



Session IV – The G4V Roadmap

CHALMERS



ENERGY IN TUNE WITH YOU.

Imperial College
London



RWTHAACHEN

tu technische universität
dortmund



UNIVERSIDAD
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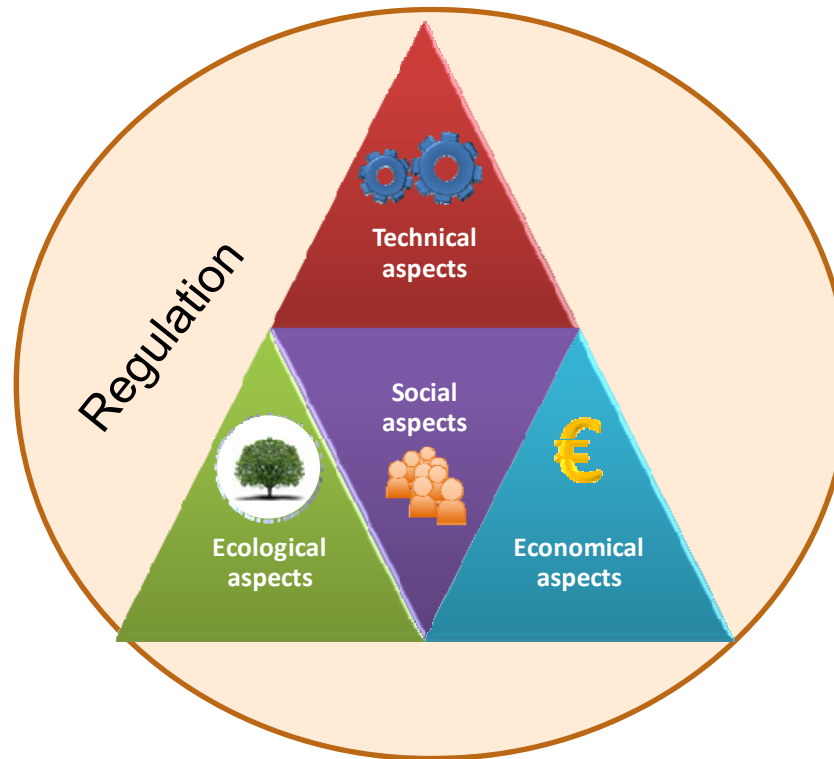


G4V Key Messages and Conclusions

Carlos ALVAREZ
UPV



One Topic. Multiple aspects.



The analysis could not be focus only on one aspect, multiple factors and impacts have to be taken into account.

Different topics are considered within the Key messages.

TOPICS

System operation:

- Control strategies
- Services provided by EVs:
 - V2G, Ancillary services ...

Infrastructure development:

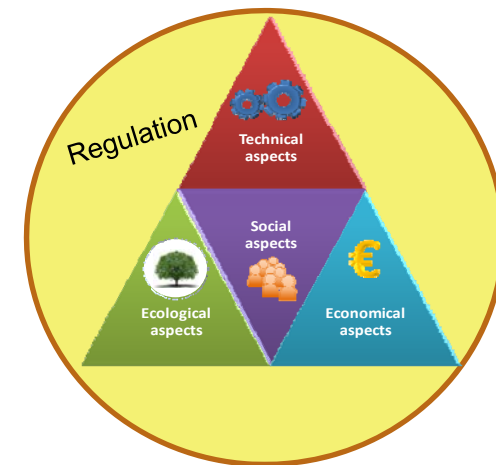
- Capability to integrate EVs
- Charging infrastructure
- Assets management


ICT:

- Technology
- Billing
- Security
- Standards

Different aspects are considered:

- Technical
- Economical
- Social
- Environmental
- Regulation



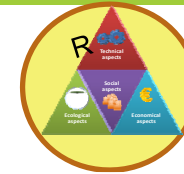
 topic	Technical	Economical	Social	Environmental	Regulation	Recommendation	Further Investigations
System operation							
Infrastructure development							
ICTs							

System operation – Control strategies



Control strategies

**SYSTEM
OPERATION**



TECHNICAL

ENVIRONMENTAL

SOCIAL

ECONOMICAL

REGULATOR

-Integrating EVs will reduce the networks margin however implementing the **right control strategies** can **postpone reinforcements**.

- **Inadequate** charging strategies may **increase network constraints**

-**Advanced solutions** as the decentralized market based approach **improve the system ability of integrating EV.**

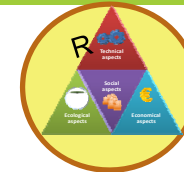


System operation – Control strategies



Control strategies

SYSTEM OPERATION



TECHNICAL

ENVIRONMENTAL

SOCIAL

ECONOMICAL

REGULATOR

- CS can postpone reinforcements.
- Inadequate CS may increase network constraints
- Advanced solutions improve the system ability of integrating EV.

- **from low** penetration of EV, charging (controlled or non-controlled) will have a **significant impact** on **environmental** performance of electricity systems.
- Controlled charging** of EV results in significant **environmental benefits** due to **avoiding the curtailment of wind energy** and a consequential **reduction of environmental emissions.**

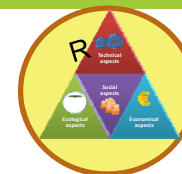


System operation – Control strategies



Control strategies

SYSTEM OPERATION



TECHNICAL

ENVIRONMENTAL

SOCIAL

ECONOMICAL

REGULATOR

-CS can **postpone** reinforcements.

- **Inadequate** CS may **increase network constraints**

-**Advanced solutions** improve the system ability of integrating EV.

- **from low** penetration - **impact** on economic performance of electricity systems

-Controlled charging : to **avoid** the **curtailment** of wind energy . **Reduction** of environmental **emissions**.

-People are **willing to participate** in off-peak charging schemes (22:00-06:00) with a price **incentive** compared to normal charging .

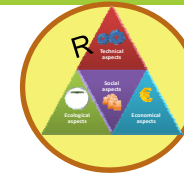


System operation – Control strategies



Control strategies

SYSTEM OPERATION



TECHNICAL

ENVIRONMENTAL

SOCIAL

ECONOMICAL

REGULATORY

-CS can **postpone reinforcements**.

- **Inadequate CS may increase network constraints**

-**Advanced solutions improve the system ability of integrating EV.**

- **from low penetration - impact** on economic performance of electricity systems

-Controlled charging : to **avoid the curtailment** of wind energy . **Reduction of environmental emissions.**

-People are **willing to participate** in charging CS with a price **incentive**

- **Control strategy could reduce** the amount of **investment** in grid reinforcement.

- **Controlled charging can reduce the cost** of supplying additional EV demand

-Advanced control strategies requires **new market design.**

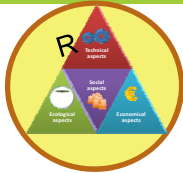


System operation – Control strategies



Control strategies

SYSTEM OPERATION



-CS can **postpone reinforcements**.

- **Inadequate CS may increase network constraints**

-**Advanced solutions improve the system ability of integrating EV.**

- **from low penetration - impact** on economic performance of electricity systems

-Controlled charging : to **avoid the curtailment** of wind energy . **Reduction** of environmental **emissions**.

-People are **willing to participate** in charging CS with a price **incentive**

- CS **reduce** the amount of **investment**

- CS **reduce the cost** of supplying additional EV demand

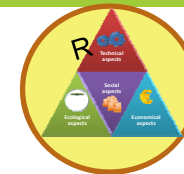
-Advanced CS require **new market design**.



System operation – Control strategies

Control strategies

SYSTEM OPERATION



TECHNICAL

- CS can **postpone** reinforcements.
- **Inadequate CS** may increase network constraints
- Advanced solutions** improve the system ability of integrating EV.

ENVIRONMENTAL

- **from low** penetration - **impact** on **economic** performance of electricity systems
- Controlled charging : to **avoid** the **curtailment** of wind energy . **Reduction** of environmental **emissions**.

SOCIAL

- People are **to participate** charging C price **incentives**

ECONOMICAL

- Development of **new rules** and modification of existing ones will be required for **economically efficient and secure reinforcement and operation** of networks

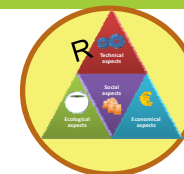
- **Regulatory evolution** is required to allow to **DSO control** over EV charge

- **Regulatory changes** are needed to permit the implementation of **advanced strategies**

System operation – Control strategies

Control strategies

SYSTEM OPERATION



TECHNICAL	ENVIRONMENTAL	SOCIAL	ECONOMICAL	REGULATORY
<ul style="list-style-type: none"> -CS can postpone reinforcements. - Inadequate CS may increase network constraints -Advanced solutions improve the system ability of integrating EV. 	<ul style="list-style-type: none"> - from low penetration - impact on economic performance of electricity systems -Controlled charging : to avoid the curtailment of wind energy . Reduction of environmental emissions. 	<ul style="list-style-type: none"> -People are willing to participate in charging CS with a price incentive 	<ul style="list-style-type: none"> - CS reduce the amount of investment - CS reduce the cost of supplying additional EV demand -Advanced CS require decentralized market design. 	<ul style="list-style-type: none"> -Development of new rules for economically efficient and secure reinforcement and operation of networks - Regulatory evolution

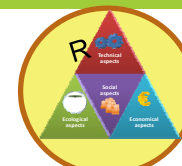
Charging Strategies should be **flexible** and **adjustable** to market penetration level of EVs. The **charging** of EVs should be **controlled** including the needs and constraints of the DSOs. DSO has to have observability and control of the system.

System operation – Services



Services

SYSTEM OPERATION



TECHNICAL

ENVIRONMENTAL

SOCIAL

ECONOMICAL

REGULATORY

- EV can serve for the provision of various system support services in a stable way (V2G, active and reactive power support...).

- The value of EV services is system specific and sensitive to the charging power and efficiency and battery degradation costs



System operation – Services



Services

SYSTEM OPERATION



TECHNICAL

- EV for the provision of various system **support services**.
- The value of flexibility services is **system specific** and **sensitive** to the charging power and efficiency losses and battery degradation costs

ENVIRONMENTAL

-Environmental gains due to bidirectional (V2G) control of EV charging/discharging process compared to controlled Unidirectional charging are found to be relatively marginal

SOCIAL

ECONOMICAL

REGULATORY



System operation – Services



Services

SYSTEM OPERATION



TECHNICAL

ENVIRONMENTAL

SOCIAL

ECONOMICAL

REGULATORY

- EV for the provision of various system **support services**.

- The value of flexibility services is **system specific** and **sensitive** to the charging power and efficiency losses and battery degradation costs

-Environmental gains due to V2G are found to be **marginal**

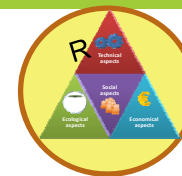
-Low user acceptance is observed for participation in V2G scheme



System operation – Services

Services

SYSTEM OPERATION



TECHNICAL

- EV for the provision of various system **support services**.

- The value of flexibility services is **system specific** and **sensitive** to the charging power and efficiency losses and battery degradation costs

ENVIRONMENTAL

-**Environmental gains** due to V2G are found to be **marginal**

SOCIAL

-**Low user acceptance** for participation in V2G

ECONOMICAL

-**Economical gains due to bidirectional (V2G) control** of EV charging/discharging process compared to controlled Unidirectional charging are found to be relatively **marginal**

REGULATORY

System operation – Services



Services

SYSTEM OPERATION



TECHNICAL

ENVIRONMENTAL

SOCIAL

ECONOMICAL

REGULATORY

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-**Economical gains** due to V2G are found to be **marginal**



System operation – Services



Services

SYSTEM OPERATION



TECHNICAL

- EV for the provision of various system **support services**.

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ENVIRONMENTAL

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SOCIAL

-**Low user acceptance** for participation in V2G

ECONOMICAL

-**Economical gains** due to V2G are found to be **marginal**

REGULATORY

-**Exploitation of EV resource for provision of system support services will require supporting policies and regulation to enable EVs to participate**

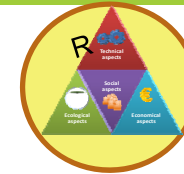


System operation – Services



Services

SYSTEM OPERATION



TECHNICAL	ENVIRONMENTAL	SOCIAL	ECONOMICAL	REGULATORY
<p>- EV for the provision of various system support services.</p> <p>- The value of flexibility services is system specific and sensitive to the charging power and efficiency losses and battery degradation costs</p>	<p>-Environmental gains due to V2G are marginal</p>	<p>-Low user acceptance for participation in V2G</p>	<p>-Economical gains due to V2G are marginal</p>	<p>-System support services by EVs require supporting policies and regulation to enable EVs to participate</p>

V2G is not a profitable business at this moment. Unidirectional charge strategies, at a distributed level, should be first promoted.
 Bidirectional strategies should be reconsidered for a large penetration of EV

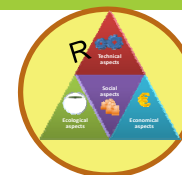


Infrastructure development– Charging infrastructure



Charging infrastructure (CI)

Infrastructure development



TECHNICAL

ENV

SOCIAL

ECONOMICAL

REGULATORY

-The **DSO** shall equip its distribution grid with **devices** able to **detect grid constraints** if he wants to apply more **advanced strategies**

- The power quality disturbances of electronic equipment has to be **limited**. Standards are proposed (IEC 61000, EN50160)

-People **prefer home recharging** due to convenience and safety reasons

-to enhance user confidence **public infrastructure will also need to be rolled-out.**

-**Private charging** constitutes the **cheapest solution** for the charge of EVs

-**Public slow charging is an expensive solution** due to its high installation and operating costs.

-**Appropriate policies and regulatory framework** will be required for development of all types of CI (i.e. private, semi and public); needs to be **coordinated at pan-European level**

-**Investigation of the possibility of shared investment**

A cost effective deployment of EV should be done by promoting home charging (up to 3.7kW), complemented with the network of faster public charging poles.



ICT– Technology, billing, security and standards



Information & communication technologies

TECHNICAL	SOCIAL	ECONOMICAL	REGULATORY
<ul style="list-style-type: none"> -Necessary communication technologies already exist -Security and reliability are the most important factors -ICTs smart grid functionalities for EVs shall be coordinated with future and utilize already implemented smart grid solutions -ICTs should focus to implement control strategies at higher EV market penetration rates to reduce grid impact. -Standardization needs: data model for the ID of the user, type of information to communicate, type of modulations and protocols 	<ul style="list-style-type: none"> -Standards are needed for the communications interfaces to facilitate customers access to charge services -guarantee data privacy 	<ul style="list-style-type: none"> -Standards for the communications interfaces reduce risk investments - cost-efficient application of ICT infrastructure is indispensable for large-scale roll-out of EVs. 	<ul style="list-style-type: none"> - European Union Legislation for protection of personal information shall be considered. -Security aspects must be a priority in the technologies selected in all the ICTs interfaces (ID, EV communications, billing,..)

ICTs do not represent a barrier for the integration of EVs. Its “utilization” to apply control strategies may help to reduce grid impacts. Synergies with Smart Grids should be respected in the development of ICT.



Conclusions



System operation:

Charging Strategies should be **flexible** and **adjustable** to market penetration level of EVs. The **charging** of EVs should be **controlled** including the needs and constraints of the DSOs. DSO has to have observability and control of the system.

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Infrastructure development:

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ICTs do not represent a barrier for the integration of EVs. Its “utilization” to apply control strategies may help to reduce grid impacts. Synergies with Smart Grids should be respected in the development of ICT.



Thank you for your attention!

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The Roadmap Enabling Grid For Vehicles

Step by step towards 2030 and beyond

Thomas THEISEN
RWE



CHALMERS



ENERGY IN TUNE WITH YOU.

Imperial College
London



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Scenarios set the framework of the market development and are the environment of the roadmap

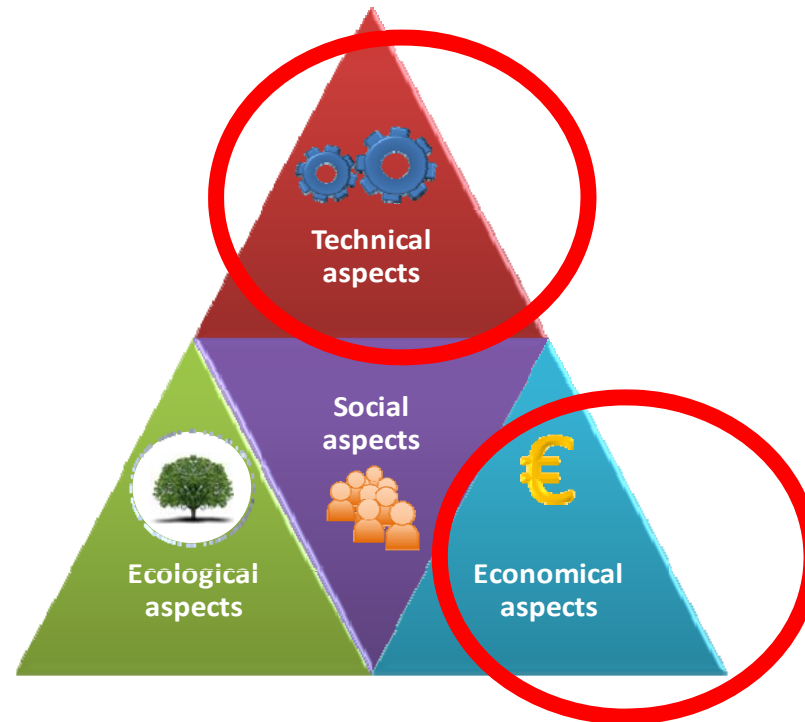


•All topics were worked out within the different G4V work packages

Topic	Conservative World	Pragmatic World	Advanced World
Charging control	No	Yes, simple charging control	Yes, complex charging control
Prices	As today	Dynamic tariffs	No limitation
Regulation	Conservative	Some liberalization	Optimal situation for EVs
Services	Unidirectional, no services	Unidirectional, all services can be provided	Bidirectional, all services can be provided
Grid infrastructure	Conventional development	Smart grids	Advanced smart grids, virtual power plant etc.
ICT	As today	Improved	Advanced
Stakeholders	Traditional stakeholders	Traditional stakeholders with new roles	New stakeholders



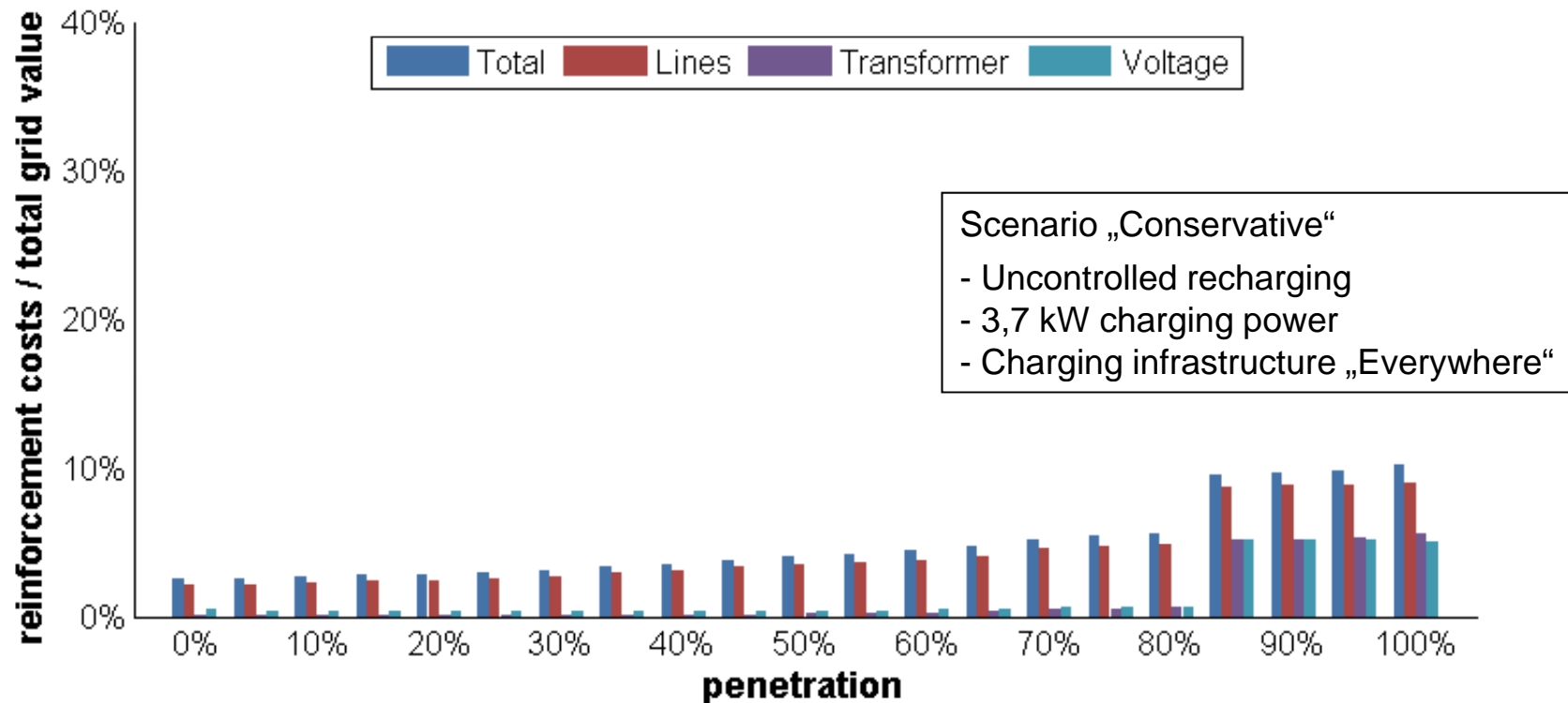
The Roadmap will describe a holistic design of the ideal technical –economical structure



The results indicate the time of grid reinforcement and impact of control strategies



- The average simulation results of all investigated MV and LV grids show the general effect of an increasing EV market
- A specific analysis of the individual state of grid has to be done to prioritize the actions for improvement



Control strategies have a great impact on grid reinforcements



Scenario: **Conservative**

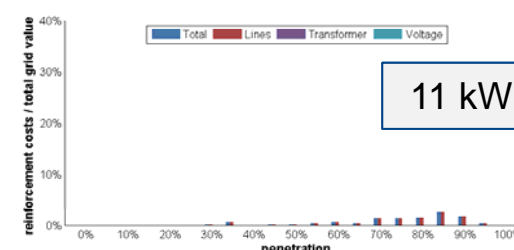
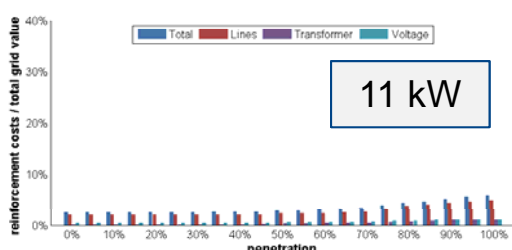
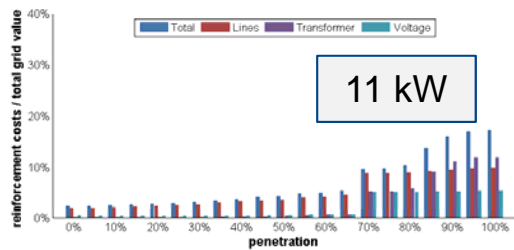
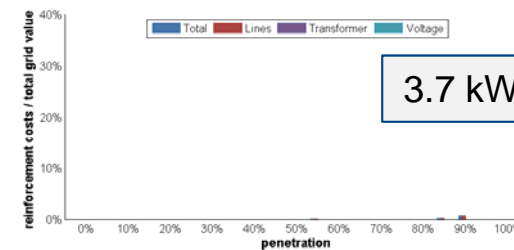
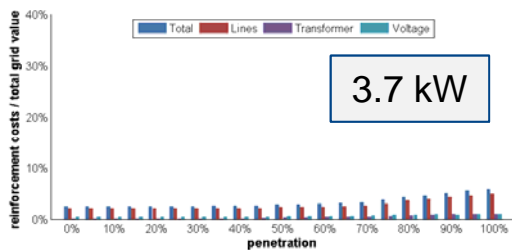
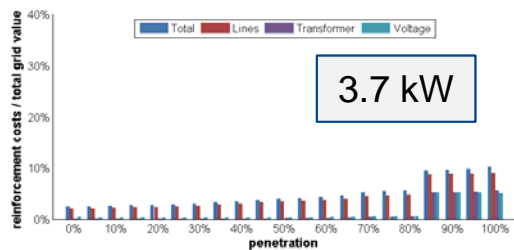
Scenario: **Pragmatic**

Scenario: **Advanced**

No control strategy

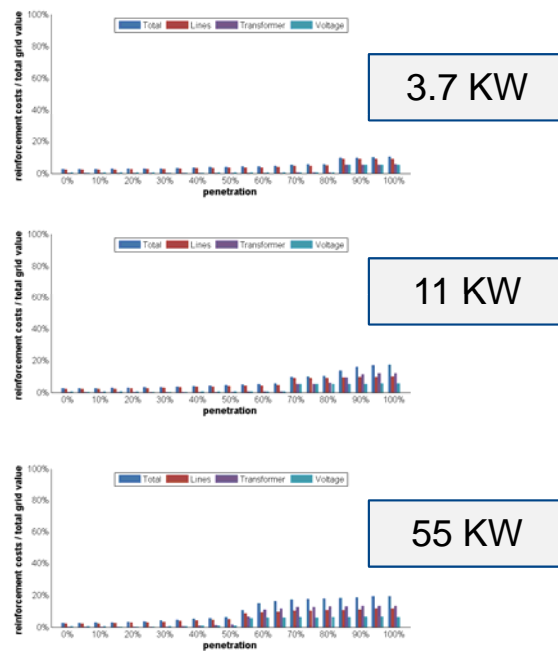
Control strategy:
Unidirectional power flow
Bidirectional communication

Control strategy:
Bidirectional power flow
Bidirectional communication

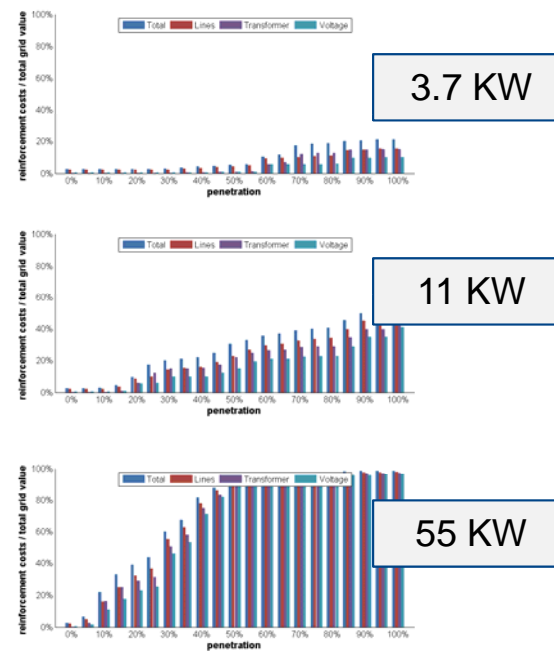


A control strategy applied in a wrong way can produce a negative effect

No control strategy



Control strategy applied in a wrong way



Simultaneous ToU

It is necessary to select the most suitable control strategies respecting the characteristics of the grid.

The scenarios are the framework where the EV integration is analysed



- Opportunities and requirements appear to apply one control strategy
- If a change of scenario is desirable (mandatory to apply some strategies) some **requirements** have to be achieved:

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Different opportunities appear in different frameworks...

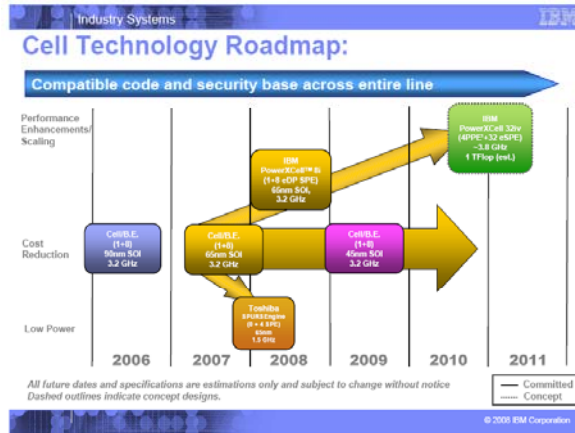


...and some **opportunities** appear as a consequence of the new framework:

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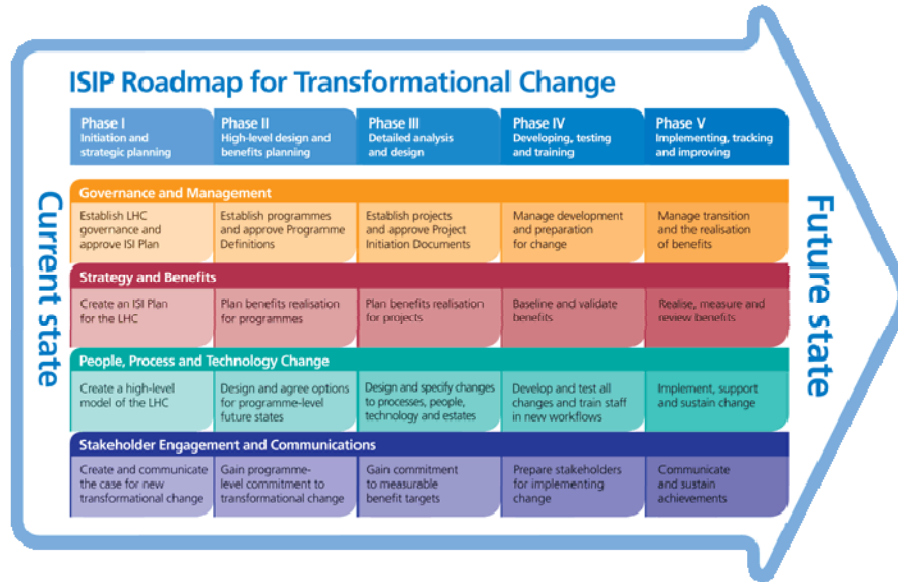


The Roadmap...



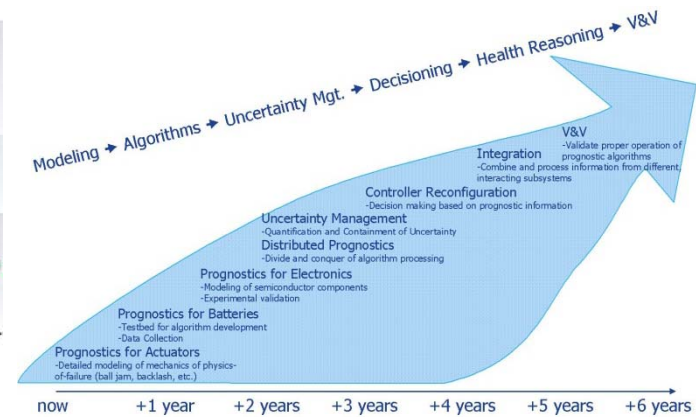
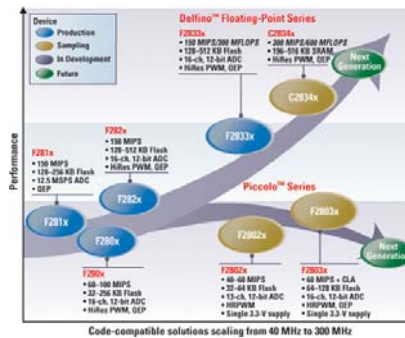
OC-4 Roadmap for Organic and Printed Electronics Applications

Organic Photoconductor	Organic Light Emitting Diode	Organic Field Effect Transistor	Organic Thin-Film Transistor	Organic Solar Cell
• High resolution printing	• High efficiency lighting	• High performance logic	• High performance logic	• High efficiency energy conversion
• Flexible substrates	• Flexible substrates	• Flexible substrates	• Flexible substrates	• Flexible substrates
• Low cost manufacturing	• Low cost manufacturing	• Low cost manufacturing	• Low cost manufacturing	• Low cost manufacturing
• Scalable production	• Scalable production	• Scalable production	• Scalable production	• Scalable production
• High performance	• High performance	• High performance	• High performance	• High performance
• Low power	• Low power	• Low power	• Low power	• Low power
• High reliability	• High reliability	• High reliability	• High reliability	• High reliability
• High performance	• High performance	• High performance	• High performance	• High performance
• Low power	• Low power	• Low power	• Low power	• Low power
• High reliability	• High reliability	• High reliability	• High reliability	• High reliability
• High performance	• High performance	• High performance	• High performance	• High performance
• Low power	• Low power	• Low power	• Low power	• Low power
• High reliability	• High reliability	• High reliability	• High reliability	• High reliability



The Tapping Road Map

Spiritual Enlightenment		
Living Your Life Purpose	Accepting the World	Ego-Detachment
Health Eating Healthily Exercising Regularly Having the Body you Want	Wealth Your Ideal Lifestyle Abundance of Money Achieving Your Goals	Relationships Open to Love Healthy Relationships with Friends and Family
Finding Happiness		
Self-Acceptance	High Self Esteem	Organised Life
Healing and dealing with Problems		
Stress and Anxiety	Forgiveness	Addictions



The jump



Scenario: **Conservative**



Scenario: **Pragmatic**



Scenario: **Advanced**

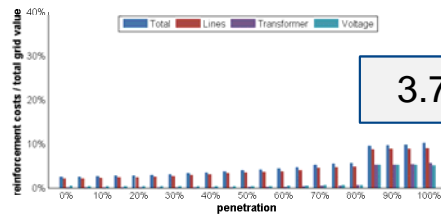
The **regulation** is conservative as today so that the conditions for EVs are difficult. EVs are **not able to generate additional benefits**. They can only adapt their behaviour to different price signals as they are possible today



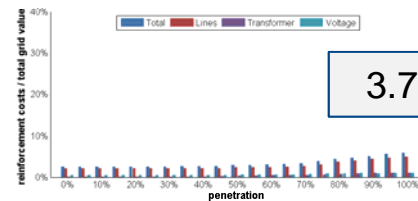
A major change compared to the conservative world is the **possible influence on the charging** of the EVs. The loading can be postponed or interrupted. **Participation in reserve market** is possible due interruptible loads



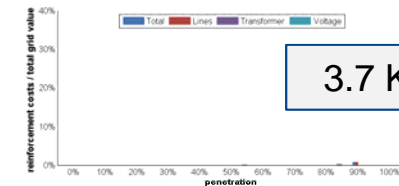
EVs have an optimal situation and **can participate at different markets providing V2G services**. Moreover, real time markets and active demand is possible and permitted by the **regulator**. EV are incentivized to support renewables integration.



3.7 KW



3.7 KW



3.7 KW



Final observation, conclusions (1/2)



- A clear **relation** between the different countries and the **capability to integrate EVs cannot be observed**. The diversity of grids in every country is too large
 - The single information of voltage level is not a decisive parameter to cluster a grid. MV and LV level are expected to show - on average - an similar ability to integrate EVs
- Actions to improve the integration of vehicles should not be carried out country by country, but in joint effort by all European countries and in common with the car industrie



Final observation, conclusions (2/2)



- **Control strategies** which allow the **steering** of the specific load of **EV charging** avoid grid re-inforcement
 - Control strategies which start from country specific enhanced „business as usual“ solutions in the short term have to be developed to more advanced solutions and taking over existing smart grid functionalities
- The **pragmatic control strategies** shall be **implemented** as an europeanwide **approach for EV integration**. The **specific requirements** in terms of regulation, ICT and grid infrastructure **have to be fulfilled**



Thank you for your attention!

Thomas Theisen. RWE
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Coffee Break

15:30 – 16:40

Presentations will be made available on: www.g4v.eu

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ENERGY IN TUNE WITH YOU.

Imperial College
London



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