G4V™ Grid for Vehicles

SEVENTH FRAMEWORK PROGRAMME

Session III –

Business/Economic, Environmental and Societal Implications for Electro-Mobility

CHALMERS · ECN · EDF · edp · endesa · Enel (ENERGY IN TUNE WITH YOU.) · Imperial College London · RWE (The energy to lead) · RWTH AACHEN · technische universität dortmund · UNIVERSIDAD POLITECNICA DE VALENCIA · VATTENFALL

Customer Perspective:
Results of the European G4V Survey

Ingo BUNZECK

ECN

CHALMERS · ECN · EDF · edp · endesa · Enel (ENERGY IN TUNE WITH YOU.) · Imperial College London · RWE (The energy to lead) · RWTH AACHEN · technische universität dortmund · UNIVERSIDAD POLITECNICA DE VALENCIA · VATTENFALL

Agenda

Customer perspective: Results of the European G4V survey

1. Objective
2. Methodology / approach
3. Key results from the customer survey
4. Conclusions

Objective

- Although discussions about technical parameters prevail, **user preferences play a large role in the success** of the introduction of electric vehicles
  - In order for EVs to reach the mass-market they need to correspond with the requirements of the majority of drivers
  - People are used to routines – how are those routines affecting the intended infrastructure rollout?
- Thus, **understanding needs to be developed** for the associated social aspects and challenges related to the introduction of EVs
  - Provides feedback for infrastructure planning and optimization of business models
- Research **focus on customer preferences and acceptance** for:
  - Choice of charging location
  - Delayed charging (off-peak)
  - Vehicle-to-Grid (V2G) services

Methodology / approach

- Web-based survey
  - It was decided to focus on the **intended behaviour** of the 'general public'
- Limited knowledge among respondents about characteristics of EVs and charging issues
  - **Information (in lay language) provided** within survey
  - Agreed technical data: 120 km range, 4h standard charging, charging costs € 3 (private) vs. € 5 (public)
  - 8 Countries: DE, FR, IT, NL, SE, ES, UK, PT
- Survey **distribution via G4V website** and project partners in respective countries
  - **1900** replies in total
  - **Perfect statistical sample not possible** within G4V (small task) – but provides already useful directions

Electric cars

G4V™ Grid for Vehicles

Hello,

Welcome to this questionnaire about electric cars. This anonymous questionnaire will give you the opportunity to indicate your preferences related to electric cars. It is open for everybody living in the European Union (above the age of 18) no matter how much you know about electric cars. Answering the questions will only take 10-15 minutes of

Carros eléctricos

G4V™ Grid for Vehicles

Olá

Bem-vindo a este questionário sobre carros eléctricos. Este questionário anónimo solicita a sua informação sobre preferências relacionadas com carros eléctricos. É um questionário para todas as pessoas a viver na União Europeia (com idade superior a 18 anos) independentemente do conhecimento prévio sobre carros eléctricos. Este questionário demorará apenas entre 10 a 15 minutos a preencher na sua totalidade e exigirá apenas alguns clicks.

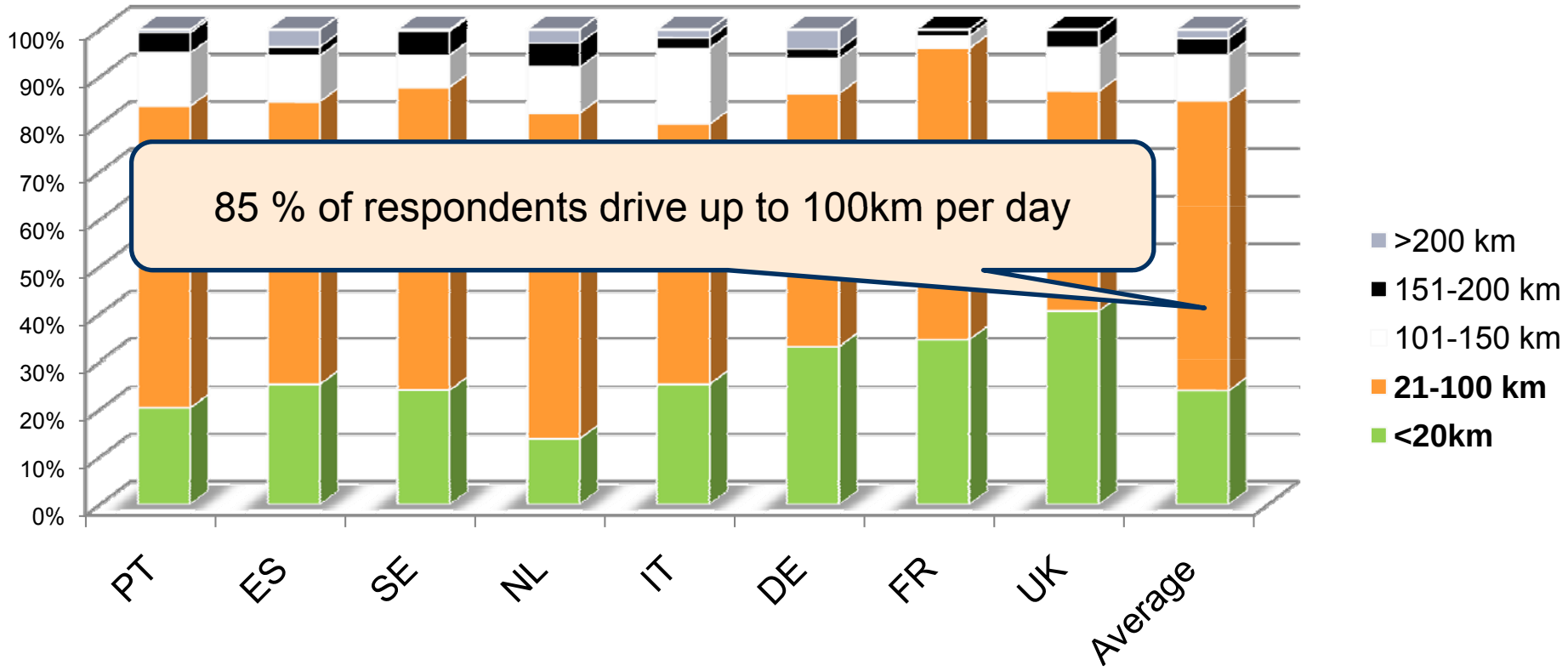
As suas respostas terão grande valor para nós e por isso agradecemos em antemão o tempo dedicado.

A equipa do questionário

*Este questionário é parte do projecto Europeu Grid for Vehicles – G4V – sobre o carregamento de veículos eléctricos, e é financiando pela Comissão Europeia. Mais informação sobre o projecto encontra-se em www.g4v.eu. Os resultados deste questionário serão também publicados neste site de 2011.

Próximo

Key results: Current daily mileage

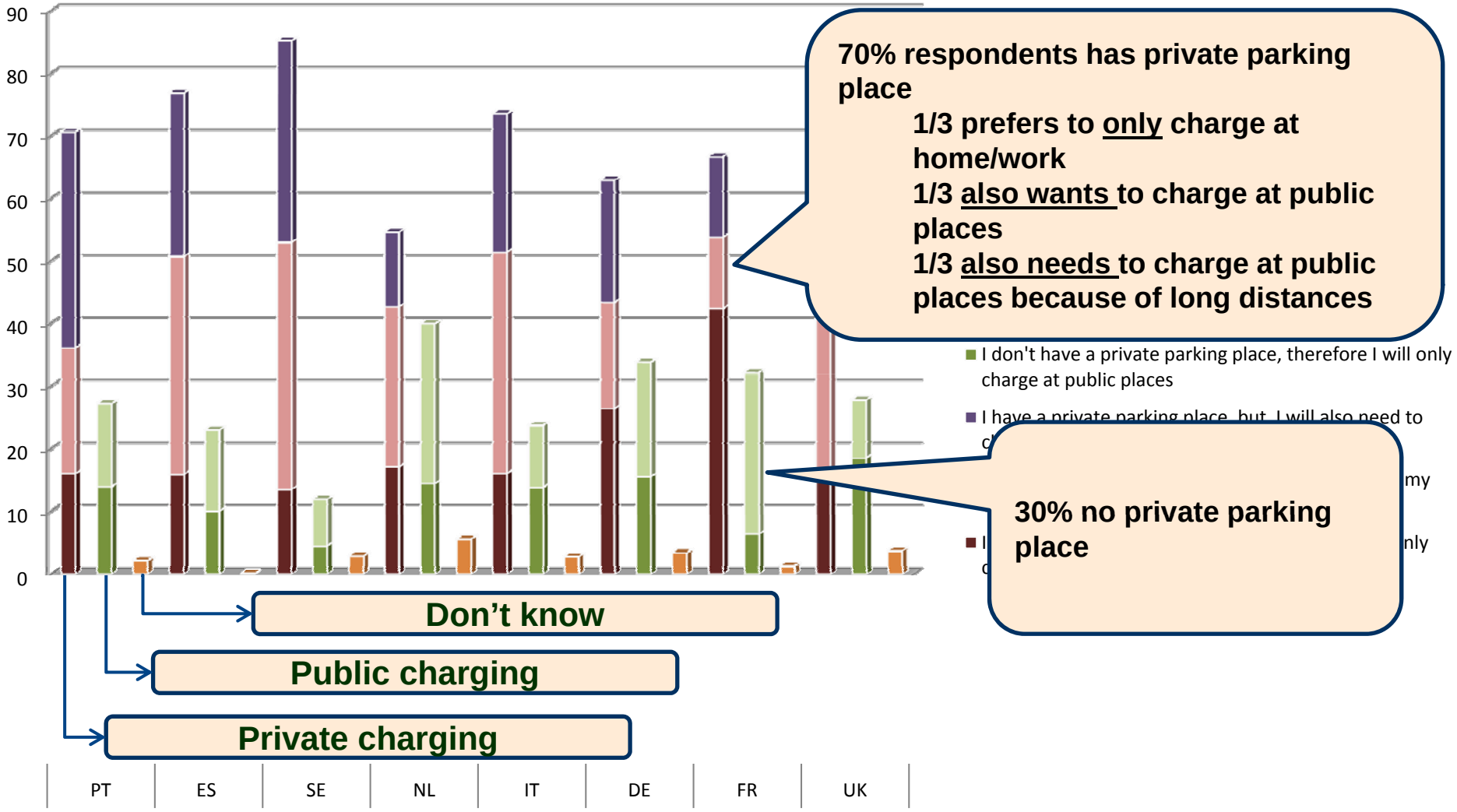


85 % of respondents drive up to 100km per day

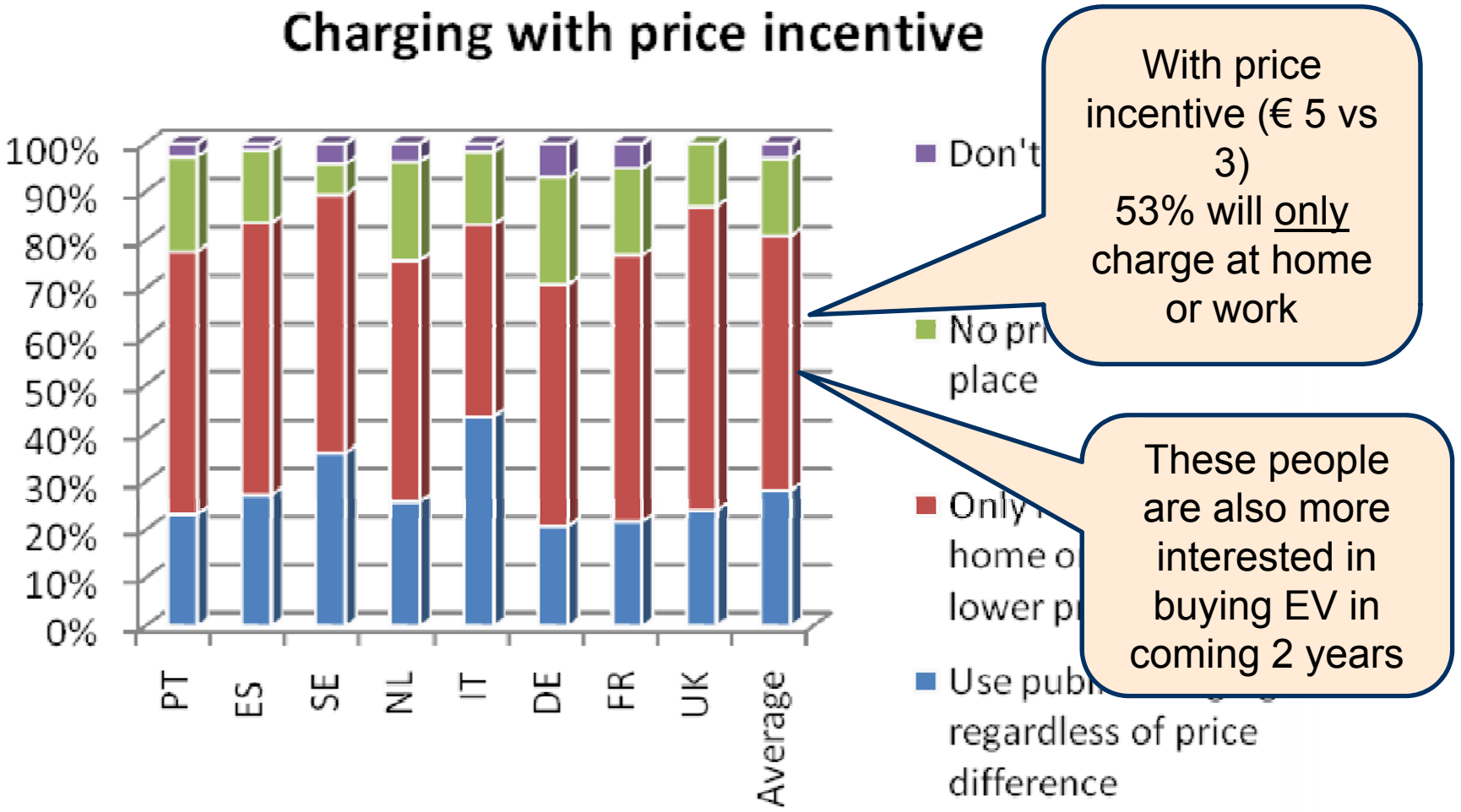
BUT: required battery capacity to be interested in buying EV: 308km (NL 389km)!

People take into account the occasional longer trip

Key results: Preferred charging location

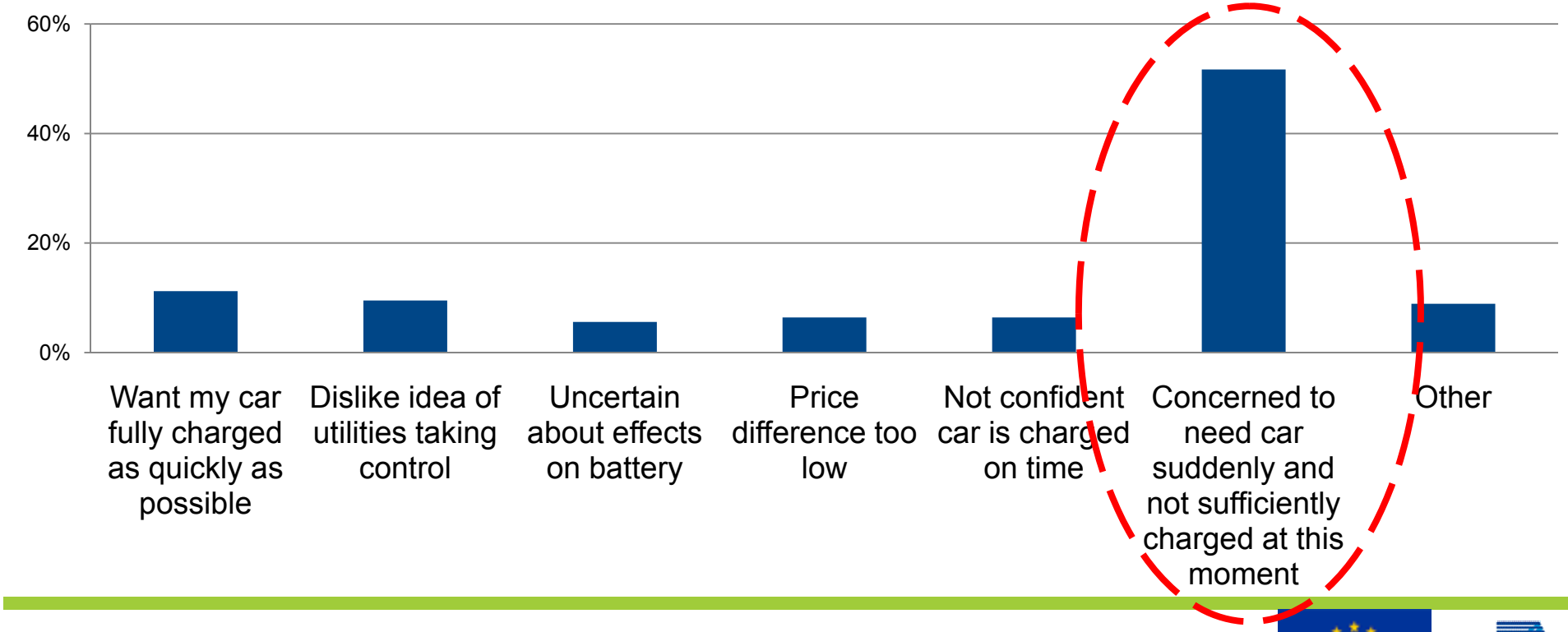


Key results: Preferred charging location



Key results: Interest in delayed charging (with price incentive)

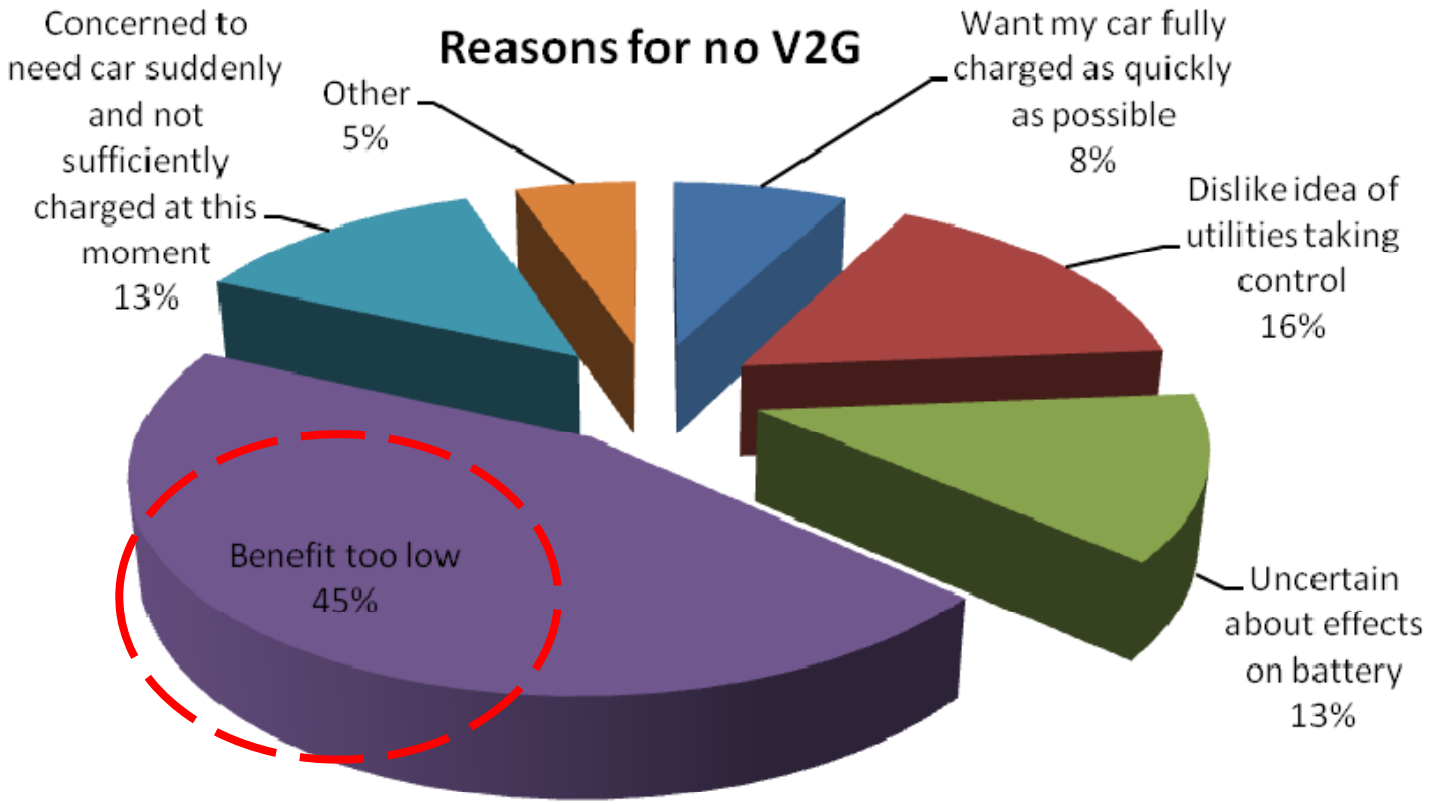
- **Charging would not start right away** after connecting the EV to the grid
- Delayed charging (22:00-06:00, battery full in the morning, €2 vs. €3
- On average **high interest** in delayed charging (5.74 on 1-7 scale)
- Reasons for not being interested: (everyone ticking 4 and lower on scale):



Key results: Vehicle-2-Grid

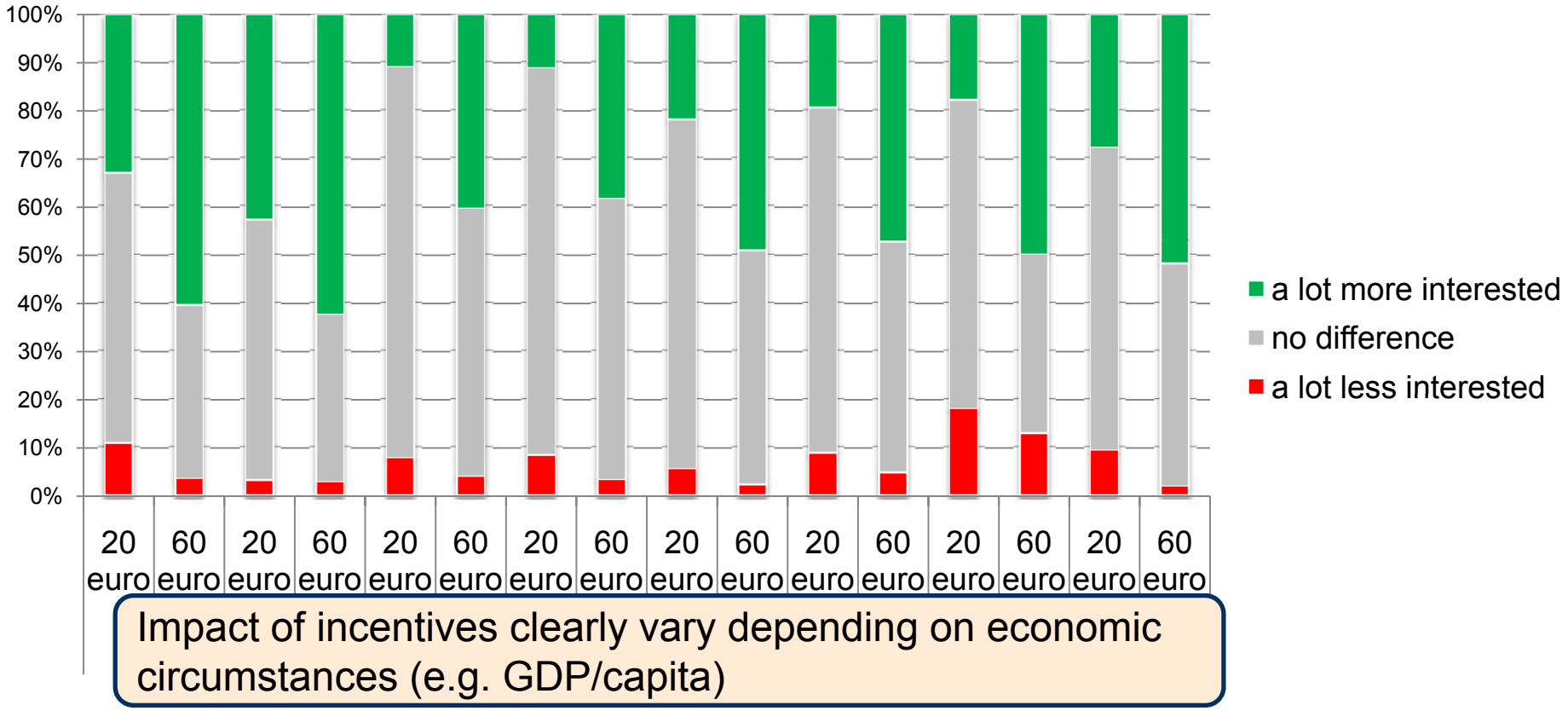
Young people & respondents (currently) without car, most interested

- V2G: unload & recharge whenever plugged in
- Least interest compared to delayed charging (4.4 on 1-7 scale)



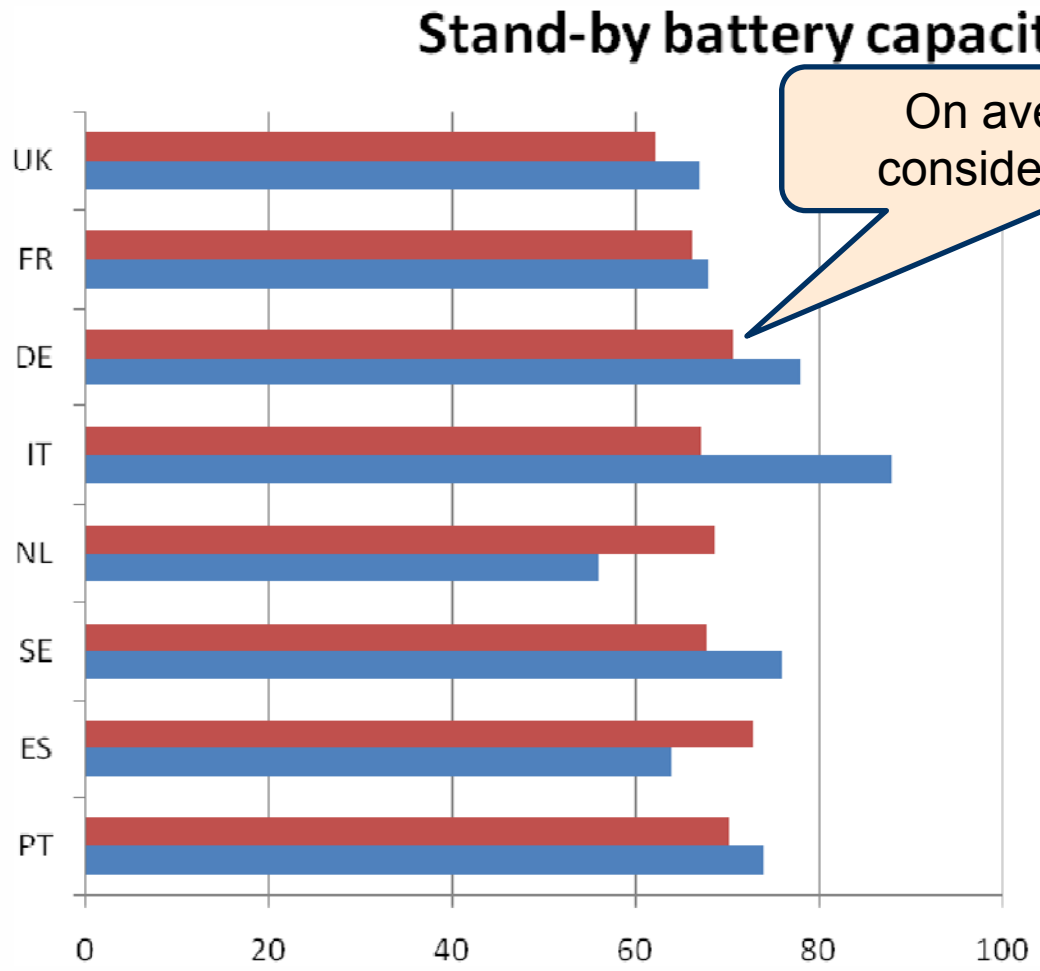
Key results: Interest in V2G – Impact of price incentives

- Interest to participate in V2G services with price incentive of € 20 and € 60 / year:



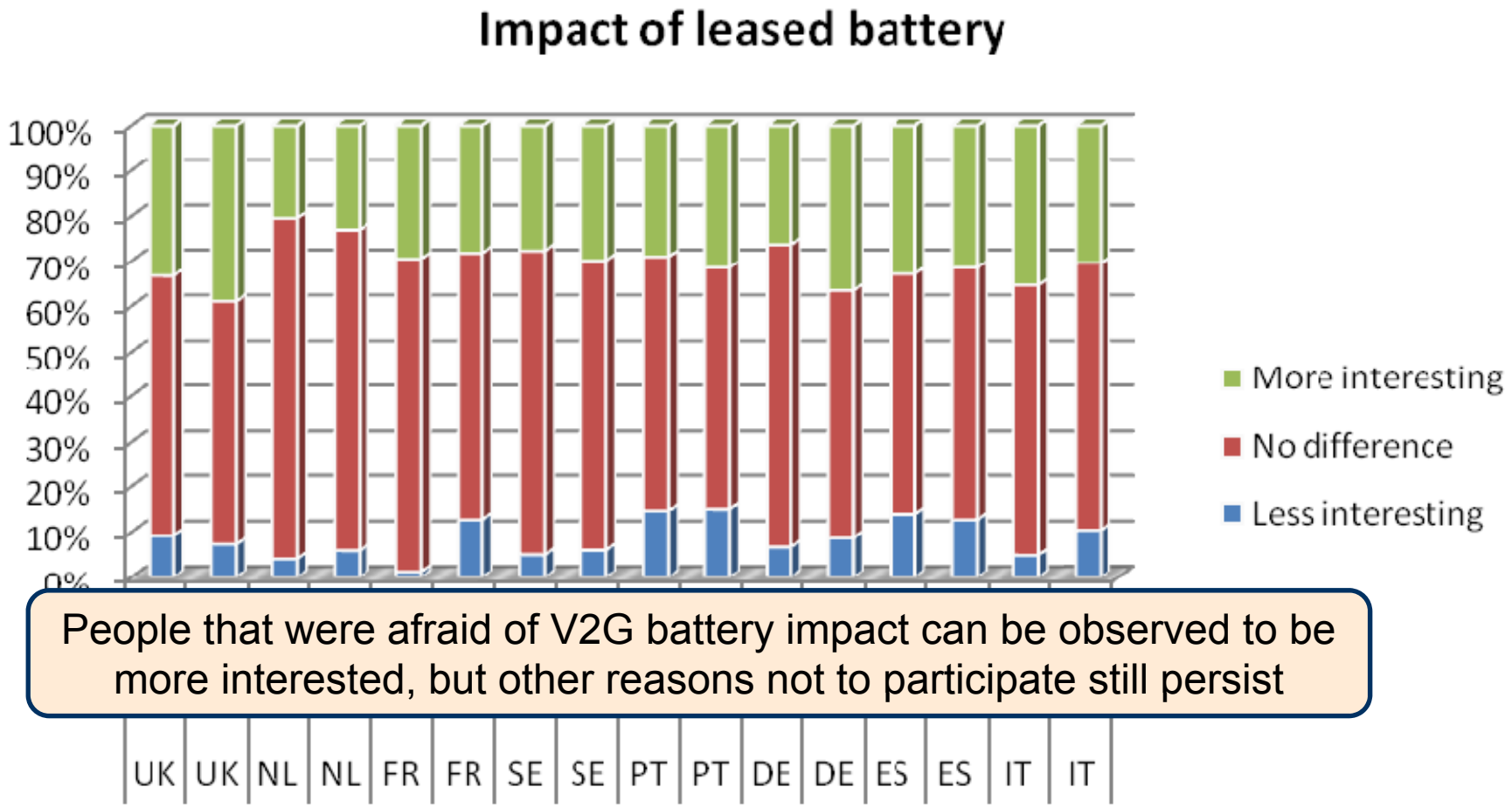
Impact of incentives clearly vary depending on economic circumstances (e.g. GDP/capita)

Key results: V2G – remaining battery capacity



- Includes only people that indicated 120km battery capacity or less (i.e. others have higher desired capacity)
- 70km = provides indication which remaining capacity could be used for services

Key results: Impact of leased battery



People that were afraid of V2G battery impact can be observed to be more interested, but other reasons not to participate still persist

Conclusions

- For mass roll-out of EV it is important that the **anxiety/fear of the people** living in urban areas of being stranded due to lack of recharging infrastructure **should be mitigated.**
  - Facilitate **roll-out of public recharging** infrastructure in cities.

- People **prefer home recharging whenever possible** mainly due to convenience and safety reasons. Even people that don't have a private parking place at the moment indicate strong interest in home recharging.
  - Provide **technical support for convenient home recharging** (e.g. through refurbishment of existing installation or Wall-Box)
  - **Support public charging infrastructure to improve user confidence** that they will have adequate access to charging facilities even when away from home/private places.

Main conclusions from the customer survey

- People are **interested in off-peak charging schemes** (22:00-06:00) with a price incentive compared to normal charging cost.
- Biggest reason for not participating in off-peak charging schemes is the **fear of being unable to travel** when car is needed for any unforeseen reason.
  - Support those charging strategies that best support the system by means of user advantageous tariff structure and assurance of user control over minimum standby battery capacity.
- **Low user acceptance** is observed for participation in **Vehicle-to-Grid** scheme (V2G, bidirectional communication) with main reason being low benefits and the inability to travel (due to empty battery) for any unforeseen reasons.
  - **Financial benefits for the user to join V2G** schemes have to be substantial enough taking into account the different economic conditions across different countries in Europe.

Contacts

In case of any questions regarding the survey, please contact:

Ingo Bunzeck

bunzeck@ecn.nl

ECN Policy Studies

Download the full report about the European survey:

http://www.ecn.nl/docs/library/report/2011/o11030.pdf

Implications for Business Models of Key Stakeholders

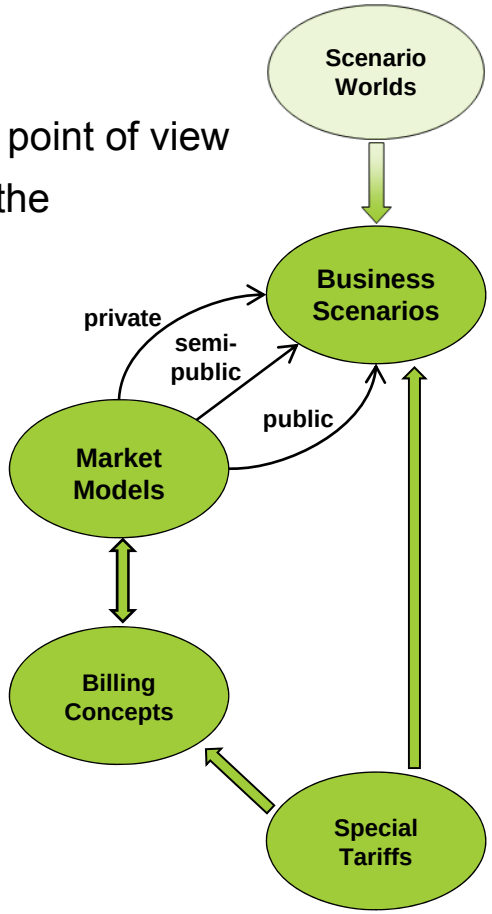
Christian REHTANZ
TUDo

Main Objectives

- Value Chain Analysis
  - Identification of value added steps and their relationships
- Stakeholder Analysis
  - Identification of relevant stakeholders and determination of new functions/roles with respect to E-mobility
- Business Concepts
  - Value chain configuration, product-market combination, revenue mechanism
- Cost Model
  - Cost model includes costs and revenues as well as various assumptions and enables the calculation of cost-benefit-analysis
- Recommendations for Business Models
  - Results of the calculations allow recommendations for business models

Further Objectives

- Business Scenarios
  - Correspond with the Scenario Worlds of WP1 from a business point of view
  - Contain a certain selection of business concepts according to the assumptions of the Scenario Worlds
- Market Models
  - Describe the different possibilities of interaction between the regulated and deregulated stakeholders of the energy sector within the business scenarios
- Billing Concepts
  - Describe the monetary flows between the stakeholders involved in the energy supply including payment methods
- Special Tariffs
  - Analysis of the variability of future tariffs for EVs



Methodology / Approach
Development of Business Concepts

- Initial point of business concepts is the business idea to take over a new function or role with respect to E-mobility
- For each Business Scenario an „Affinity Matrix“ has been created

	Stakeholder	Added values in the area e-mobility						
		Energy Charging Gateway	Battery swapping	ICT Gateway Operation	Measure-ment Service	Aggre-gation	Information and Control Service	Clearing house
	Customer	private						
existing branches	DSO	public						
existing branches	Retailer							
existing branches	MPO/MSP	public						
existing branches	Information Service Provider							
existing branches	Car-park Operator	semi-public						
new	Swapping Station Operator							
new	E-mobility Provider	public						
new	Aggregator							

business affinity/idea of respective stakeholder

Methodology / Approach
Business Case approach

- Business Case approach

1. Utilization of net present value (NPV) method
2. The NPV is set to zero: $NPV_0=0$
   (due to competition and regulation)

Net Present Value | Investment | Return | Interest rate | Operating life

$$NPV_0 = -I + R_T \cdot \frac{(1+i)^T - 1}{(1+i)^T \cdot i}$$

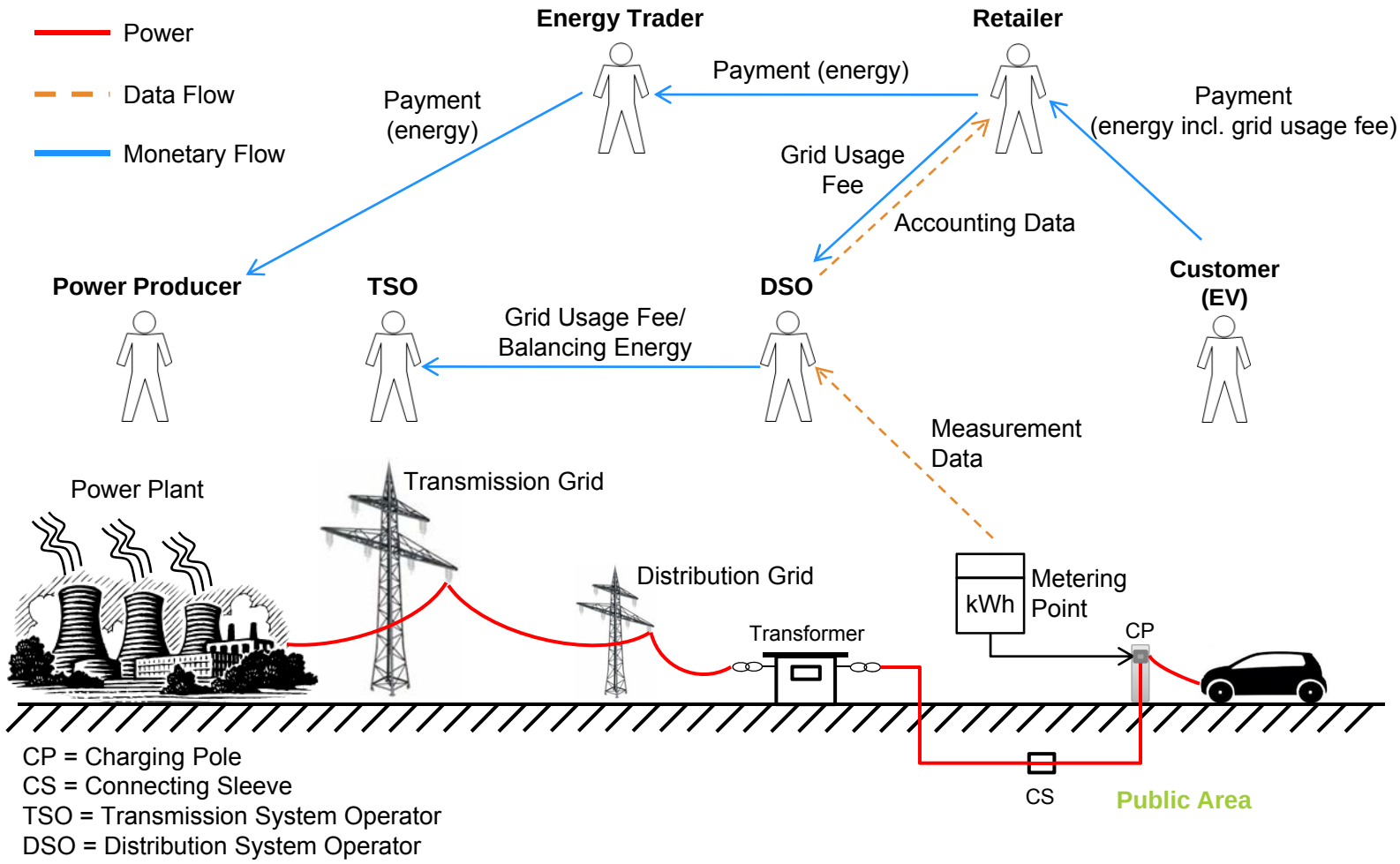
3. Determination of the required return R_T
   by converting the formula

$$R_T = [0 + I] \cdot \frac{(1+i)^T \cdot i}{(1+i)^T - 1}$$

4. Price calculation of services/products $p_{\text{service/product}}$
   by means of service sales amount A_s

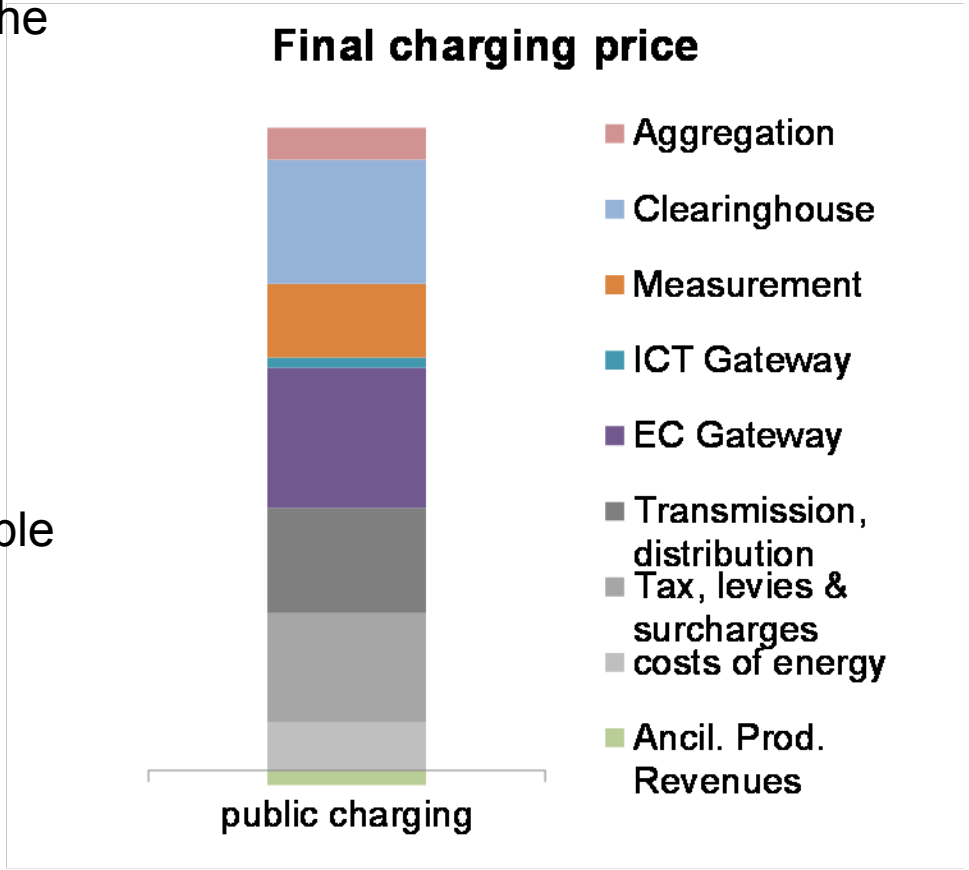
$$p_{\text{service/product}} = \frac{R_T}{A_S} \left[\frac{€ct}{kWh}\right]$$

Methodology / Approach
End-consumer price (energy sector)



Methodology / Approach
Evaluation of Business Scenarios

- The sum of the determined prices for services/products $p_{service/product}$ and the remaining commodities of the electricity branch result in the final charging price of the EV customer
- The EV user pays all services provided by different stakeholders
- The final charging price is the suitable basis to compare the costs and benefits of the different business scenarios
- Ancillary services reduce the final charging price



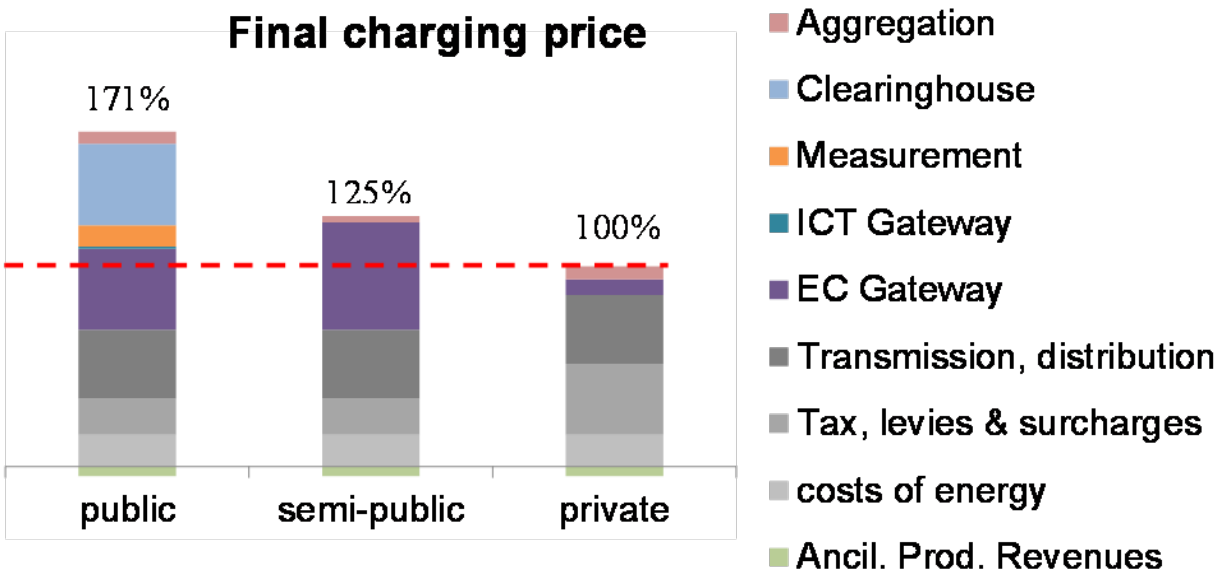
Key Results
Private and Semi-public Charging

Private Charging

- Private charging constitutes the cheapest solution if
  - low investment and operating costs incur for the installation of a delivery point
  - existing ICT structure is used

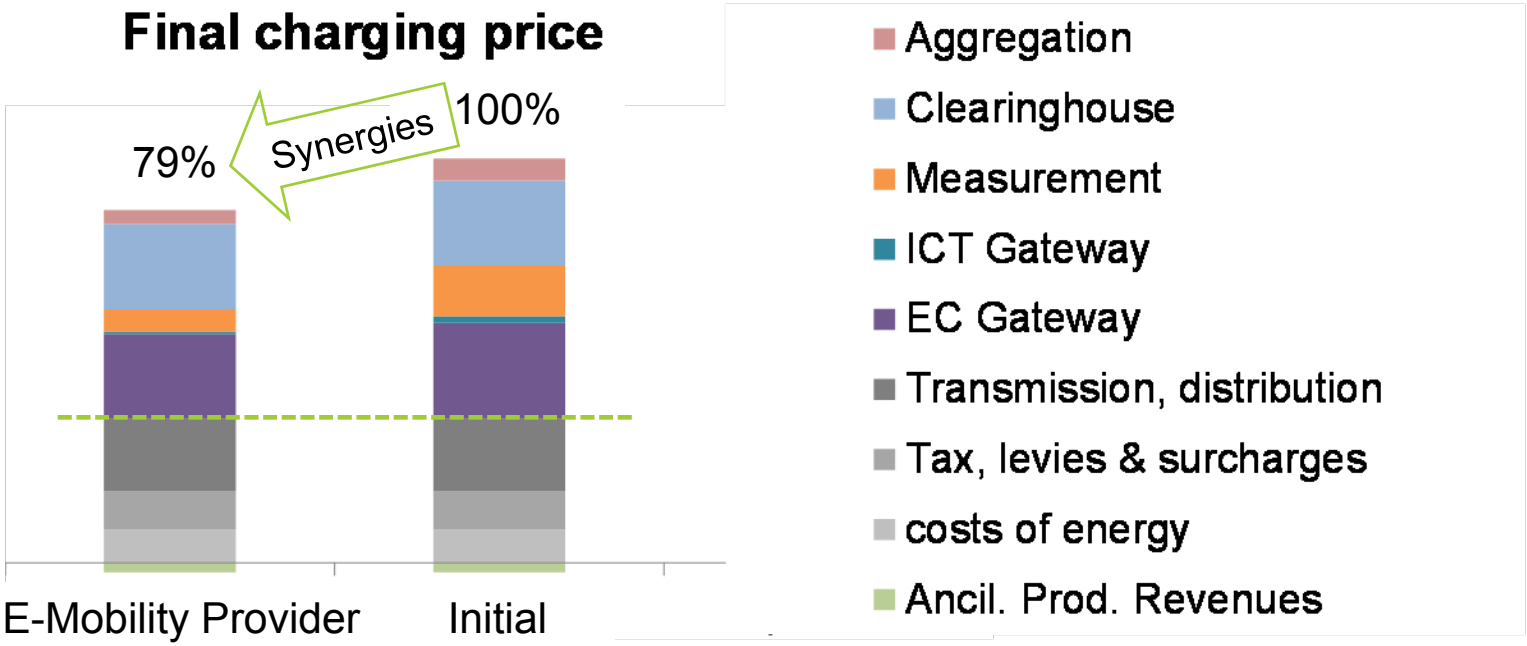
Semi-public Charging

- Semi-public charging constitutes a very promising alternative for the energy supply of EVs apart from private charging



Key Results
Public Charging

- Public slow charging is an expensive solution for an infrastructure due to its high installation and operating costs
- **Synergy effects** (economies of scope, economies of scale) which are caused in certain business models can highly impact the final charging cost

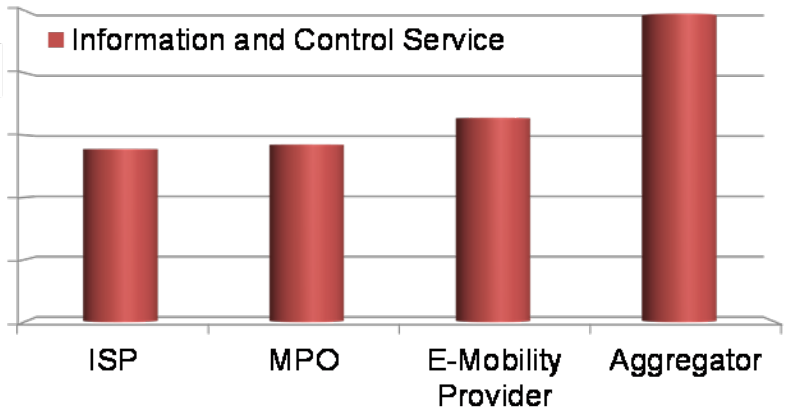


Key Results
ICT Functions

- Comparison of different Business Models

Stakeholder	Added values in the area e-mobility					
	Energy Charging Gateway	ICT Gateway Operation	Measurement Service	Aggregation	Information and Control Service	Clearinghouse
Metering Point Operator (MPO)	public					
Information Service Provider (ISP)						
E-Mobility Provider	public					
Aggregator						

- Synergy effects between ICT functions cause that different stakeholders can provide ICT services by different prices
- Example: Information and Control Service is executed by the ISP to the most convenient price



Conclusions for Business Models

- Aggregator should focus on **business functions,** because he cannot compete in the technical functions
- **ICT stakeholders** are able to create huge economies of scale and of scope due to their existing business (know-how, synergy effects) and are likely to take over some new ICT functions of the *E-Mobility Branch*
- Revenues from **V2G** (Ancillary services) with battery discharge are nowadays insignificant, but future market development may open new opportunities
- Public parking space for EV is a cost driver, municipalities should leave the **parking space** for a low, transparent and uniform fee

Conclusions for Market Models

- Stakeholder which can use several **synergy effects** are likely to provide the cheapest solution
- **Public charging** infrastructure should only be built in those areas where the markets are not able to establish semi-public infrastructure
- **Energy supply of EVs** should be opened for all kind of stakeholders to increase competition
- Thereto **legal requirements** are needed to allow the provisioning of a charging service in the semi-public area
- Country and region specific solutions for **private charging in multi-family houses** (condominium) space have to be pursued in further research projects

Contacts

- **Prof. Dr.-Ing. Christian Rehtanz**

Institute of Power Systems and Power Economics
TU Dortmund University

BCI-G2, 4. OG, 4.09A
Emil-Figge-Straße 70
44227 Dortmund

Phone: +49 (0)231 755 2396
Fax: +49 (0)231 755 2694
E-Mail: Christian.Rehtanz@tu-dortmund.de

G4V™ Grid for Vehicles

SEVENTH FRAMEWORK PROGRAMME

Economic and Environmental Impacts of Electro-Mobility

Goran STRBAC

Imperial College London

CHALMERS ECN EDF edp endesa Enel

ENERGY IN TUNE WITH YOU.

Imperial College London RWE The energy to lead RWTH AACHEN technische universität dortmund UNIVERSIDAD POLITECNICA DE VALENCIA VATTENFALL

Key Objectives

Quantitative Analysis of:

- **The economic impact of the integration of EV on the development and operation of electricity system**

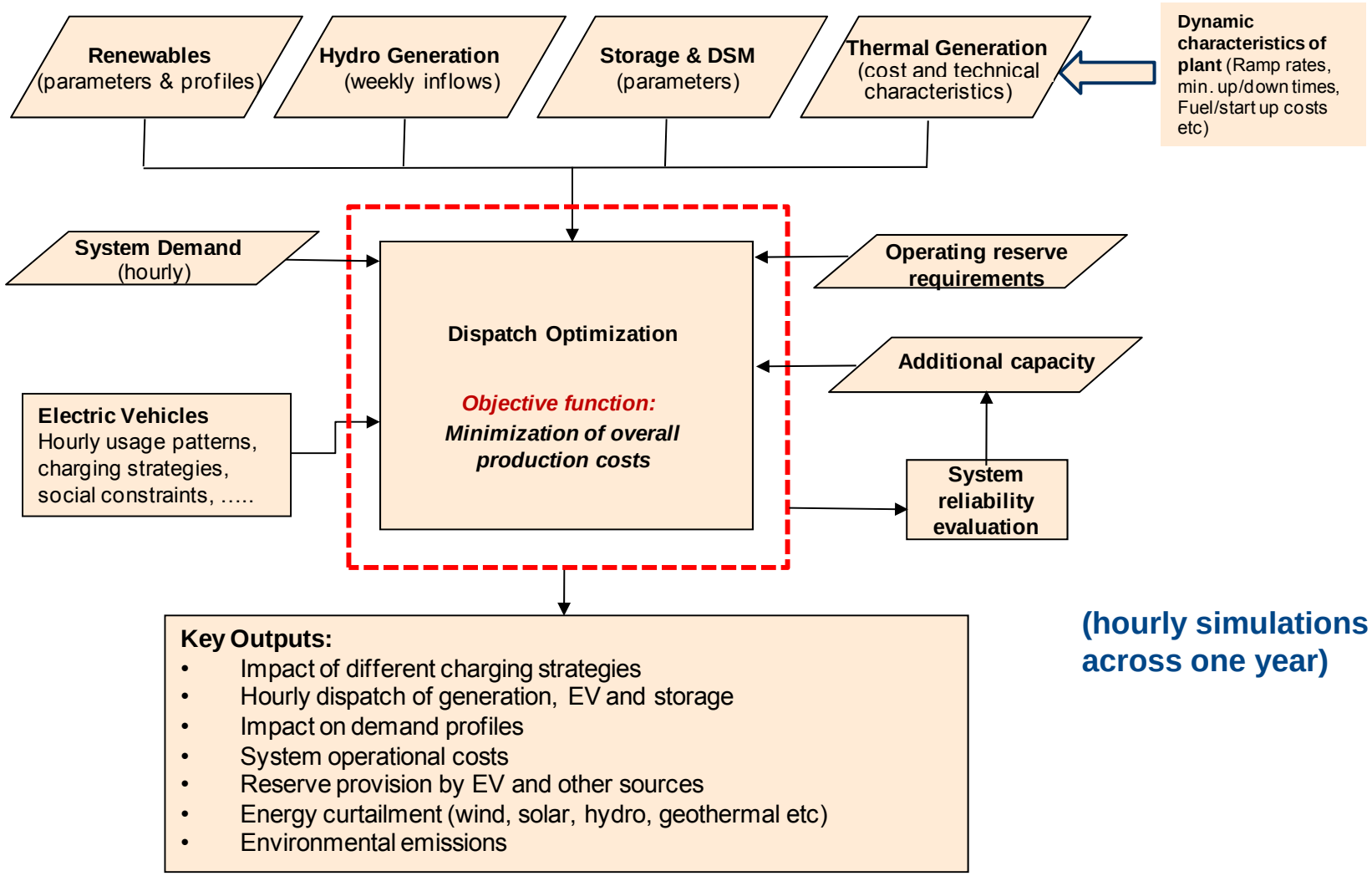
- **The role of EV in the integration of renewable (intermittent) energy sources**

- **The impact of EV integration on CO2 emissions**

Challenges and Opportunities of Integrating EV in the Power System

- **EV charging may have a profound impact** on operating and investment costs of electricity distribution, transmission and generation systems
  - Increase in peak demand due to EVs uptake will be disproportionally higher than increase in energy demand
  - Potentially significant reduction in asset utilisation if uncontrolled
- **Flexibility of EV is very significant**
  - (i) Energy demand increase modest, (ii) Battery power significant (iii) Cars are stationary 90% of the time
  - Significant opportunity for being smart with charging
- **Optimized charging leads to lower additional operational costs and increase in asset utilisation** due to:
  - Greater ability of the system to absorb intermittent generation, peak management and lower usage of expensive generators, provision of response by EV, reduced emissions and associated costs
  - Vehicles to Grid; supporting frequency regulation and security of supply

Methodology (Modelling Framework)



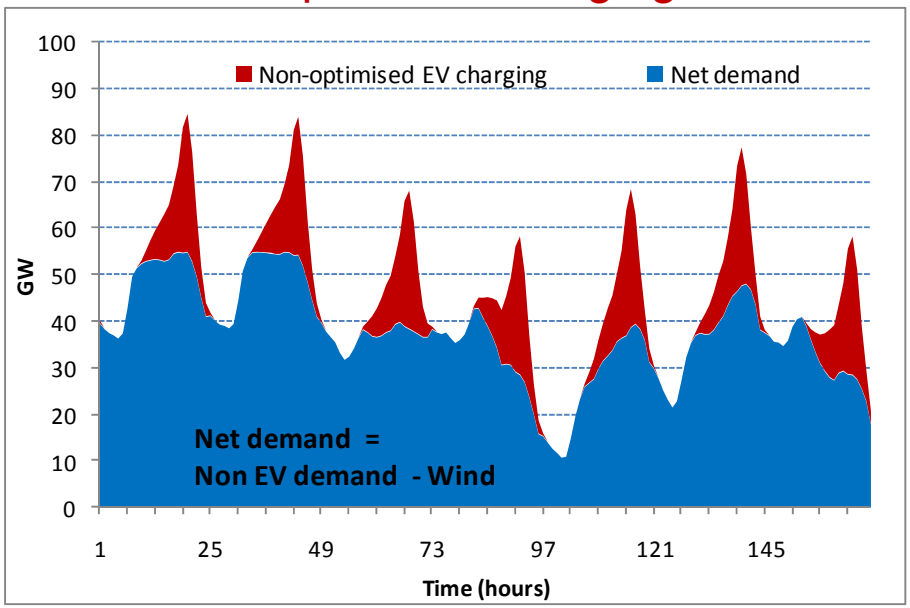
(hourly simulations across one year)

Selected Key Results

Impact of Charging on Aggregate Demand to be Served by Conventional Plant

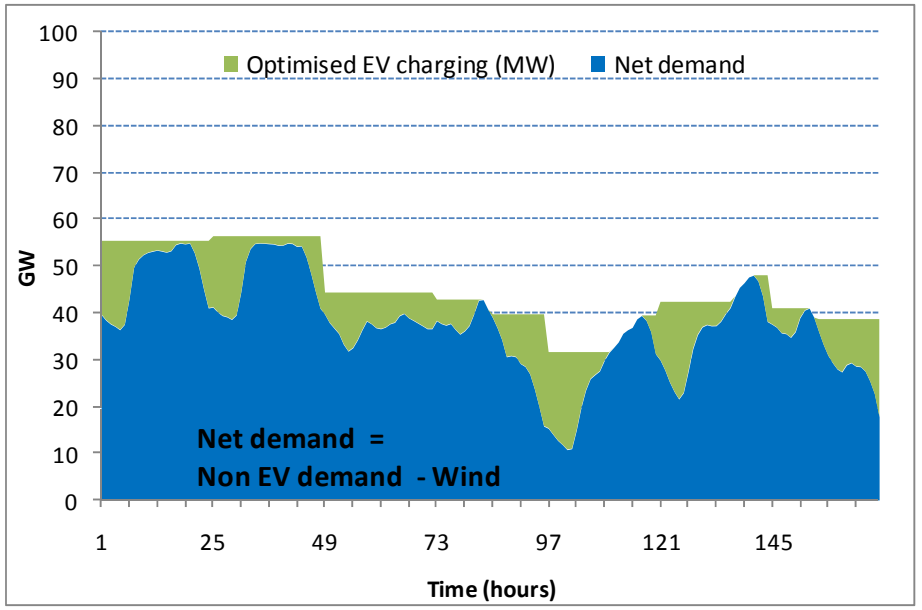
A peak demand week in December
(100% EV penetration)

Non-optimized charging



EV Charging coinciding with peak demand periods

Optimized charging (unidirectional)

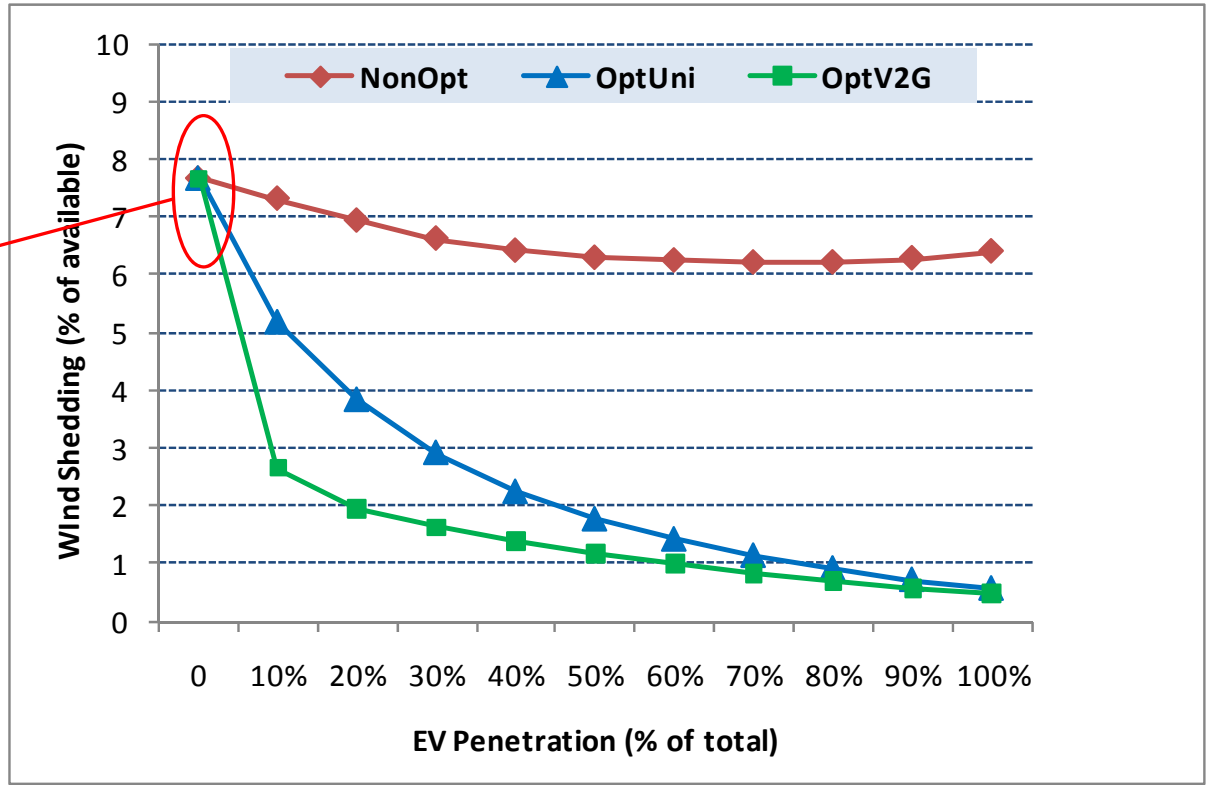


EV Charging optimized during low net demand periods

Impact on Wind Energy Curtailment

(30% wind penetration in the system, Available wind energy :110 TWh)

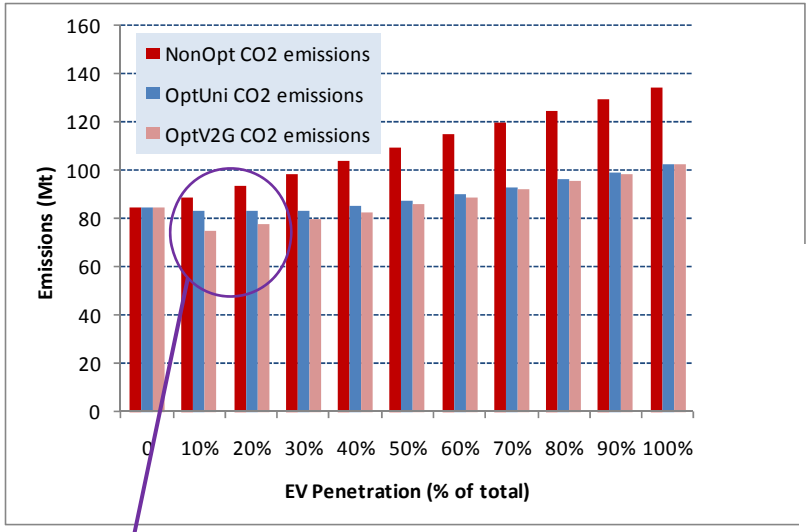
Annual curtailed energy is more than the energy required for annual charging req. of ~15% EV



Significant avoidance of wind energy curtailment by optimized EV charging, even at low levels of EV penetration.

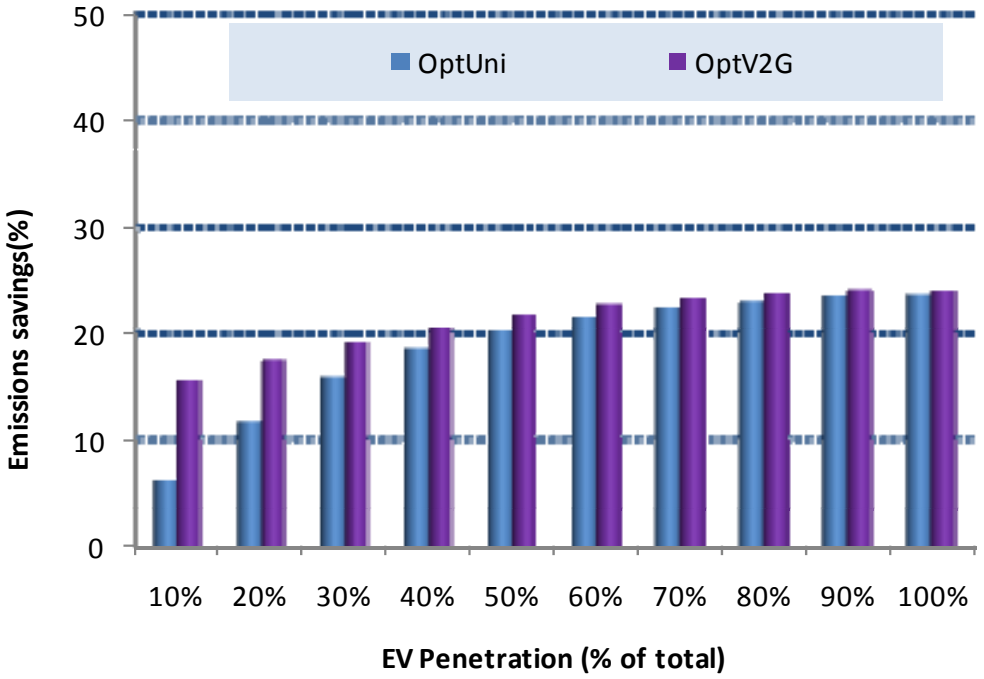
Impact on CO2 Emissions
(from electricity generation)

Emissions

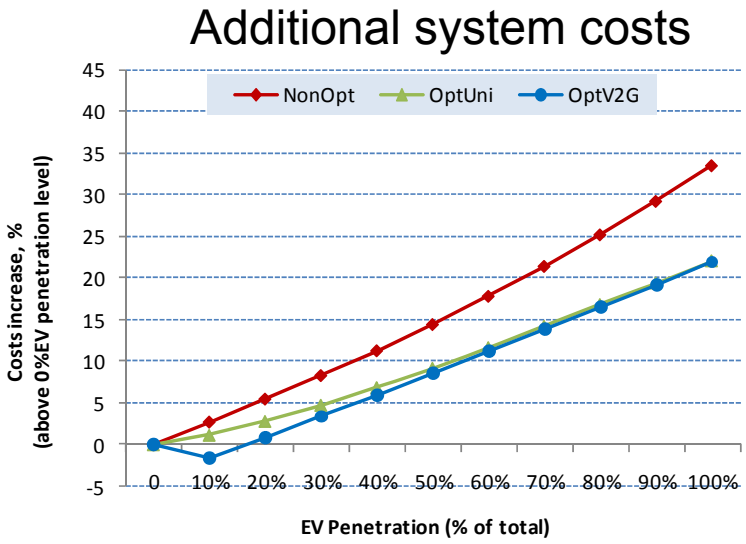


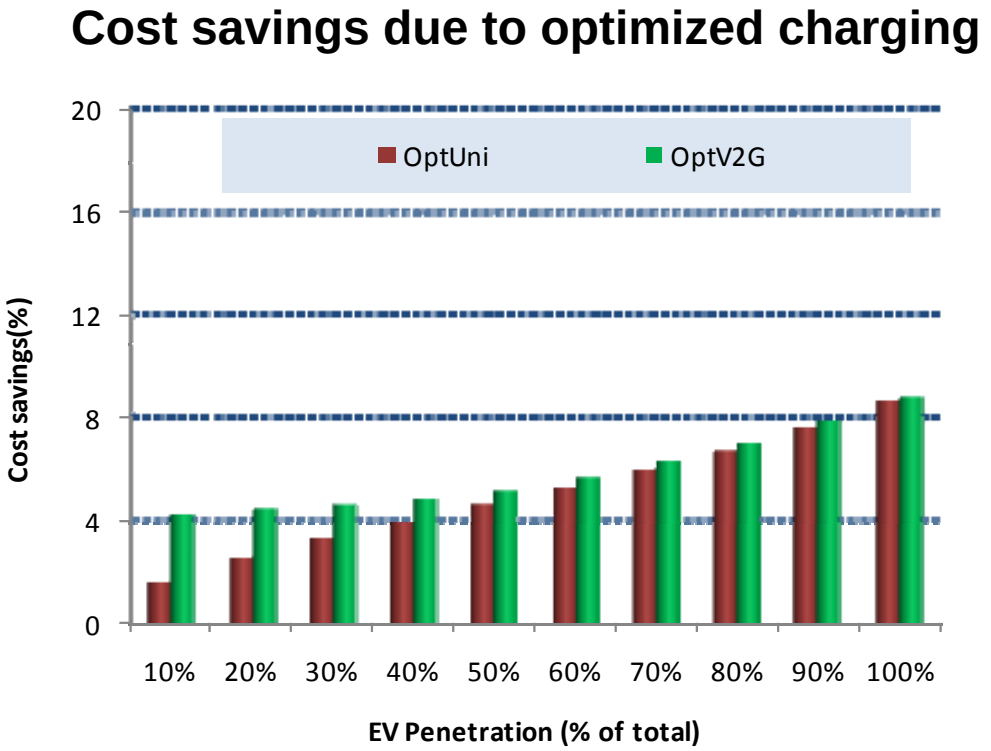
Drop in CO2 emissions in optimized cases is due to:
-greater absorption of wind energy and
- reduced utilization of CO2 emitting (coal) plants

Emission Savings due to optimized charging



Annual System Operational Costs





Key reasons for cost savings in Optimized EV charging:

- **Avoidance of wind energy curtailed**
- **Reduced usage of expensive generators**
- **Reduced provision of response by conventional generators**
- **Reduced emission costs**

Key Factors Affecting the Economic and Environmental Performance of Electricity Sys with EV

- **EV specific factors:**
  - **Driving patterns**
  - **EV Penetration (% share in total vehicle fleet)**
  - **Charging strategies**
    - **Uncontrolled (user dependent)**
    - **Controlled Uni/Bi directional flows**
  - **Provision of services (system support) by EV**
- **Correlation between non-EV and EV related electricity demand**
- **Characteristics of the incumbent system (Generation mix, flexibility)**
- **Penetration level of intermittent generation in the system**
- **Cost parameters (Fuel, CO2,..)**
- **Security standards**

Conclusions

- **Benefits of EV integration start to appear at even low penetration**
- Optimized charging of **EV enhances the systems ability to absorb large share of intermittent energy** (wind).
- **EV charging strategies have a profound impact** on the production mix, system operational costs and additional infrastructure requirements.
- **Additional system costs and emissions** (of the electricity system) are system specific i.e dependent on the capacity mix of the incumbent system.
- Optimized charging leads to **lower additional operational costs due to**:
  - Greater ability of the system to absorb intermittent generation
  - Lower usage of expensive (thermal) generators
  - Provision of response by EV
  - Reduced emissions and associated costs
- The **additional gains due to V2G compared to Uni-directional charging are relatively marginal** and further in-depth analysis involving all relevant costs (ICT, battery value etc) is proposed.

Contacts

Goran Strbac

Professor in Electrical Energy Systems

Imperial College London

G.strbac@imperial.ac.uk

Thank you for your attention!

Recommendations for Formulating Regulatory, Market and Incentive Mechanism

Goran STRBAC

Imperial College London

Objective

Propose 'policy and regulatory recommendations' for facilitating large-scale deployment of electric vehicles in pan-European electricity systems.

Approach

- Identify most relevant areas and challenges for policy and regulation requirements for efficient integration of EV
- Suggest policy and regulatory recommendations in identified areas for facilitating the large scale efficient integration of electric vehicles in the European Electricity Systems

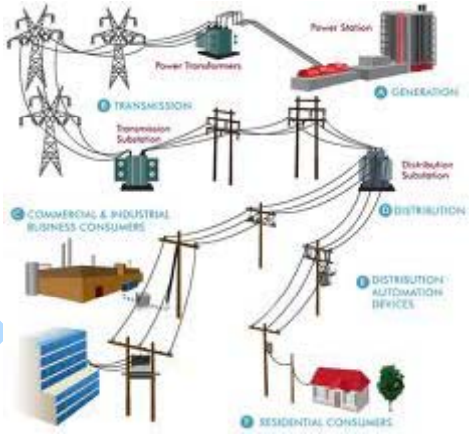
Qualitative analysis based on:

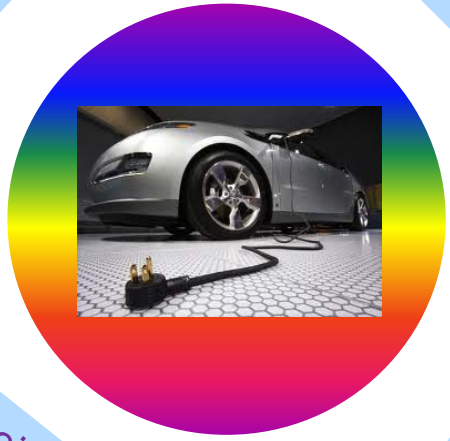
- Expert discussions and meetings
- Stakeholder's workshop,
- Customers survey and
- Literature review.

Identified Major Relevant Areas

Charging infrastructure

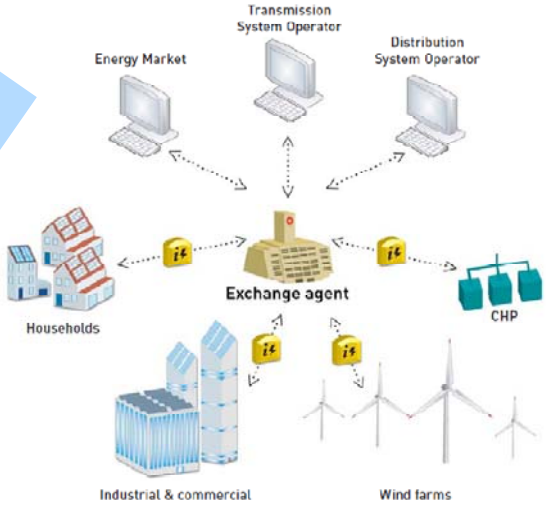
Impact on distribution grid





Ancillary (balancing) services

ICT



Key Policy, Market and Regulatory Challenges

- Clarity on **infrastructure cost allocation** and recovery mechanisms
- Derivation of **tariffs and tax** regimes
- **Incentives/subsidies** – Time, magnitude and area ?
- Development of conducive environment to **facilitate EV (Demand side) participation in markets**
- Encouraging **new value chains and business models** to support EV integration
- Development of **transparent payment and metering mechanisms**
- **Safety, control and access of data** - privacy concerns
- Definition of **contracts among interlinked market players** and settlement procedures
- Efficient operation of historically unconnected markets (auto industry/utilities/mobility providers)

Charging Infrastructure Development

- Clarity on the **responsibility for the development, ownership and operation of (public) charging infrastructure** (CI).
- **Support for roll-out of public charging infrastructures** - incentives or subsidies at initial stages.
- **Standardisation of CI** - as most of the EV users should be technically able to benefit from most of the CI.
- **Provision of system support services by EV -** need standardisation of EV as well as CI to be at least prepared/ready with necessary technical features
- **Non discriminatory access to network**
- **Monopoly control in the charging business -** ensuring fair competition among CI developers and operators

Network Impacts

- **Establishment of clear roles and interactions among relevant actors** (DSOs, retailers, municipalities etc), including :
  - Possibility of shared investment including rules to share required investment among the beneficiaries.
  - Non discriminatory access i.e. clear rules shall be defined to regulate the request of new connections to the grid for charging station.
- Update of existing **remuneration practices** to ensure that all grid investments related to e-mobility are fairly remunerated
- The **"right to the plug"** regulation should clarify all installation aspects both for the customer as well as for the DSO
- **Support for non-network solutions** (smart grid approach) for cost optimal development of networks
- **Support for pragmatic control strategies** including control of EV load by DSO under certain conditions to manage overloads and compensate (pay) the load accordingly

Provision of Ancillary Services by EV

- Regulation must ensure a **non-discriminatory access of EV/demand side to participate in ancillary services markets** and remove existing barriers.
- **Remuneration schemes** needs to be made clear for various services offered by EV such as;
  - Capacity payments.
  - Regulation down - simply charging the battery when it is optimal for the system,
  - Regulating up - more costly due to battery degradation costs, efficiency losses
- **Optimal market time frame and size of balancing bids** for the regulation markets will need to be adjusted for EV.
- There is a need to establish the benefits of using EV for reserve provision compared to conventional sources (hydro or thermal) (this area needs further research)
- A pan-European approach towards provision of ancillary services by EV should incorporate the differences and characteristics of individual systems

Application of Information and Communication Technologies (ICT)

- Support for **Upgradeable ICT infrastructure**.
- **Harmonization of ICT interfaces** within national boundaries as well as across Europe
- **Clear definition of the terms and conditions of the e-roaming** related agreements among involved market players
- **Careful adoption of business models** - complicated models may require more intelligence and hence significantly high ICT costs.
- **Security of the data** including: storage, transmission, retrieval and the privacy of the customer
- **Procedural automation and simplification** through smart metering systems for; data exchange, supplier switching procedure etc.
- **Customer-friendly operation of ICT infrastructure**

Conclusions

- Transparency and clarity is required for the development (investment) of different types of **standardized charging infrastructure** and **network reinforcements**
- At initial stages (with low EV penetration) incentives will be required for **developing the Public Charging Infrastructure**
- Adaptation **of existing network planning and operation rules** is required to **embrace smart charging control strategies** and **promoting non network solutions**
- Exploitation of EV resource for **provision of system support services will require fair access to relevant markets** (capacity, energy or balancing) **and clarity on the remuneration schemes**
- Regulation must ensure **secure, standardized and cost-effective application of ICT infrastructure** for large-scale roll-out of EVs and their efficient integration into the electricity systems.

Contacts

Goran Strbac

Professor in Electrical Energy Systems

Imperial College London

G.strbac@imperial.ac.uk

Thank you for your attention!

G4V™ Grid for Vehicles

SEVENTH FRAMEWORK PROGRAMME

Session III –

Business/Economic, Environmental and Societal Implications for Electro-Mobility

Questions and answers

CHALMERS

ECN

EDF

edp

endesa

Enel
ENERGY IN TUNE WITH YOU.

Imperial College London

RWE
The energy to lead

RWTH AACHEN

technische universität dortmund

UNIVERSIDAD POLITECNICA DE VALENCIA

VATTENFALL