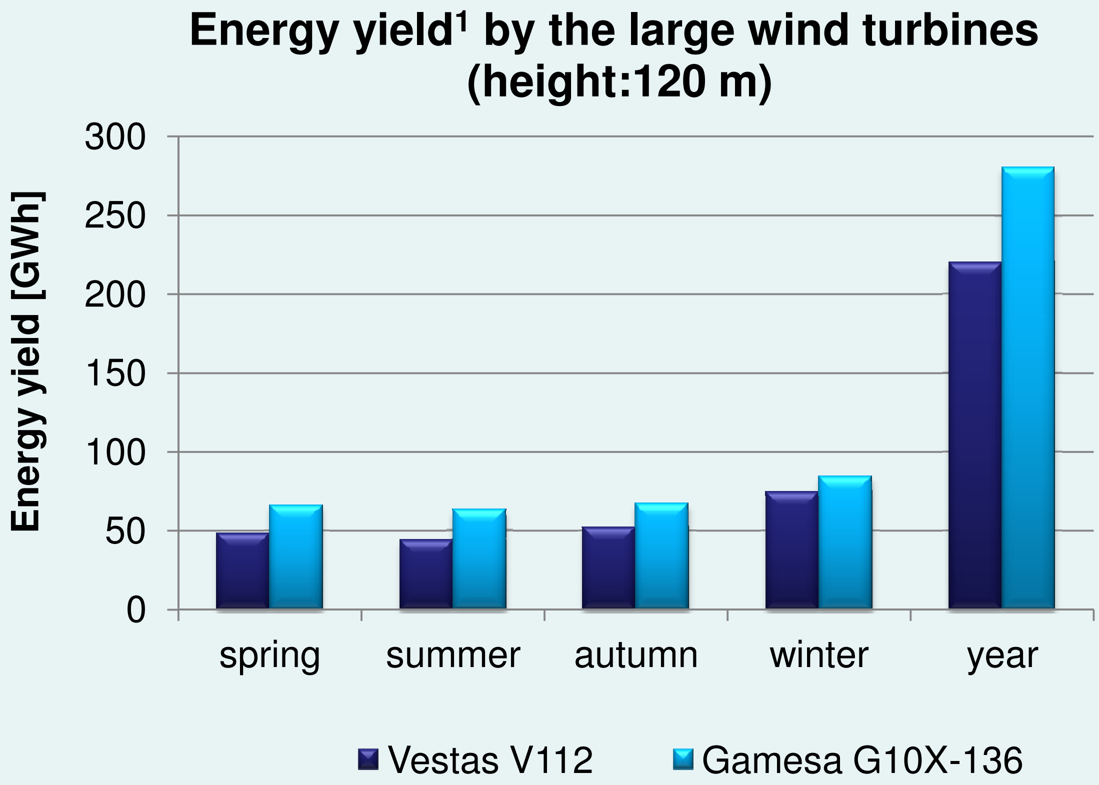
large wind turbine, (small wind turbine)	+	additional or integrated photovoltaic

variant B3:

photovoltaic, large wind turbine, (small wind turbine)	+	additional or integrated photovoltaic

2.3 First results for the energy production

a) Wind energy

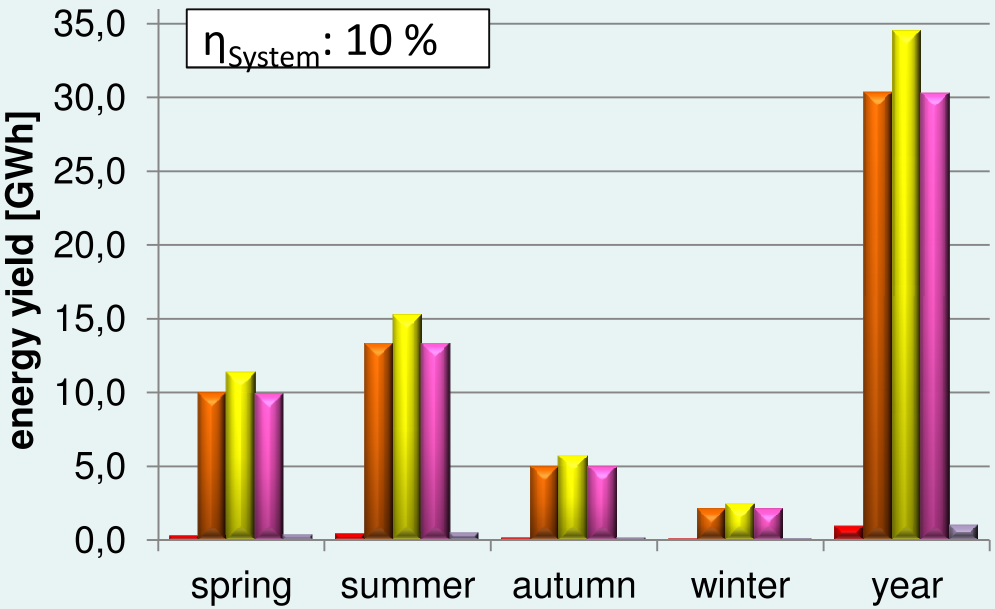


	Vestas V112	Gamesa G10X-136
unit power [MW]	3	4,5
diameter [m]	112	136
distance between turbines [m]	500	700
units in a row (10 km)	20	14

[1] without consideration the land use plan for the area next to the highway, e. g.: development, agriculture

b) Solar energy

Energie yield[1] by photovoltaic



median strip | solar road | roof with photovoltaic — on the highway

free area | noise barrier — next to the highway

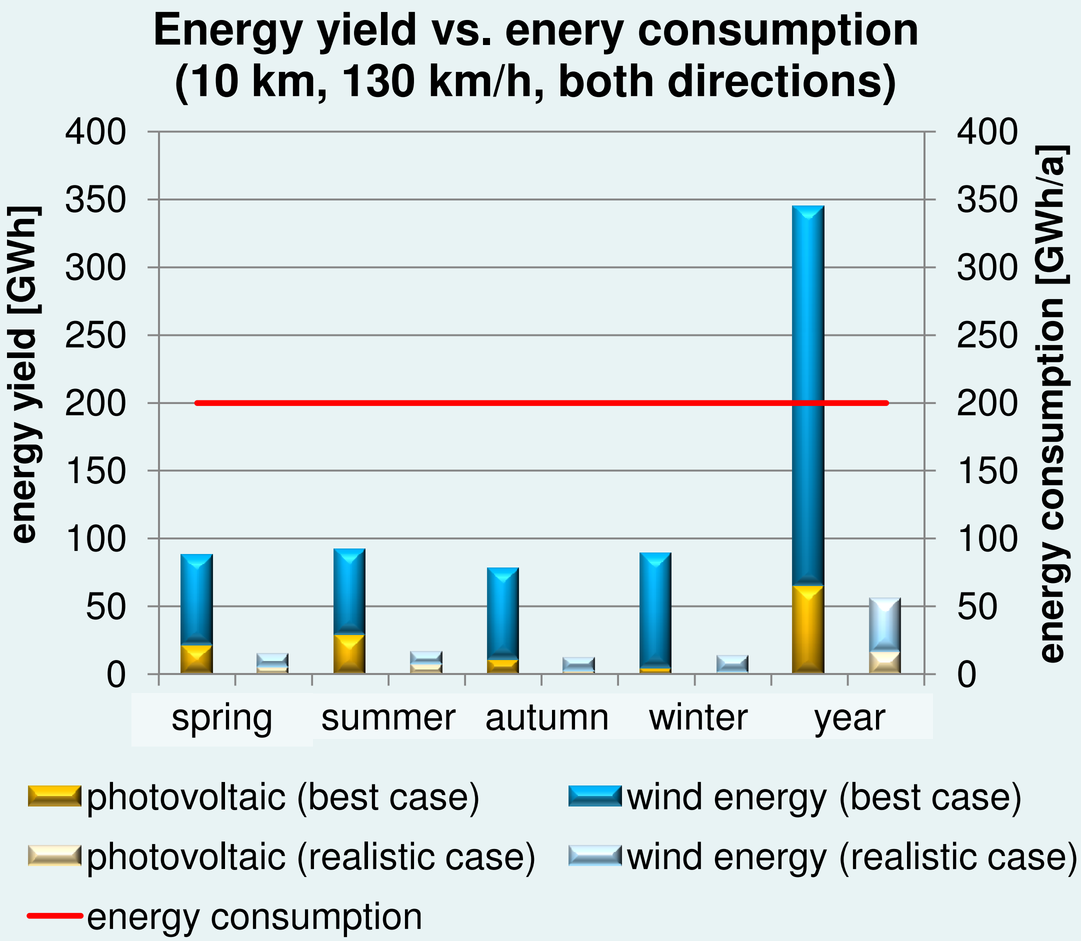
	area [m²]	tilt [°]	usable part [%]
road	290.000	0	100
roof	330.000	0	100
median strip	20.000	35	37
open space[2]	652.400	35	37
noise barrier[3]			
noise protection wall	6.500	90	100
noise protection dam	4.410	35	100

[1] without consideration the land use plan for the area next to the highway, e. g.: development, agriculture

[2] open space is the area next to the highway (40 m) minus the area of traffic security, tunnels,bridges and noise protection dams

[3] only one side of the noise barrier is provided for the photovoltaic utilization,

c) The energy consumption vs. the energy production by renewable energies



	on/above the highway	next to the highway
best case	roof with photovoltaic	large wind turbines + photovoltaic + noise barrier with photovoltaic
realistic case	not provided	20 % large wind turbines + 50 % photovoltaic + noise barrier with photovoltaic

4 Summary

- the energy consumption of present days is about 600 MWh/a for 10 km with a speed of 130 km/h
- at 100% e-mobility the energy consumption can be reduced to 1/3
- the maximum energy yield of renewable energies along the higway (10 km) is about 350 GWh/a
- realistical there might be only provided ca. 27% by the average of the enery consumption of e-cars
- the main part (71%) of produced energy is supplied by the wind turbines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Thank you for your attention!