BMW Group, Xaver Pfab

# POWER UP - HOW E-MOBILITY WILL SUPPORT THE TRANSITION TO RENEWABLE ENERGIES.

## ENERGY STORAGE IN GERMANY—R&D FOR THE ENERGY SYSTEMS TRANSFORMATION

**1. MÄRZ 2015**

BMW GROUP

# ENERGY TRANSITION AND ELECTRIC-MOBILITY AS WELL ARE UNDER DISCUSSION.

## Energy transition

- Electricity becomes too expensive
- Resistance against new power lines
- Resistance against new pump hydro power plants
- Resistance against new wind power plants

- Does the energy transition really help against the climatic change?

## Electric mobility

- Batteries too expensive, poor range
- E-mobiles reasonable, but boring
- No sufficient charging infrastructure
- Electricity supply already without E-mobility more and more critical

- Is E-mobility really sustainable?

# WITHIN A CHANGING WORLD E-MOBILITY BECOMES A VERY INTERESTING SOLUTION.

## Environment

Climatic change and damages

## Urbanisation

2030 more than 60 % of the word wide population will live in cities

## Customer

Change of values

**Pushing E-Mobility**

## Culture

Sustainable mobility as an element of a modern urban lifestyle, take-over of social resonsibility.

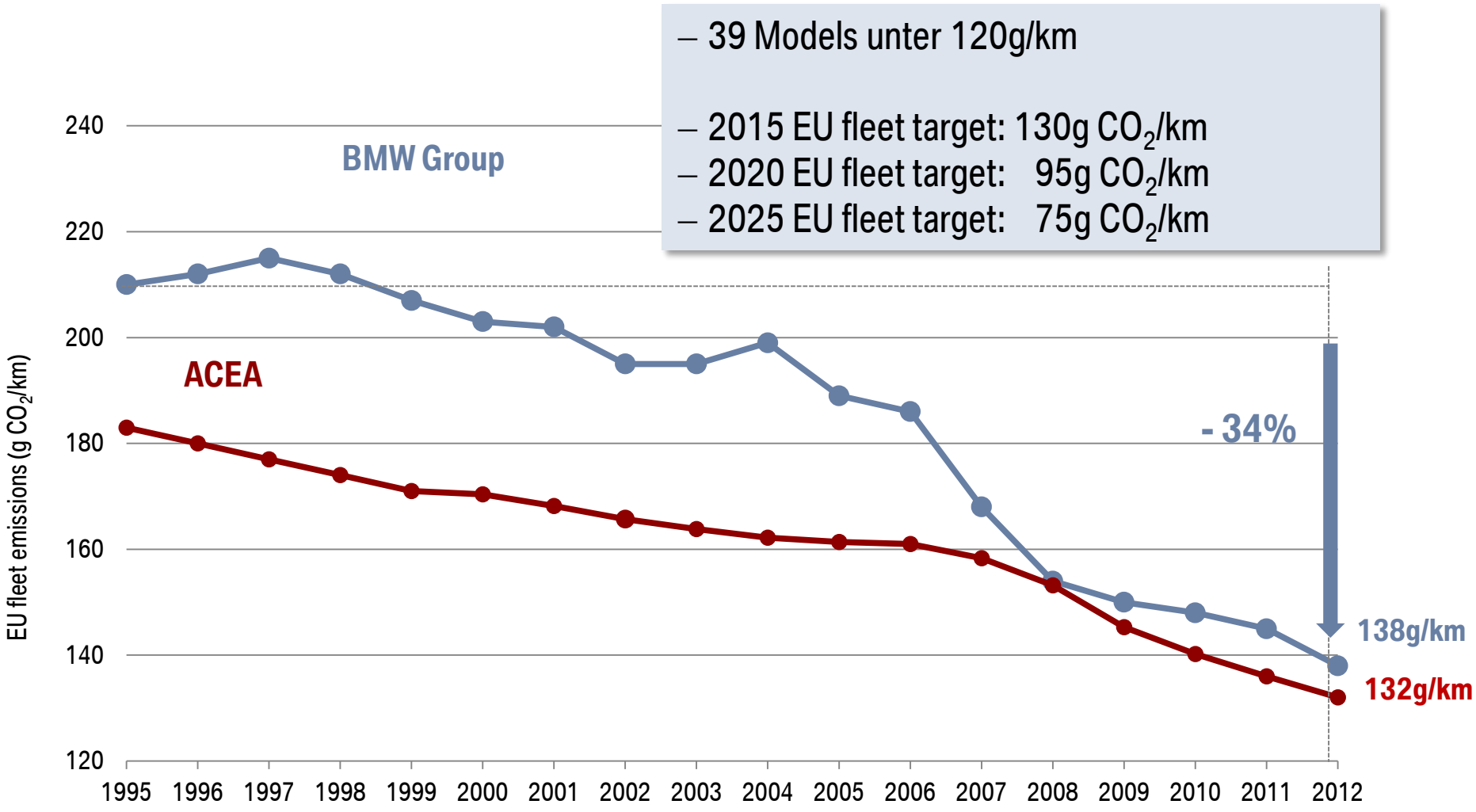
## Economy

Limited ressources, increasing prices for fossil fuels

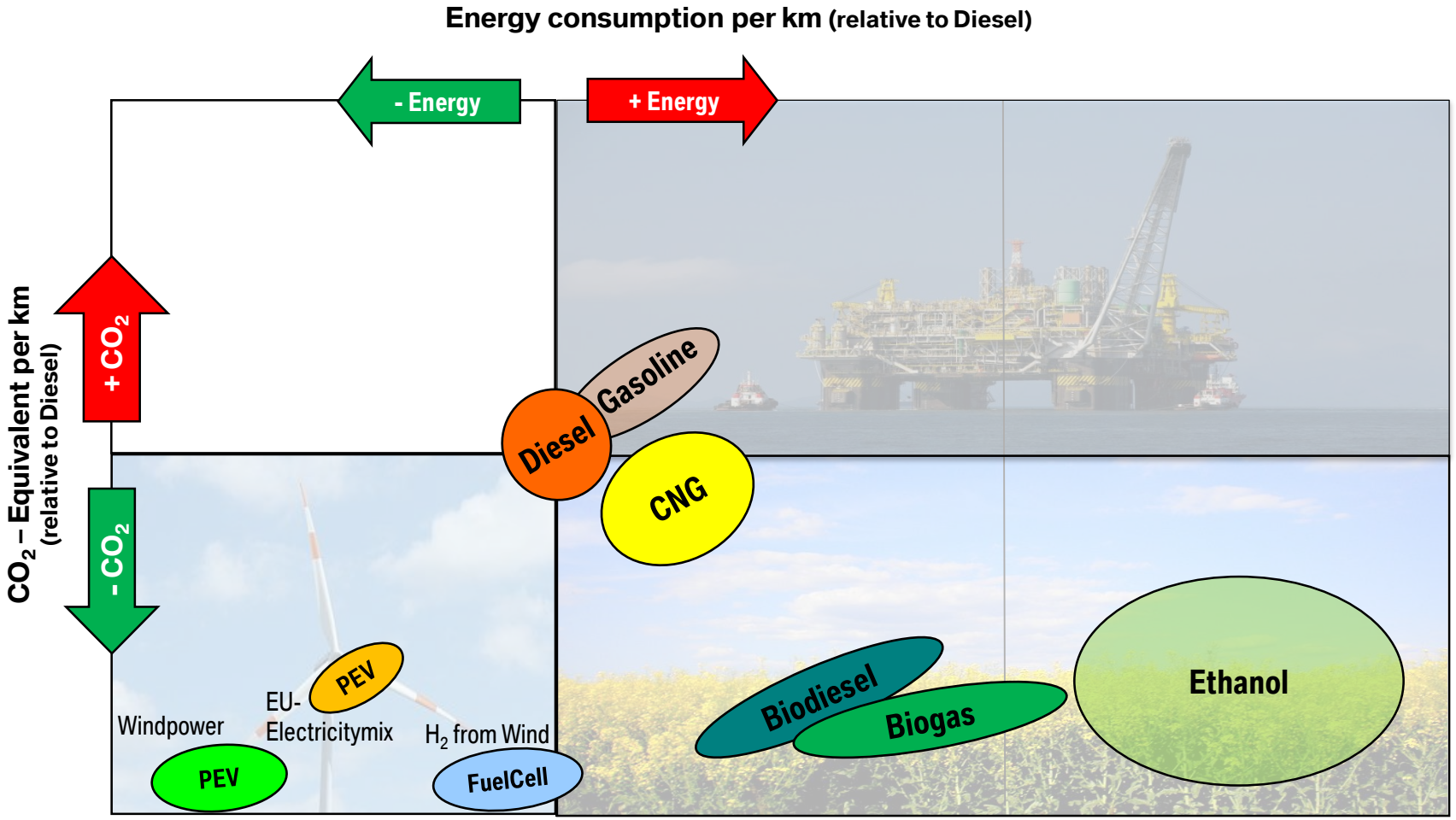

## Politics

$CO_2$ – taxes, Fleet regulation, Limited access, congestion charge

# THE BMW GROUP HAS THE ACEA COMMITTMENT MORE THAN FULFILLED.



# E-VEHICLES ARE BEST CHOICE IN TERMS OF $CO_2$- AND EFFICIENCY COMPARED TO ALL POWERTRAIN CONCEPTS.

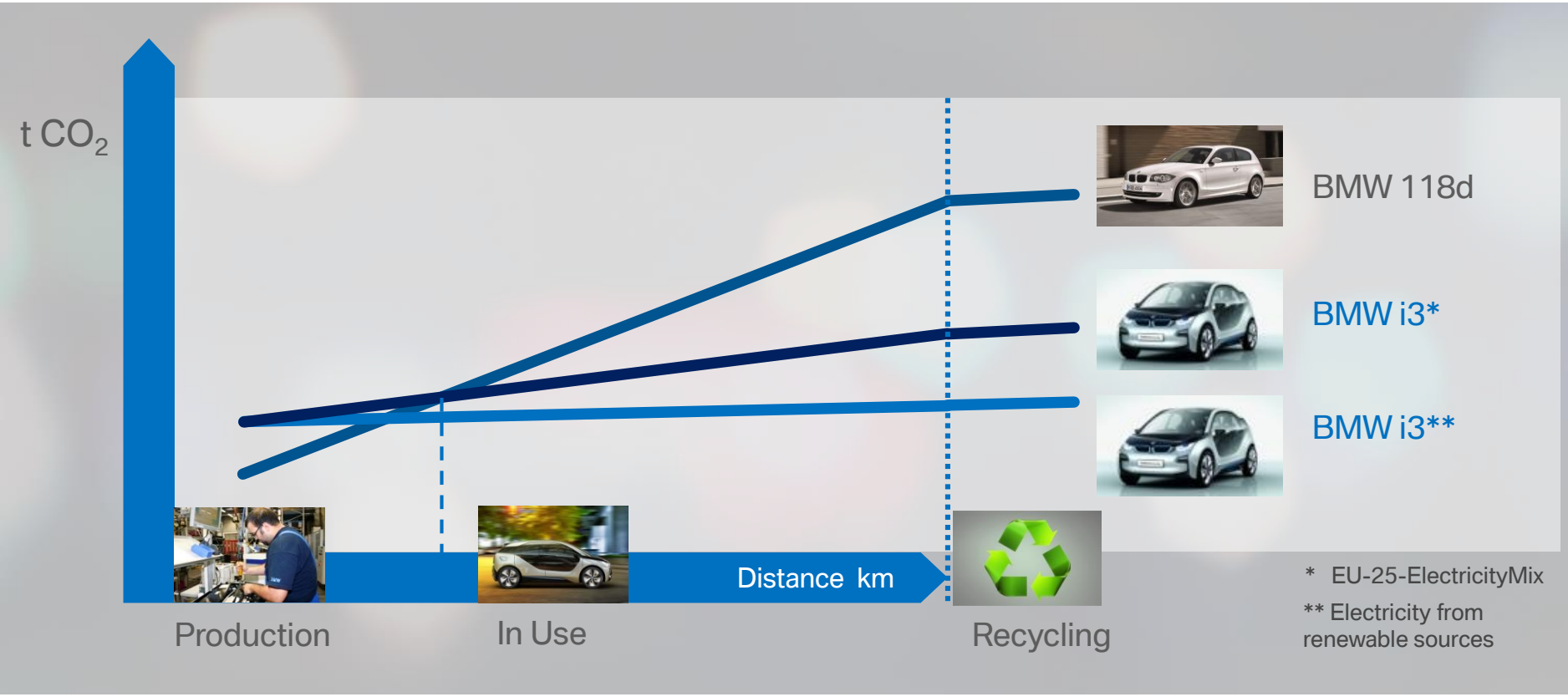



Source: own slide according to EUCAR/Concawe/JRC Well-to-Wheels-Report

# BMW IS CONSEQUENTLY PROCEEDING TIHIS PATH - E-MOBILITY IS A MAJOR PATH.

E-Mobility opens a new approach to the Ultimate Driving Machine.

# BEYOND LESS THAN 50.000 KM THE HIGHER AMOUNTS OF CO2 EMISSIONS ARE ALREADY COMPENSATED.



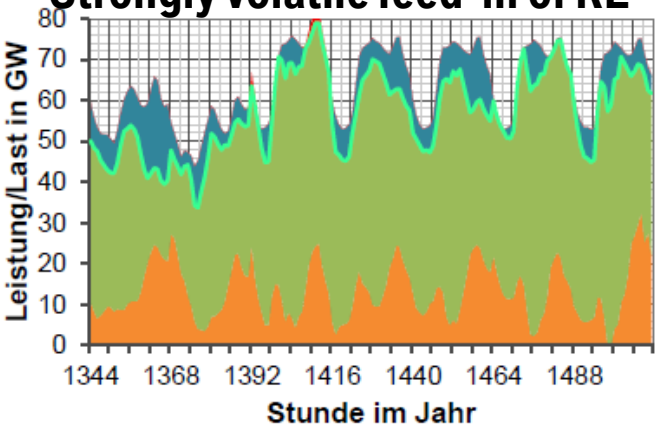
# ENERGY TRANSITION AND E-MOBILITY. A STRONG INTERFERENCE.

1 Electric vehicles as consumers of green energy

+

= **Sustainable, emissionfree mobility**

**Strongly volatile feed-in of RE**

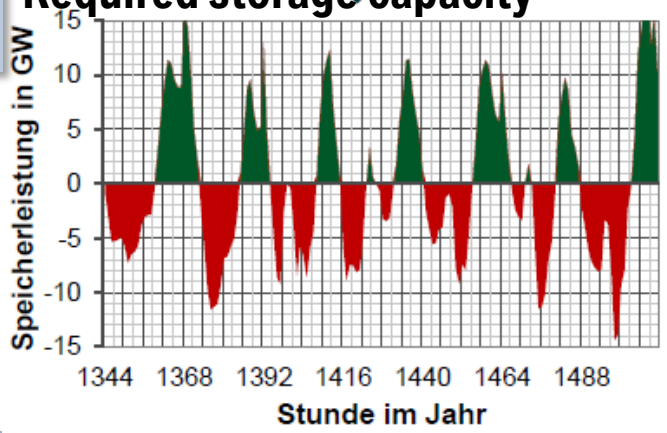



2 Electric vehicles as flexible loads

**+ Flexible loads (functional storage)**

**+ Storage (physical)**

**Required storage capacity**




3 Electric vehicles as storage devices

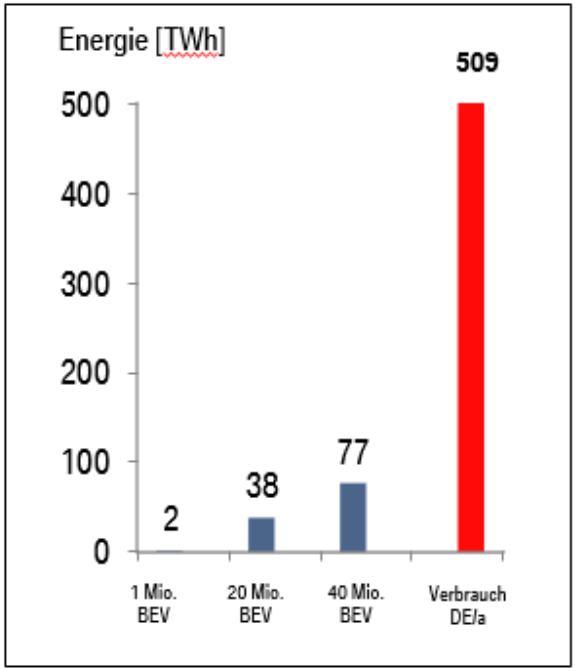
4 Batteries from Electric vehicles in 2nd use

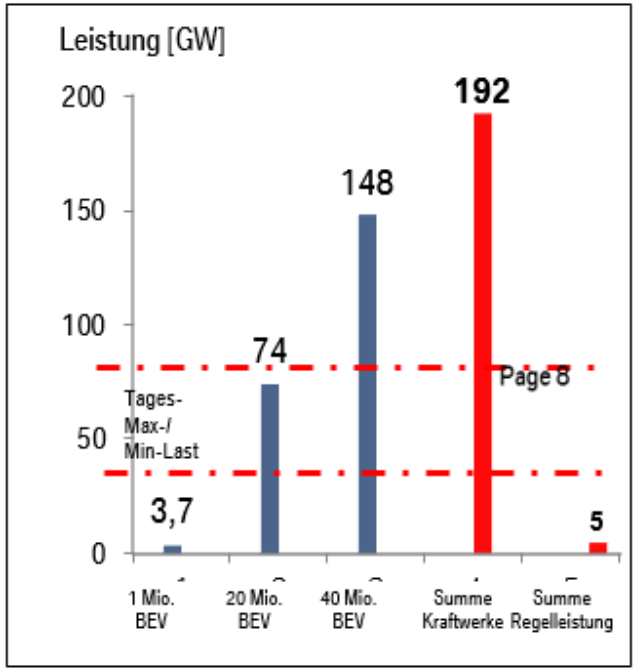
Forschungsstelle für Energiewirtschaft e.V. FfE

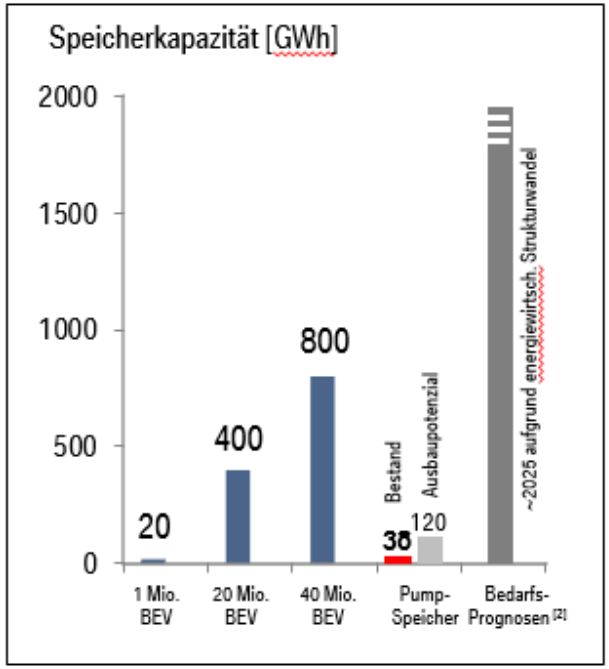
Source: Research project „Merit Order Energiespeicher 2030“

# E-MOBILITY AND ENERGY TRANSITION.
# KEY-FIGURES GERMANY.

*Maximum potentials*




- Required energy for E-Mobility is quite low. Enough RE available.
- Chance: Intelligent power and load management by controlled charging.
- Chance: Sell capacity in wholsale markets or ancillary services.

Quellen: Bundesministerium für Wirtschaft, Zahlen und Fakten Energiedaten (Bruttostromverbrauch), 02/2013
BDEW: installierte Kraftwerksleistung 2014
Auer, Deutsche Bank (DB) Research: Moderne Stromspeicher, Unverzichtbare Bausteine der Energiewende, Jan 2012 . Speicherbedarfsprognosen.
Prämissen E-Fzg: Lade(anschluß)leistung 3,7kW; Energieverbrauch p.a.1920kWh (12.000km);
Annahme nutzbarer Speicherkapazität für untertägige Ausgleichsdienste ~ 20kWh bei sich weiterentwickelnden Batt.-Kapazitäten 2020ff

# BMW`S APPROACH OF GRID INTEGRATION. TWO WAYS CHARGING PEV`S.

… renewable energy from the grid




- Controlled charging in the grid
- ancillary services
- Markets: EU, US, J, CN

- vehicle enabled for intelligent energy services
- Standard interfaces
- Meeting worldwide specs.

- Local, energy-autarcy
- Integrated Energy-Management vehicle ←→ local facility
- Markets: EU, US, J, CN

- Intelligent functions and services enabling access for renewable energy
- Expirience of sustainable mobility
- New business opportunities

… from local generation

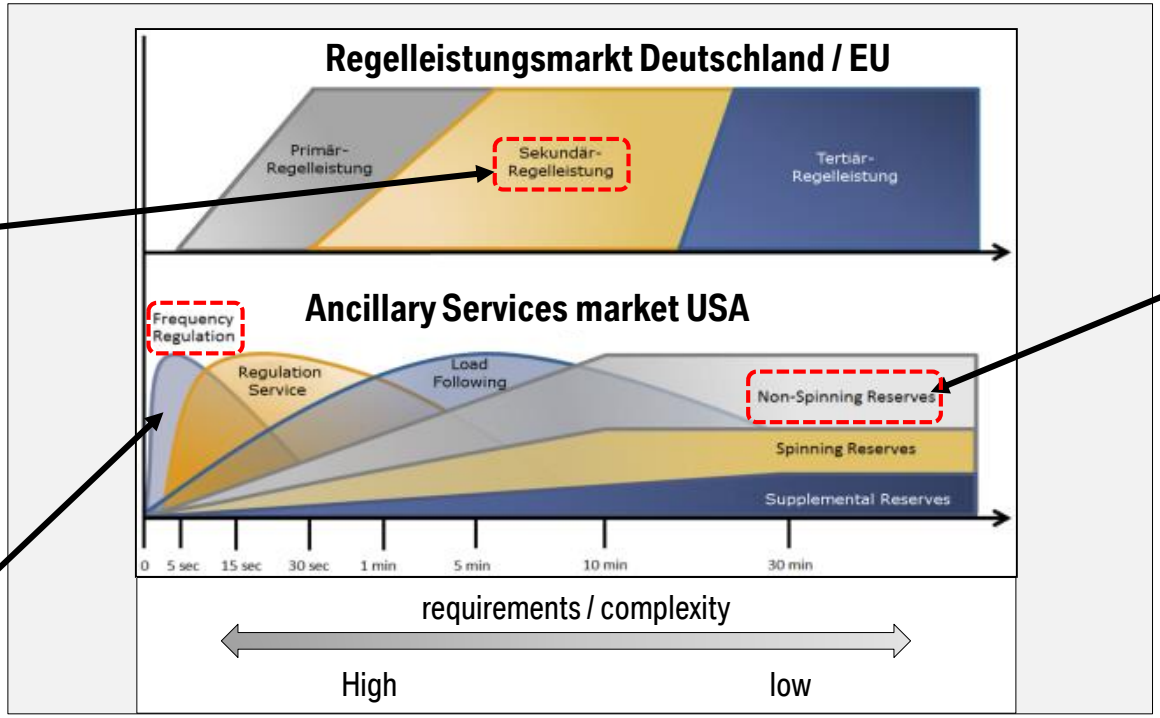


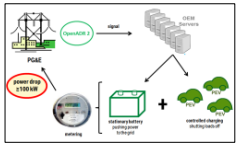

# GRID-INTEGRATIONS-PROJECTS. OVERLOOK.

**Goal:** Evaluation of future markets, products and combinations. Identification of chances.

Gesteuertes Laden V3.0
- Pool with 10 BMW Active E
- Customer research
- Businessmodel
- Pool-control for SRL

V2G „GRID ON WHEELS“
- Pool with 35 Mini E
- Reverse charging V2G
- Real market participation
- Pool-control for FQR



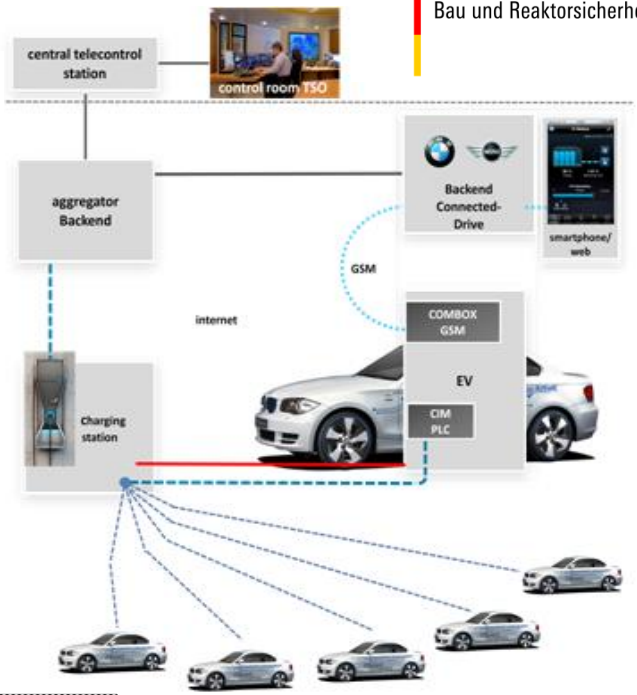
ChargeForward
- Pool with 100 BMW i3 & stationary storage
- Customer research
- Real market participation
- Pool-control for „non-spinning reserves“

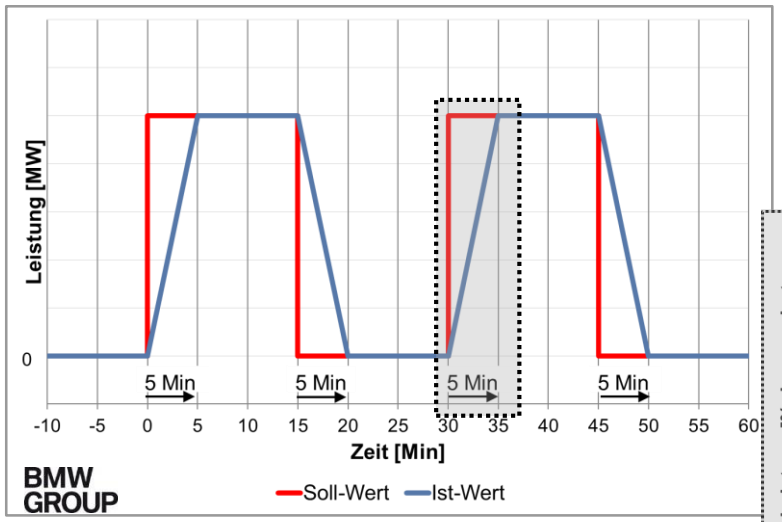
# GRID INTEGRATION – SHOWCASE IN GERMANY. CONTROLLED CHARGING 3.0.

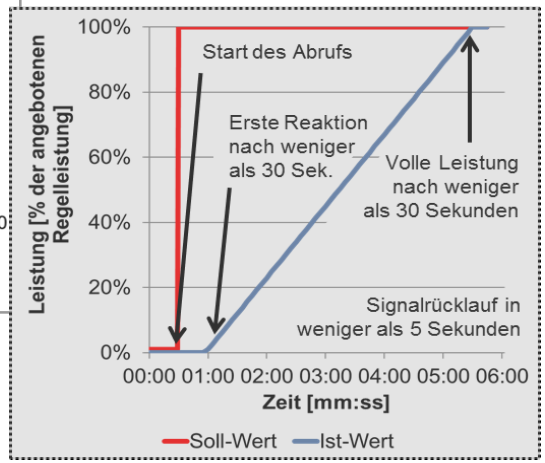
Funded by
Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit

## Gov. funded research project

- 2013 – 2015 duration
- 10 BMW Active E fleet test with 30 customers (3 phases)
- Start March 2013 in Berlin
- Busines model: incentives for grid friendly charging behaviour
- Challenge: meet SRL spec (German TSO transmission code


CLEAN ENERGY SOURCING
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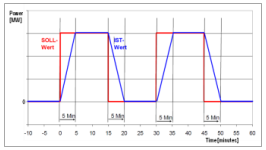
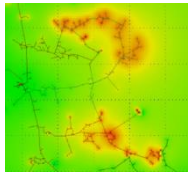
TECHNISCHE UNIVERSITÄT ILMENAU

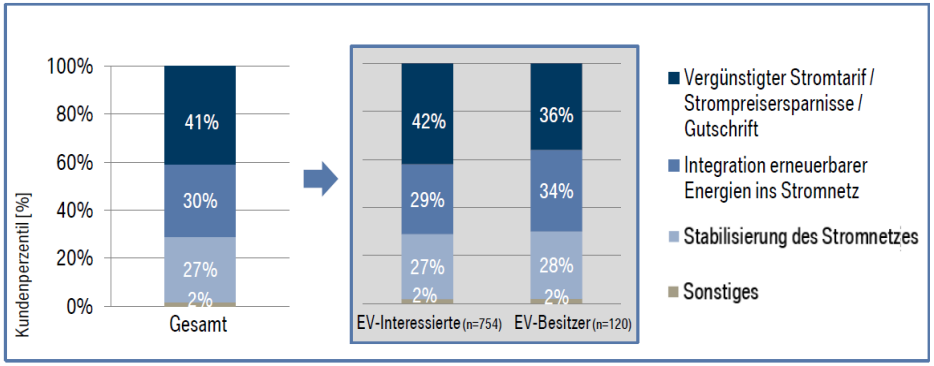
# CONTROLLED CHARGING V3.0. FIRST RESULTS.

| | | |
|---|---|---|
| System services to be met by EV`s? |  | DE: SRL neg.<br>US: D/R |
| Concept meets requirements |  | Timing & dynamic requirements fulfilled |
| Potential and Profitability?<br>➔ Businessmodel |  | Revenue around 55€ p.vehicle/year<br>No positive businesscase today (2014)<br>Perspective with V2G |
| Competing technologies and business models? |  | Growing number of research and pilot projects. |
| Usability and customer acceptance? |  | 85% interested in participtionPositve feedback from test users |
| Grid load with growing EV-fleets |  | Distribution grids have to be prepared for E-Mobility rollout |

# CUSTOMER RESEARCH: MAIN MESSAGES.

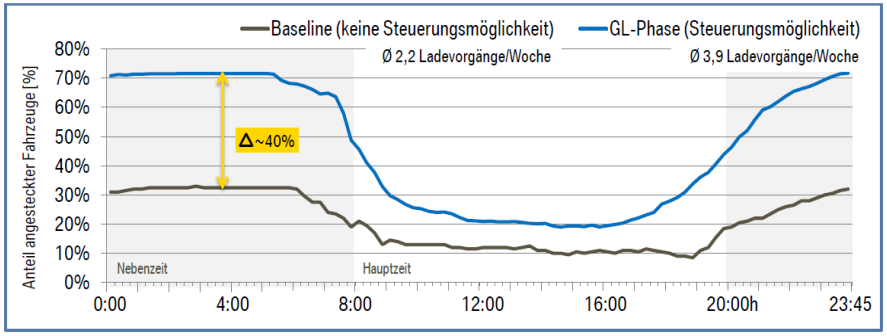

85% of the test group are willing to participate. Main reason:
Cost savings, but non-monetary reasons as well.

Gewichtung von Beweggründen zur Teilnahme an Gesteuertem Laden* (n=874)



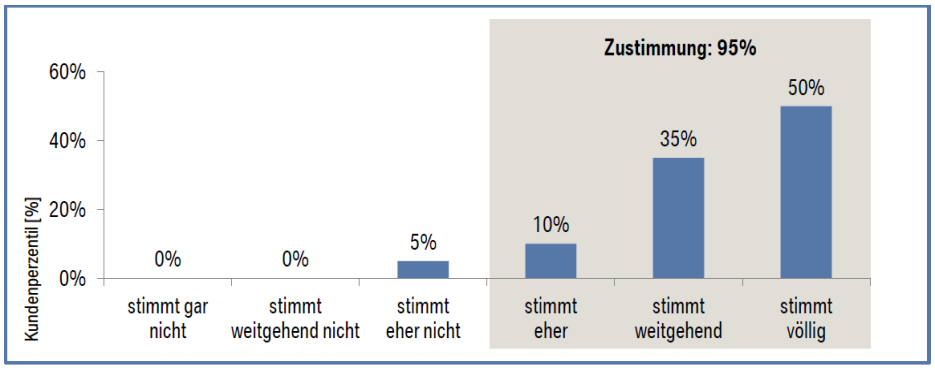

Availability of customer vehicles in the target time-window increases on 70% and more.

Verfügbarkeit von angesteckten Fahrzeugen mit versus ohne Steuerungsmöglichkeit (MO-FR)* (Testnutzer: n=10)

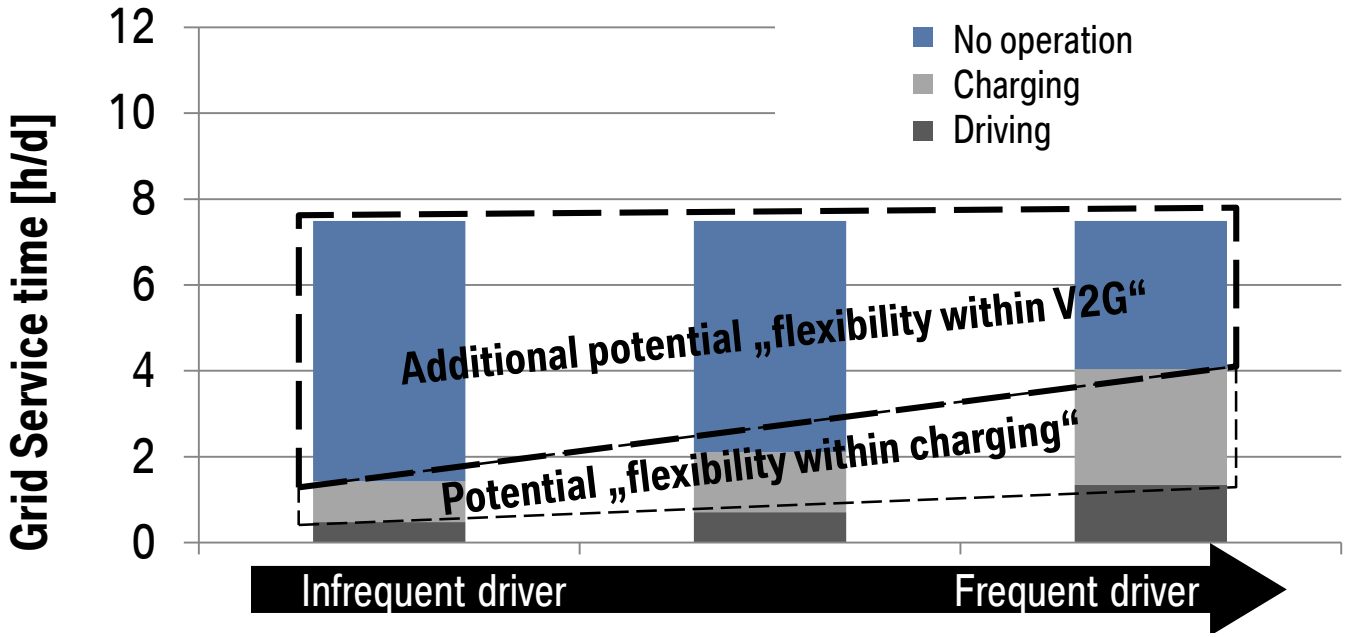



95% of the test-customers like to use the system in their daily life.

Teilnahmebereitschaft am Ende der Testnutzung* (n=20)



# USING THE FLEXIBILITY WITHIN CHARGING ONLY, NO POSITIVE BUSINESS CASE IS IN SIGHT. V2G MAY HELP.




For V2G operation of EV`s there are two restrictions evident:
- Limited charging/discharging cycles of the battery
- Limited operational lifetime of the E/E components and charging system

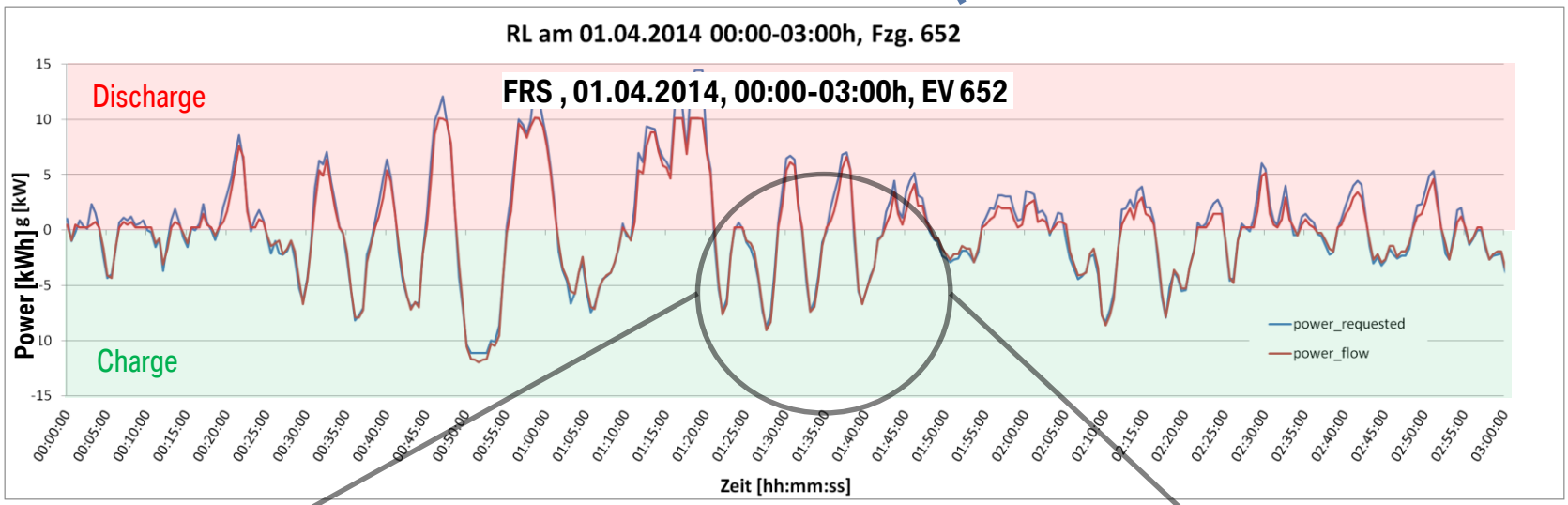
Next generation of system components and BMW- PEV models will be prepared, if there is demand and significant advantage.

# V2G-RESEARCH PROJECT DELAWARE, USA. "GRID ON WHEELS".

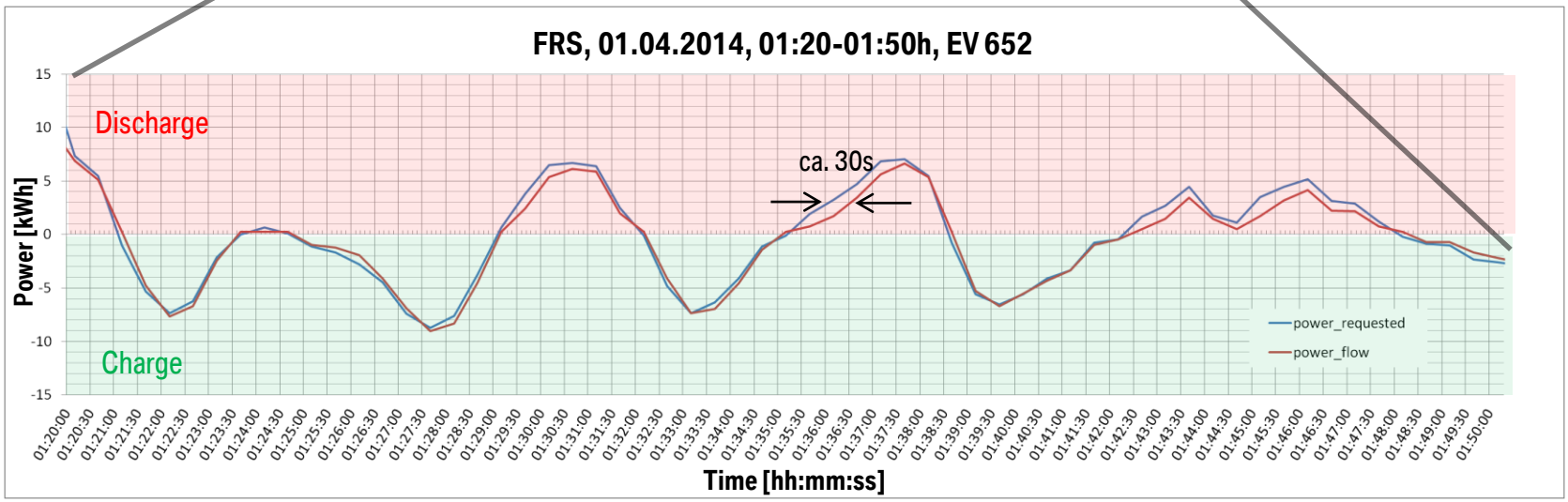
**Gov. funded research project**

- 2012 – 2016 duration
- 60 Mini E in stationary and mobile service
- Start February 2013 in Newark, Del., USA
- Bi-directional EV charging
- Business model: revenues from grid services
- Challenge: meet frequency regulation specs.


# V2G: TYPICAL REQUEST (FREQUENCY REGULATION). V2G-ENABLED MINI E MEETS REQUIREMENTS.




Time [hh:mm:ss]



# POTENTIAL REVENUES SEEM TO BE PROMISING.

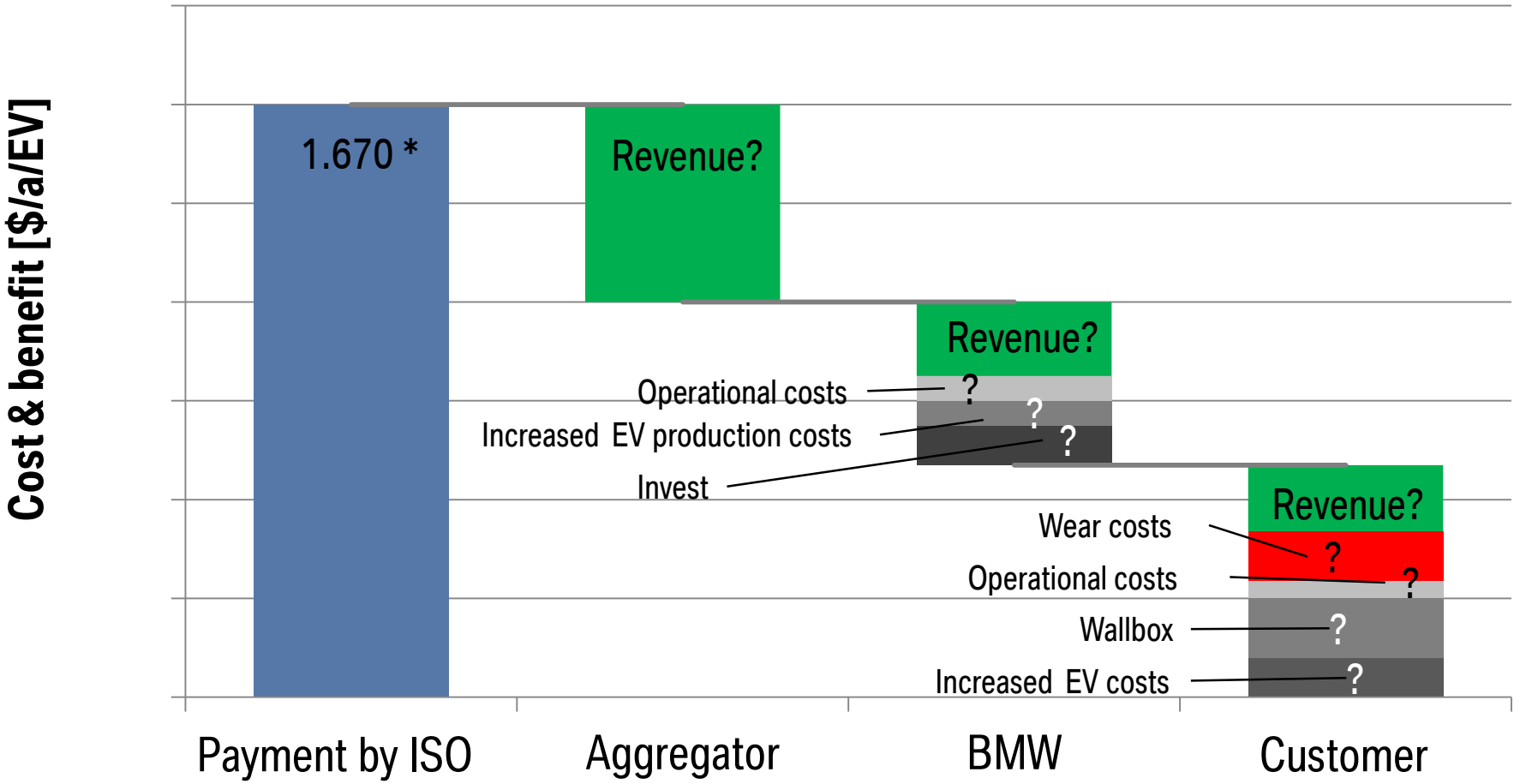
Ancillary service

| Market | Charging power | Type of ancillary service | Payment by ISO / a / EV |
|---|---|---|---|
| Germany „Only charging“ GL V3.0 | 3,70 kW | SRL negativ | 55 €[3] |
| Germany (2008) | 3,50 kW | SRL negativ & positiv | 960 €[1,3] |
| Germany (2008) | 15,00 kW | SRL negativ & positiv | 4680 €[1,3] |
| Austria (2012 → 2020) | 10,50 kW | SRL negativ & positiv | 215 €[1, 2,3] |
| Smart Grid Project Modelregion Salzburg (7/2011) | - | SRL negativ & positiv | 465 €[3] |
| France (2011) | 3,00 kW | PRL negativ & positiv | 232 €[3] |
| USA (ISO, 2000-2003) | 2,90 kW | Frequency regulation( ~ PRL) | $ 600[3] |
| USA (ISO, 2000-2003) | 6,60 kW | Frequency regulation( ~ PRL) | $ 1290[3] |
| USA (ISO, 2014) | 19,00 kW | Frequency regulation( ~ PRL) | $ 1670[4,5] |
| USA (CAISO, 2000-2003) | 6,60 kW | Frequency regulation (~PRL) | $ 2640[3] |
| USA (CAISO, 2000-2003) | 15,00 kW | Frequency regulation (~PRL) | $ 6000[3] |

→ Revenue strongly depends on conditions

[1]Battery wear considered
[2]Request probability considered
[3]Theoretical value
[4]Real market participation
[5] V2G-Project in Delaware with MINI E
Sources: Link

# … BUT THE COMPLETE COST STRUCTURE HAS TO BE CONSIDERED.




Business case & customer`s TCO under work.

Source: University of Delaware
*Participation 22 h/d

# BMW I CHARGE FORWARD. OVERLOOK.

- Pool with100 BMW i3 customers
- 7/2015 – 12/2016
- Stationary storage as backup
- Businessmodel: Incentive for customer participation :
  - 1000$ „Up-front“
  - 1$/ day @ DR Event-participation


San Francisco-Peninsula: Highest EV-population worldwide


BMW Drivers Get Paid $1,000 to Delay Charging i3 Electric Cars


CITYLAB
BMW's Plan to Prevent Electric Cars From Overwhelming the Grid


BMW, PG&E Team Up To Offer Incentives to i3 Owners Who Delay Charging


Forbes
BMW E-Car Drivers Asked To Delay Charging In San Francisco

BMW GROUP

Pacifc Gas & Electric

Sulzer US LLC
Smartphone App

GELI: Microgrid energy management software

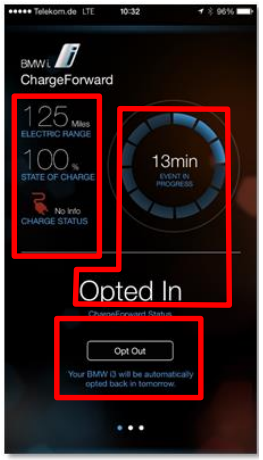
Princeton Power Systems
100 kW grid-tied inverter

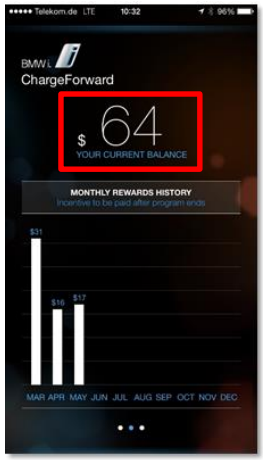
2nd life MINI E battery packs and battery management system

# BMW I CHARGE FORWARD. INTERACTION AND EFFECTS.

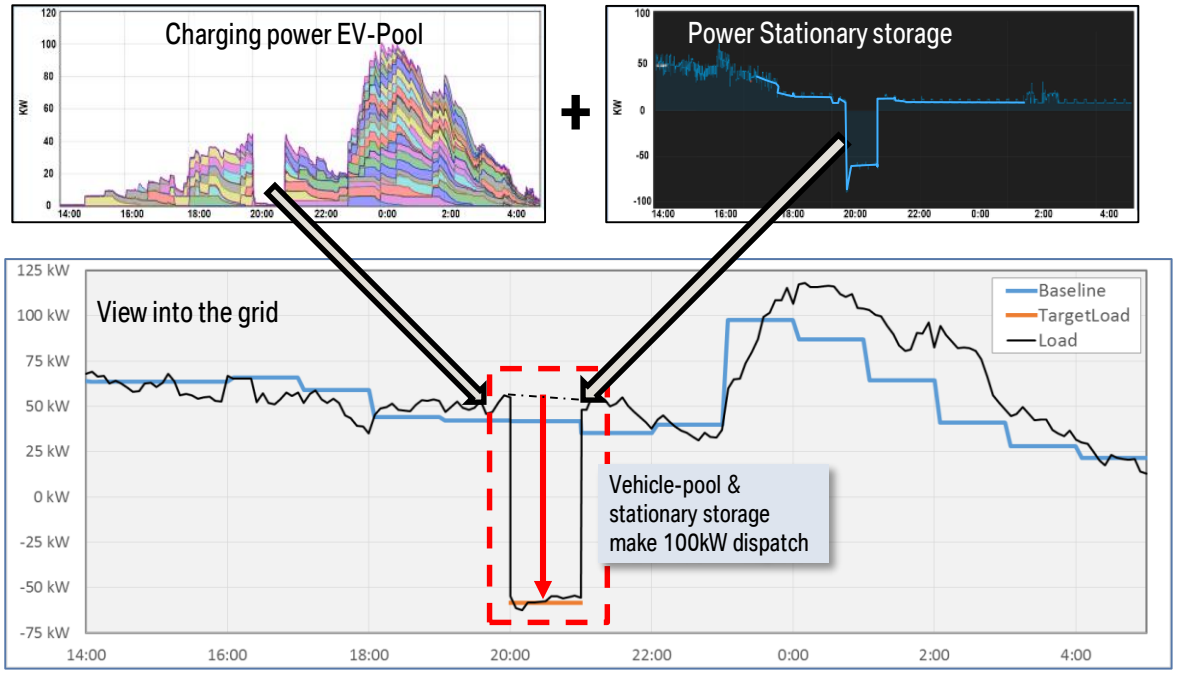
Quite simple:

- Charging status
- Revenue, savings




- Customer keeps control: can opt-out




Incentive: 1$ / day if opted-in

Revenue for D/R – Service: 3.000 $ / month (from PG&E to BMW)

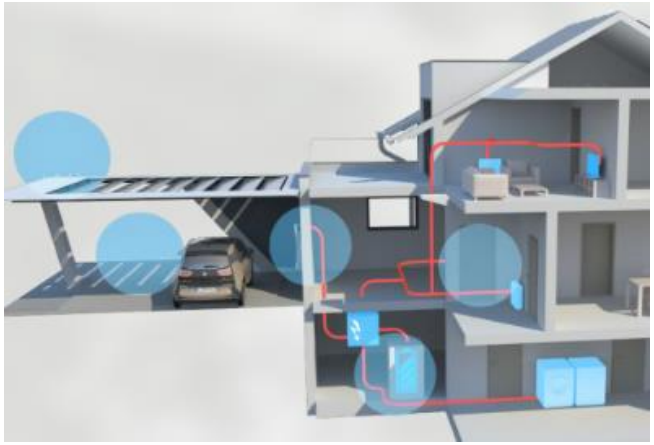
# CONCLUSION.

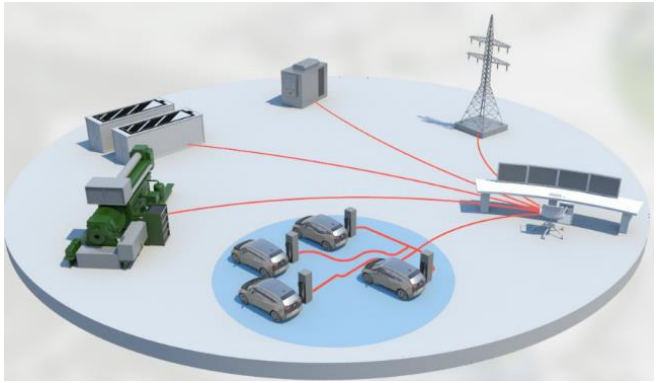
– Electric vehicles as flexible loads or storage devices will have significant potentials in future smart homes and smart grids.

– Therefore, a reliable, safe and cost effective communication between electric vehicles and backend systems will be mandatory - with respect to OEM liability responsibilities!

– Electric vehicle grid integration has to be in line with customers interests.

– Given markets and regulatory conditions assumed - BMW Group will develop electric vehicles and systems to support grid integration.





# MANY THANKS FOR YOUR ATTENTION.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