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Sustainable Fleet Operations in the Postal Sector

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Outline of Discussion

Background to the study

- Kyoto and Low-carbon Initiatives
- Postal priorities

Strategic Interests of 4 Organizations

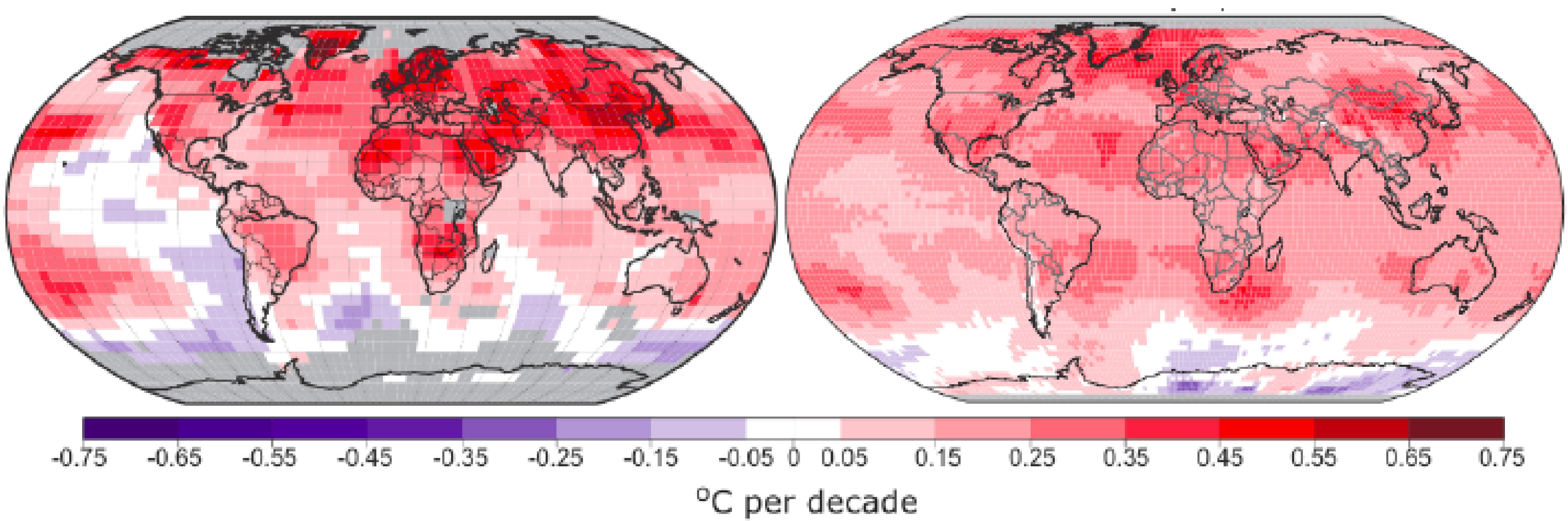
- Postal Operator
- Automotive supplier
- Electricity supplier
- Government

The Basic tradeoffs

Conclusions and open research questions

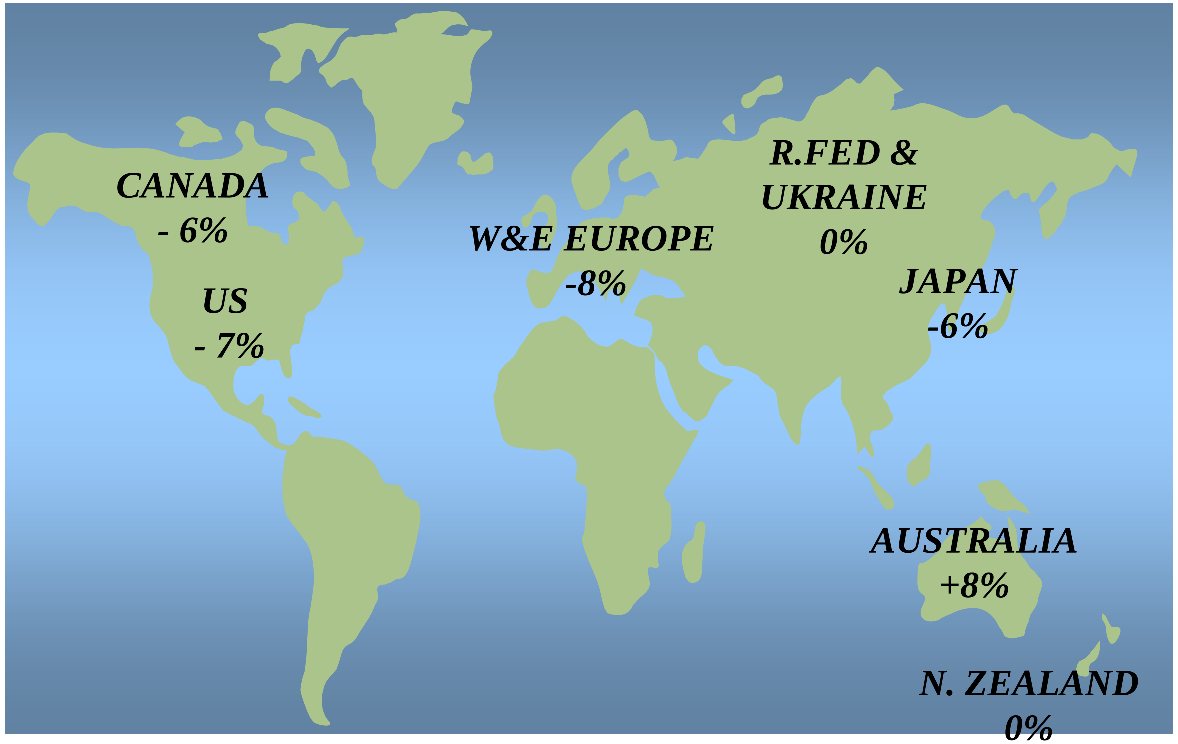
IPCC 4th Assessment: 2007
(Satellite measurements since 1979)

- Warming everywhere at surface except in Eastern Pacific, Southern Ocean and parts of Antartica.
- Land warming significantly faster than ocean over last 20 years.
- Mid-troposphere warming consistent with that at surface.



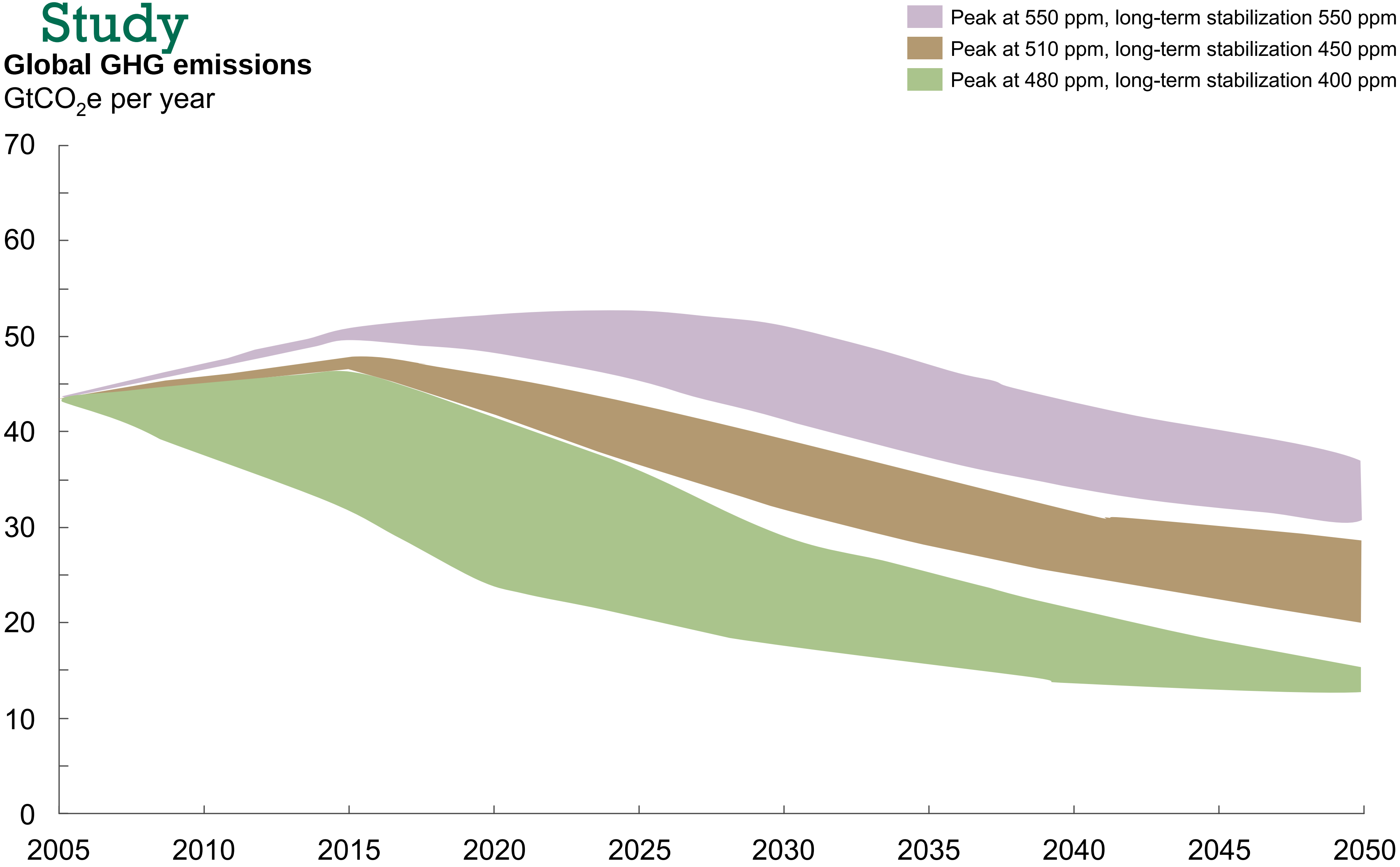
Global Kyoto Commitment

- 38 countries (EU is considered as one) faced reduction limitation commitments - overall reduction of 5.2% from 1990 emission levels
- Commitments lead to a GHG reduction of 10%-20% below business as usual forecasts over period 2008 - 2012



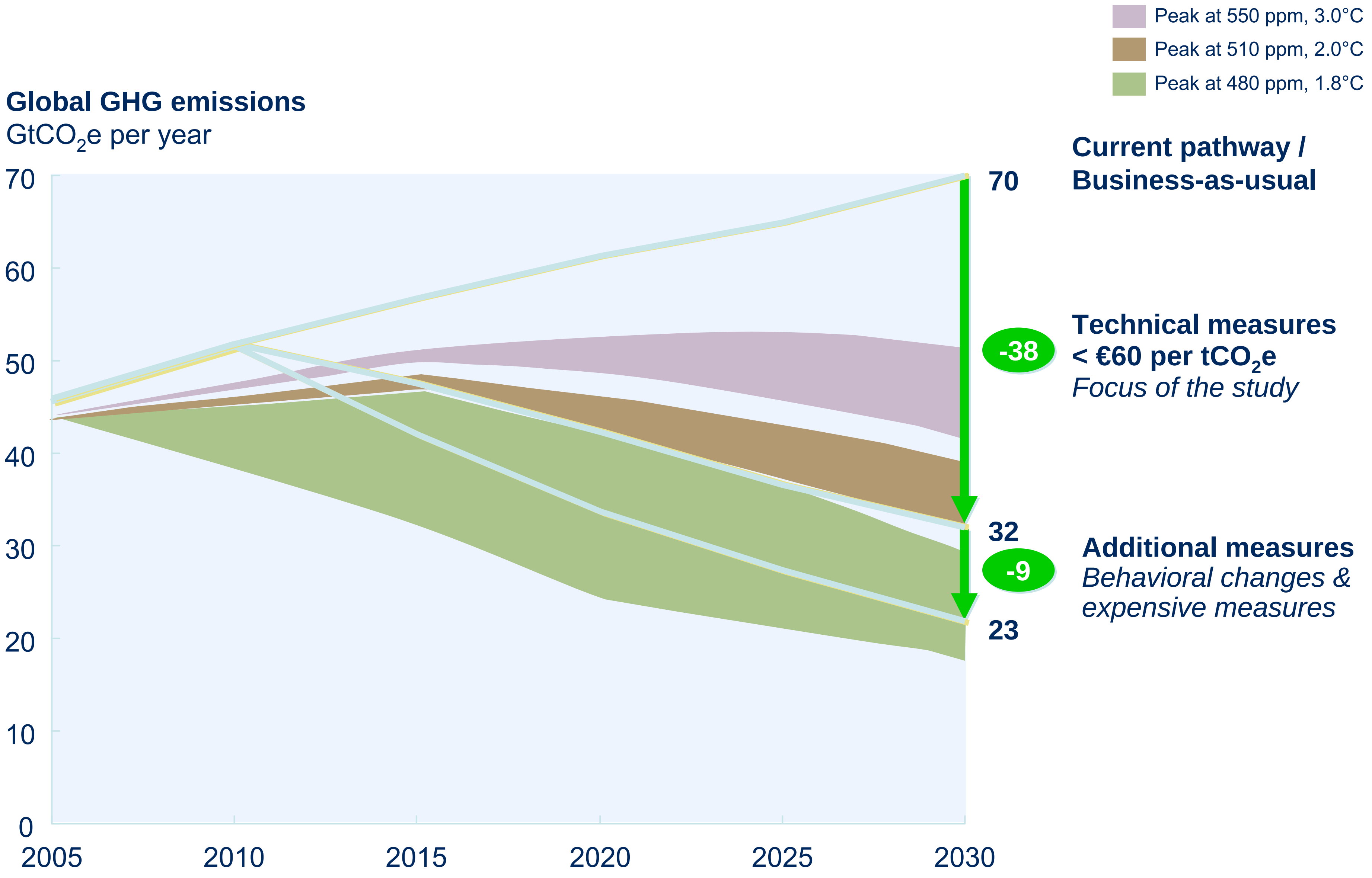
- U.S. In the middle of debate whether to “join” in 2010-2011; voluntary market and state/regional-level activities at this time
- Kyoto Parties also agreed to successive commitment periods (2013-2017 and 2018-2022) but have not agreed on reduction targets

Allowable emission pathways over time: McKinsey Study

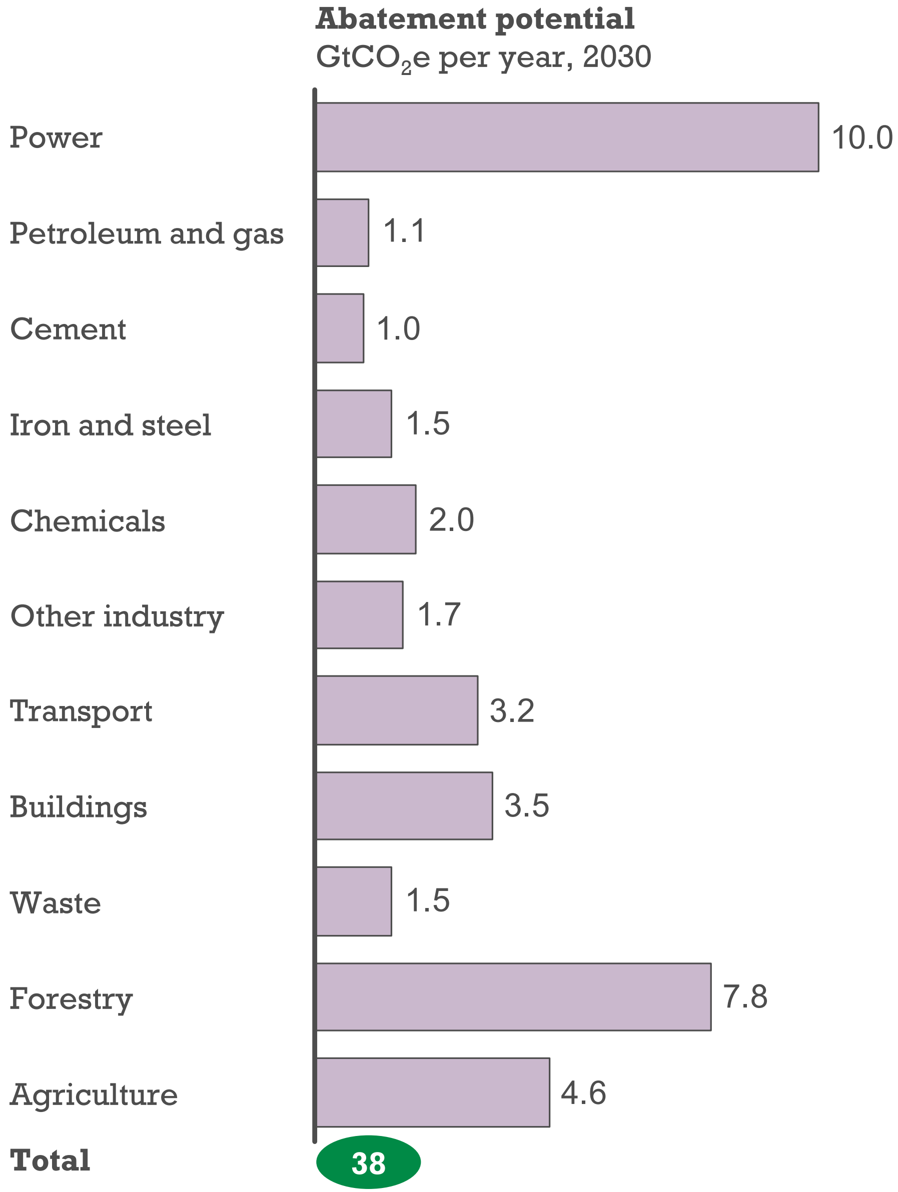


Source: den Elzen; Meinshausen; van Vuuren; Global GHG Abatement Cost Curve v2.0

Possible to contain global warming below 2°C



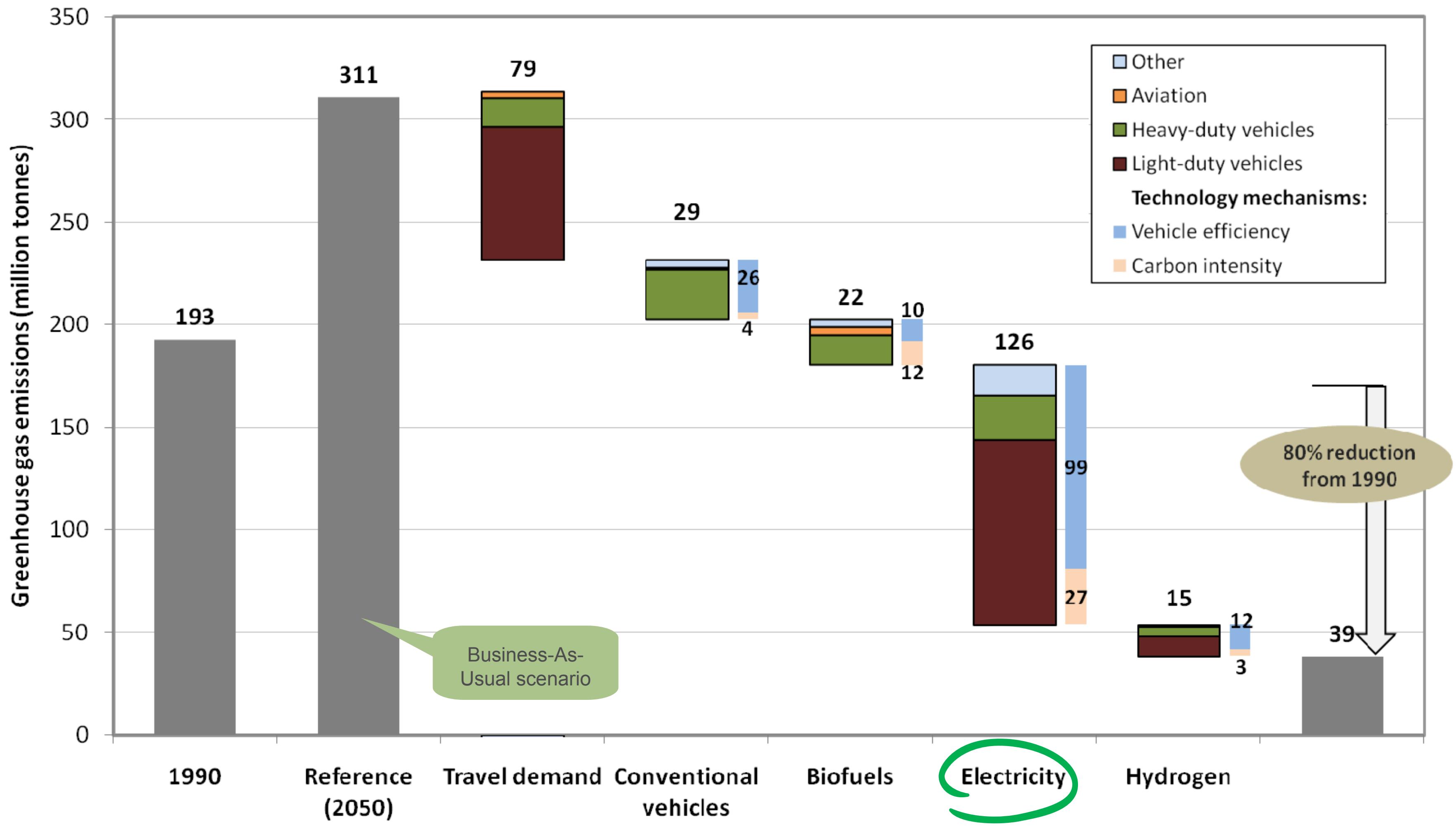
Abatement potential by sector and key levers



Key levers	Abatement potential
▪ Renewables (Solar, wind, biomass)	4.0
▪ Nuclear	2.0
▪ CCS	1.7
▪ CCS	0.4
▪ Energy efficiency	0.3
▪ Clinker substitution	0.5
▪ Alternative fuels	0.3
▪ Energy efficiency	0.5
▪ Co-generation	0.3
▪ CCS	0.4
▪ Motor systems	0.3
▪ ICE improvement, hybrids, EV	1.9
▪ Biofuels	0.5
▪ New build efficiency packages	0.9
▪ Lighting and lighting controls	0.7
▪ Waste recycling	0.9
▪ Land fill gas direct use	0.2
▪ Avoided deforestation	3.6
▪ Afforestation/reforestation	2.4
▪ Grassland management	1.3
▪ Organic soil restoration	1.1

Note: This is an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: Global GHG Abatement Cost Curve v2.0

Why EV's? 80% GHG reduction by 2050 possible with radical changes in transportation sector



Source: Daniel Sperling, "Transforming Transportation: two billion cars and climate-energy policy", 2009

Emissions from various energy & EV power systems

Energy Source	Motive Energy for Automobile	Power System	Liters of Gas Eqv./100 km *	Gr of CO2 Eqv./km *	Gr of CO2 Eqv/km-Auto Alone
Oil	Gasoline	Internal Combustion	6.7	164	140
Oil	Diesel	Internal Combustion	6.4	156	131
Oil	Diesel	Internal Combustion	5.2	129	108
EU Elect Mix **	Electricity	EV with LI–Ion Battery	6.0	87	70
Wind	Electricity	EV with Li-Ion Battery	2.2	0	0

This calculation is for a VW Gulf-sized auto

* Includes energy/CO_2 for all upstream activities

** Electric Power Mix based on EU-15 use of nuclear, coal, gas, oil & renewables 2008

German Data 2008.

Source: WHU Research & Press Material (zeit.de)

EU: Carbon Markets provide backbone for pricing carbon & driving change in energy-intensive industries

Regulation

Legal Framework: UNFCC, EU Commission, Voluntary Standard sponsors (CCX or Gold Standard…)
Regulatory bodies: UNFCC Secretariat, CDM EB, JISC, Compliance Committee, National Agencies (DNA…), NGOs

Suppliers

-**Project Developers**: stand alone and aggregators (Ecosecurities, MGM, local communities, NGOs…)
- **Mandated installations** willing to sell allowances
- **Financiers**: IFIs, Carbon Funds, Major Banks,
- **Consultants:** development agencies, engineering companies, PDD writers, methodology developers, NGOs
- **Technology development transfer:** traditional and green technology providers, local or international
- **Policy environment:** local authorities, development agencies

Primary ERs

Financing & hedging products

Intermediaries

-**Brokers** (Evolution Markets, Cantor, CO2…)
-**Traders**
- **Exchanges** (ECX, Bluenext, CCX) & platforms (Asia Carbon Exchange, CDM Bazaar)
- **Private Sectors Financial Companies** (Banks, Asset Managers – RNK, Natsource…; Insurance Cies): liquidity, arbitrage, structured products for project financing and risk mitigation, capital leveraging and financial diversification (index and bonds)
- **Large Compliance Buyers**

Secondary ERs

Structured risk mitigation products

End Users

-**Compliance buyers**: Annex B gov'ts, EU ETS installations

- **Voluntary buyers**: private companies (CSR or pre-compliance purchases), public entities (gov'ts, municipalities), NGOs, individuals (often bundled with consumers products)

-**Public and Private organizations** using carbon credits to leverage and finance investments

Primary ERs

Information and Risk Management Services

Quality control: DOEs, NGOs; **Legal advisory services**: Baker&McKenzie, Climate Focus…; **Information & Analysis:** Carbon Finance, Point Carbon, New Carbon Finance, IDEA Carbon, Ecosystem Marketplace, Reuters, IETA, Academics…; **Capacity building**: MDBs, development agencies, National entities (DNAs), IETA, NGOs, networking events…

5 Poles of the PO EV Problem

- Operator (PO)
  - Real-options framework to evaluate alternatives
  - Multiple objectives (financial, carbon, labour, …)
- Electricity supplier
  - Improved sales and load factor
  - Externalities (V2G synergies with wind)
- Automotive Manufacturer
  - Sustainable mobility strategies and related technology scenarios
  - Interacting economies of scale with overall EV market penetration and EV pricing/design/infrastructure
- Carbon accounting, financing (JI) and markets
  - Impact on total PO value chain
  - Transport-specific activities
- Government
  - Taxes on oil (revenue)
  - Subsidies and regulations

POs: Sustainable Fleet Initiatives are aligned with Broader Sustainability Agenda of POs

Social Impact

- Beneficial reputation for both local and global community
- Increased employee motivation
- Increased legitimacy in dicussions with regulators and the public

The impact of Low-carbon Fleet Operations

Economic/Profit Impact

- Reduced CO^2 emissions as potential revenue generator via JI credits
- Energy savings
- Potential attractiveness for sustainable portfolios

Environmental Impact

- Reduced CO^2 emissions
- Reduced particulate matter in urban areas
- Noise reduction
- Reduced level of ozone precursors

Sustainable Fleet Initiatives will also have considerable impact on POs vehicle expenses

PO Transportation Expenditures

	La Poste	USPS
Total Number of Vehicles	45,000	200,000
Number of Collection & Delivery Vehicles that are candidates for switch to EVs*	30,000	142,000
Current Vehicle Expenses	**Millions of Euros**	**Millions of Dollars**
Capital and Depreciation	93.6	169.8
Maintenance and Operating Costs	132.9	777.7
Fuel Costs	68.8	148.3
Total Vehicle Expense	**295.3**	**1095.8**

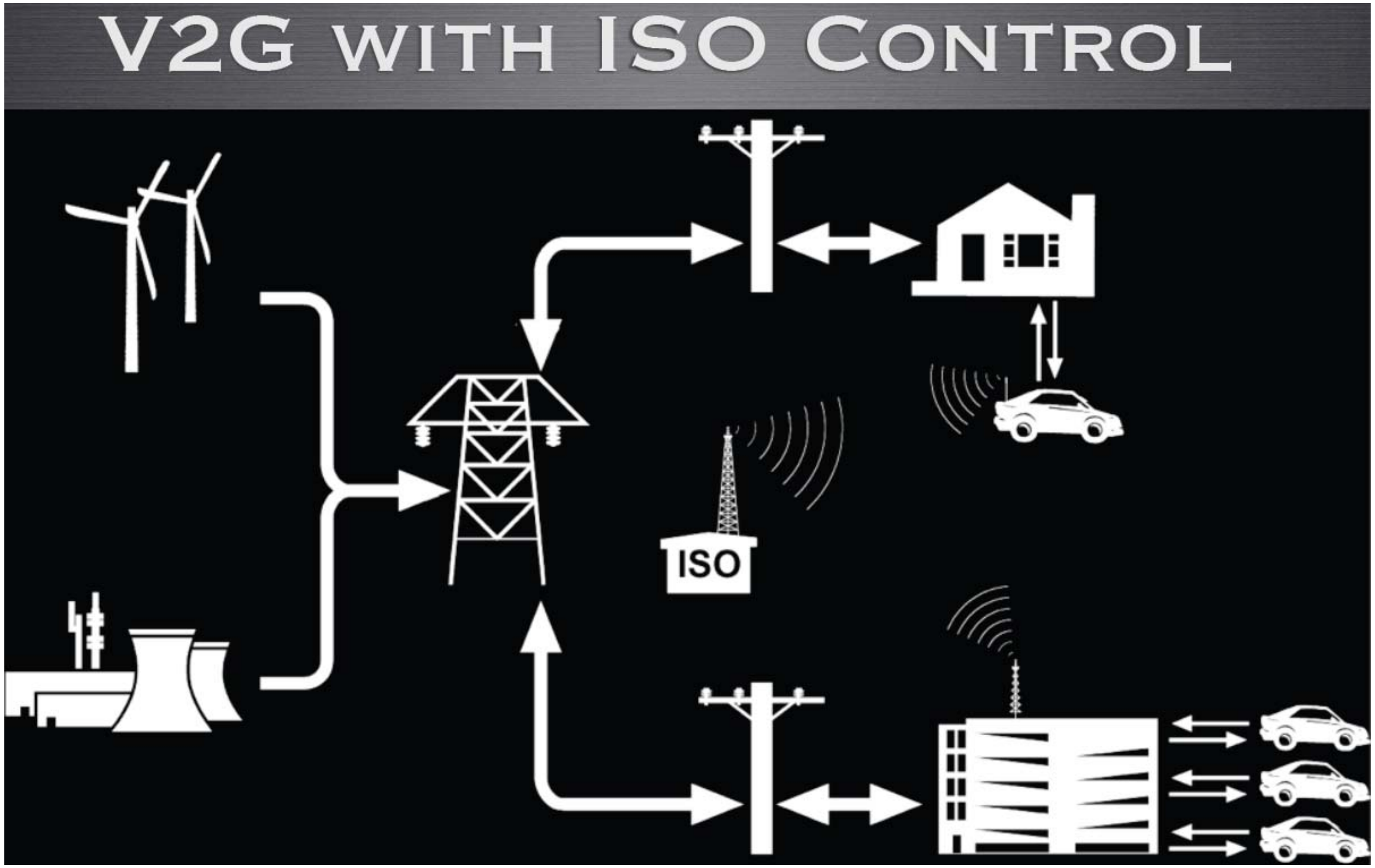
Illustrative Comparison of (EV) and (ICE) Cost and Environmental Performance

	EV	ICE
Purchase Price (€)	25,000	10,000
Resale Value at End of Year 5 (€)	5,000	2,000
Vehicle Expenses (€)		
Annual Capital Cost	5,225	2,090
Annual Operating Cost	1,029	1,139
Annual Maintenance Cost	1,110	2,221
Total Annualized Vehicle Expense	**7,364**	**5,450**
CO2e Emissions (tons/year)	**0.0**	**1.8**
Annual Value of CO2e Emission Reductions (€)	**54.00**	**0.0**
Other Environmental Benefits	**---**	**---**
TOTAL ANNUAL COST/vehicle	**7,418**	**5,450**

Motivation for Electricity Supplier

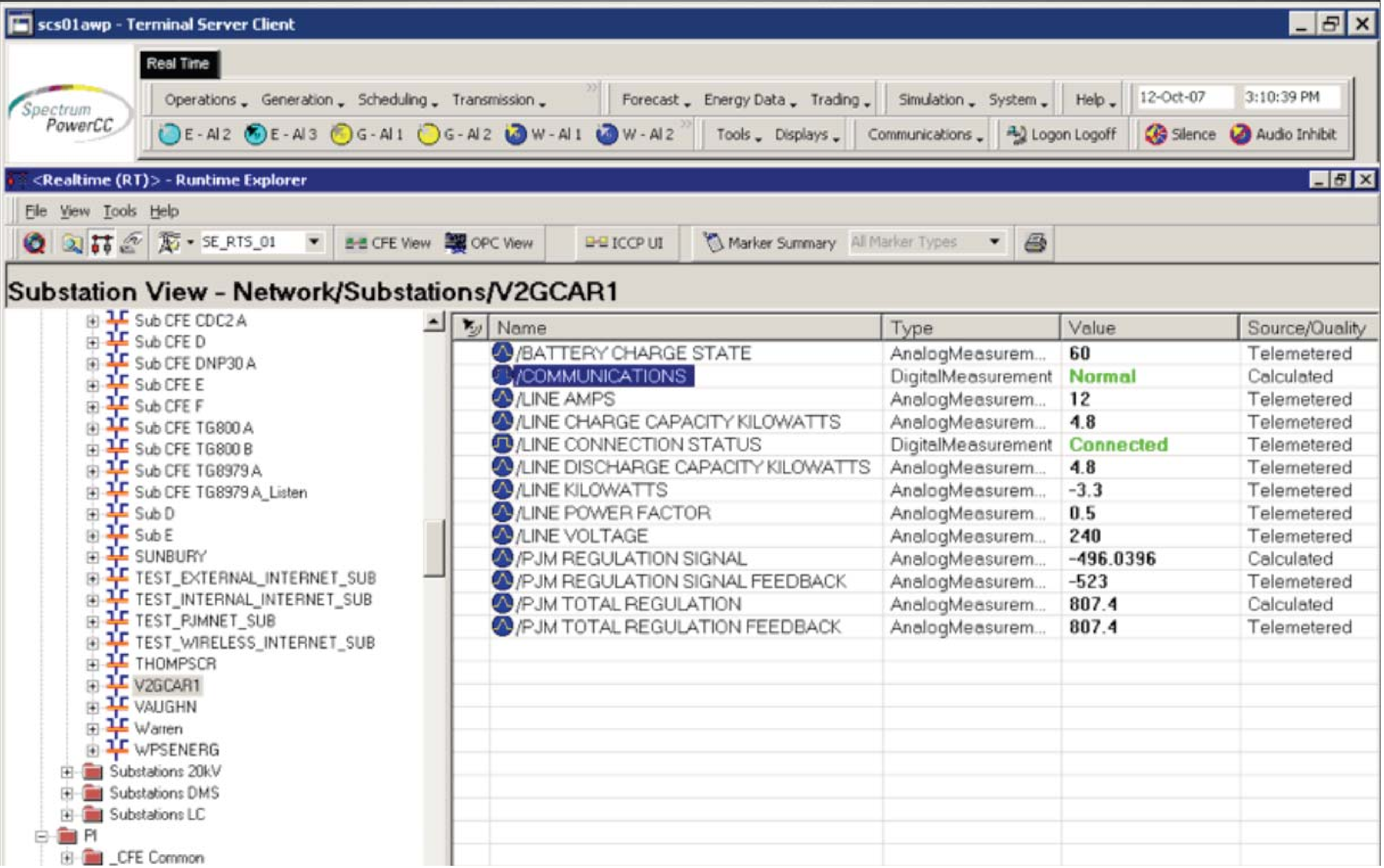
- Generally part of smart grid initiatives to improve energy efficiency at distribution and consumer level
- Improved load factor from off-peak sales (especially true for most commercial fleet operators)
- Vehicle to Grid (V2G) operations allow a potentially valuable storage source
  - During vehicle life time—bidirectional charges
  - After vehicle life of battery ended, use banks of batteries for centralized storage
- Relatively inexpensive hook-up for undirectional flows... A bit more complicated for bidirectional flows.

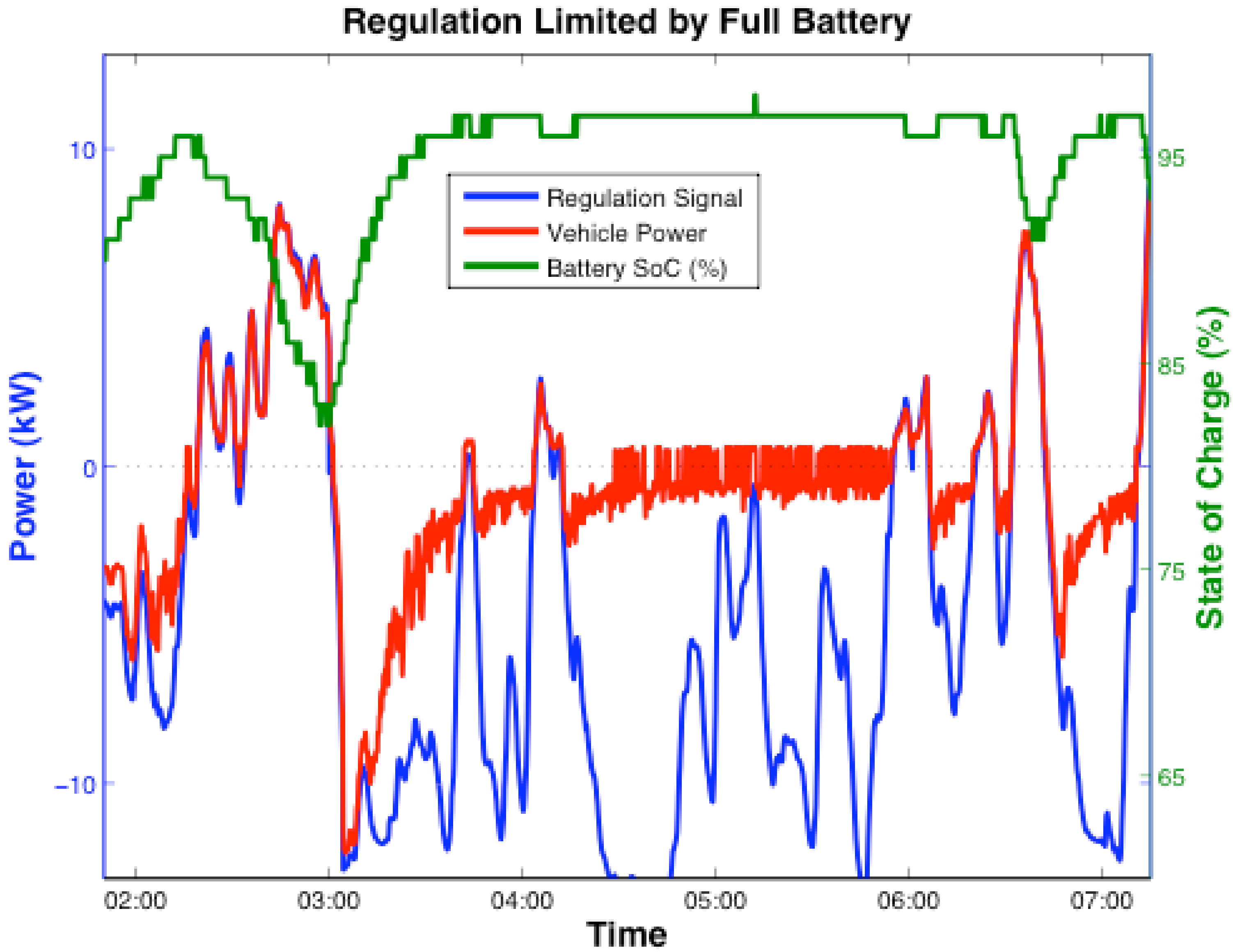
Vehicle to Grid (V2G) and Commercial Fleets*



*For an introduction to V2G issues from a GRID perspective., see
http://www.magicconsortium.org/_Media/test-v2g-in-pjm-jan09.pdf

What the ISO sees





Regulation Limited by Full Battery
Regulation Signal
Vehicle Power
Battery SoC (%)
Power (kW)
10
0
−10
State of Charge (%)
95
85
75
65
02:00
03:00
04:00
05:00
06:00
07:00
Time

Too few energy storage devices exist to cope with the energy surplus at off-peak times

Problem

- There is more electricity produced by wind farms than is actually used;
- Subsidized excess electricity from wind farms is exported;
- Further giant wind farms are planned throughout the EU (2020, 5050)

Existing Puffers

e·on: Huntorf, Germany: Compressed air energy storage (CAES) efficiency 54%. During off-peak time, the air is pumped into a cavern (about 300.000 qubic meters). At peak time, the air is released, together with natural gas to power the generator. Released air needs to be warmed to avoid freezing. This CAES is able to take up 60MW for about 8 hours and able to deliver a maximum of 290MW for two hours. A similar CAES power station is located in the USA;

EnBW: New project for 2011: Adiabatic compressed air puffer has a higher efficiency of 70% since the warmth from compressing the air is recycled;

- In Germany, there are about 30 pump-water generating facilities which usually have an efficiency of 75%. During off-peak time, water is pumped into a higher placed reservoir and released back through turbines at peak-time. This could be e.g. used to export the off-shore wind electricity of Bremerhafen to Scandinavia to store it there in hydropower stations;
- However for most applications it is more economical to fire a gas powered station to compensate for the peak-time;

Source: WHU Research & Press Research material (zeit.de)

EVs could play significant role in buffering energy peaks

- During about 90% of the time, cars are not driven;
- Additional earning potential for car owners when using their EVs as energy buffers. Cheaper night-time electricity can be sold during day-time in the power market at a higher price;

Vehicle to Grid (V2G)

Using H2 as energy carrier

- During night-time, when the electricity is cheap, cars electrolyze H2 with their fuel-cells from water;
- At day-time, when the car is not used, fuel-cells generate electricity from stored H2 and feed it to the network;
- Provide power plants with the H2 generation capability in order to fire it later with CH2 at peak times to run the turbine/generator;

Using batteries

- During night-time, when the electricity is cheap, cars charge their batteries;
- At day-time, when the car is not used, batteries feed the electricity to the network;
- Given 2.5 million EVs in 2020, an additional storage capacity of about 25GWh would be available, enough to provide half of Germany with electricity for half an hour;

Decentralized solar and wind power production is highly complementary to decentralized energy storage facilities

Regulators and Parliaments are involved!

- In 2008 Australia started producing its first commercial all-electric vehicle. Originally called the Blade Runner, its name was changed to Electron, and is already being exported to New Zealand. The Electron is based on the Hyundai Getz chassis and has proven popular with governmental car pools;

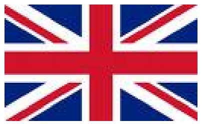
- In British Colombia it is legal to drive a LSV EV on public roads, although it also requires low speed warning marking and flashing lights. Quebec is allowing a three year LSV pilot project;

- Chinese government adopted a plan with the goal of turning the country into one of the leaders of all-electric and hybrid vehicles by 2012. It provides subsidies for EV research and up to 8,000USD subsidy for each EV or hybrid vehicle purchased by taxi or governmental agency;

Only 19% CO2 pollution would be reduced by replacing ICEVs with EVs, since 75% of Chinese electricity is generated with coal;

- Infrastructure provider “Betterplace” (started in 2007), together with the government, begin first efforts to make Israel the world’s first mitigated EV network. An infrastructure of 500,000 charging points and 200 battery exchange stations are planned. By 2011, 150,000 charging stations are planned;

- Ireland has reached agreements with Renault and Nissan to boost the use of EVs. EVs will be a feature on Irish roads within next time before 2011;



- UK’s prime minister Gordon Brown suggested that by 2020 all new cars sold in Britain could be electric or hybrid with less than 100g/km CO2 emissions; Large subsidies planned (3000 to 4000 Euros)
- Nissan’s Sunderland plant – the largest car factory in the UK – has been granted a £380mil EU-backed loan to develop EV technology;
- Plans announced to deliver 25,000 EV charging places across capital by 2015, in order to make London the “electric car capital of Europe”;

The Auto Industry is Responding to the Trend

Following EVs are available in the sub-100 km/h class

City speed

Cars capable of at least 60 km/h (37 mph), but not 100 km/h (62 mph)

Model	Top speed	Capacity (Adults)	Charging time	Nominal range
Kewet Buddy	80 km/h (50 mph)			40 to 80 km (25 to 50 mi)
Citroën C1 ev'ie	97 km/h (60 mph)[99]	4[99]	6-7 hours[99]	100 to 110 km (60 to 70 mi)[99]
CityEl	63 km/h (39 mph)	1		80 to 90 km (50 to 56 mi)
MyCar	64 km/h (40 mph)	2	5 to 8 hrs	64 to 110 km (40 to 68 mi)
NICE Mega City	64 km/h (40 mph)[100]	4[100]		96 km (60 mi)[100]
REVA i	80 km/h (50 mph)	2 + 2	8 hrs (80% in 2 hrs)	80 km (50 mi)
REVA L-ion	80 km/h (50 mph)	2 + 2	6 hrs with onboard charger 1 hrs with external charger	120 km (75 mi)
Stevens Zecar[101]	90 km/h (56 mph)[101]			80 km (50 mi)
ZAP Xebra SD and PK	64 km/h (40 mph)	PK 2 person - SD 4	4 hours 120 volt 20 amp 220 volt compatible	40 to 64 km (25 to 40 mi)

Source: WHU Research and Internet Research material (www.wikipedia.org)

The Auto Industry is Responding to the Trend

Following EVs are available in the super 100 km/h class

Highway capable

Cars capable of at least 100 km/h (62 mph)

Model	Top speed	Acceleration	Capacity Adults+kids	Charging time	Nominal range	Market release date
Tesla Roadster[102]	217 km/h (135 mph) (limited)[102]	0 - 97 km/h (60 mph) in 3.9 sec	2	3½ hours	320 km (200 mi)[102]	Available
Th!nk City	100 km/h (62 mph)		2 (+ 2 optional)		170 km (110 mi)	Available
Nissan EV-02[103]	100 km/h (62 mph)		2 (+ 2 optional)		160 km (99 mi)	2010 in US
Venturi Fétish[104]	170 km/h (110 mph)[104]				300 km (190 mi)[104]	
BEV, 'Electron' [74]	110 km/h (68 mph)	0-60 in 7 seconds	4 Adults	9 hrs with onboard charger 1.5 hrs with external charger	120 km (75 mi)	Available

Source: WHU Research and Internet Research material (www.wikipedia.org)

Alternative charging methods to “home plug” are evolving

Propositions and ideas for infrastructure, storage and charging methods

better place

- On a charging station, a robot replaces discharged battery of the car with a charged one in about 40 seconds solving the problem of long charging time. 100 of such stations are planned for 2011 in Israel;
- Ambitious goals of 150,000 charging points (e.g. parking lots) by 2011 set as an attempt to ease country’s the dependence on crude oil and solve political problems;
- Solar energy should be primarily used later;
- Introduction of battery leasing contracts, similar to mobile phone contracts with included km’s. However, problem to find the structure, financing this, since none of the car producers would be able to give away a car “for free”;
- Apart from Israel, the concept is to be implemented in Denmark, Australia, etc. in cooperation with car producers;

- **Refilling** zinc-bromine flow batteries or Vanadium redox batteries, instead of recharging;
- **Flywheel** offers an alternative storage capacity (long life-time, energy densities 0.36-0.5 MJ/kg);
- **Super-capacitors** offer an another alternative storage capacity (fast (re-) charging times). EEStor claims to have developed one with 1MJ/kg energy density (compared to 0.59-0.95 MJ/kg of a Li-Ion battery) – this would allow to charge an EV for 5 minutes sufficient to drive for 400 km;
- **Induction** coils under the road to provide battery charging while driving or on a parking lot (Project “Vision Elektromobilität 2050”). This would provide protection against vandalism of charging stations and allow transmission of control signals over the charging network. The efficiency of such methods lies at 95%;

Source: Press Research material (zeit.de)

Model — General Notation

- To solve the model, we first formulate each party's revenues and costs, where:

$N =$	Set of stakeholders, $N \in \{PO, AM, ES\}$
$K =$	Total vehicles that must be replaced
$x =$	Number of vehicles replaced with EVs, $x \leq K$
$K - x =$	Number of vehicles replaced with ICEs
$y =$	Number of PO EVs providing V2G services, $y \leq x$
$R_i(x, y, P) =$	Revenue benefits from strategy (x, y) for $i \in N$ when prices are P
$C_i(x, y, P) =$	Costs of strategy (x, y) for $i \in N$ when prices are P

Postal Operator Revenues and Costs

- Related Postal Operator revenues are:

$$R_{PO}(x,y) = \underbrace{P_C g_E \Delta x}_{\text{Revenue from carbon reduction}} + \underbrace{P_{BE} y}_{\text{Revenue from V2G services}}$$

$P_C =$ Discounted carbon allowance price

$g_E =$ Carbon intensity in t-CO_2/km of the EV relative to benchmark ICE

$\Delta =$ Total km's per vehicle driven over the lease period

$P_{BE} =$ Discounted carbon allowance price

- Related Postal Operator costs are:

$$C_{PO}(x) = \underbrace{\left(P_{AE}(x) - S_E + C_{ME} + C_{OE}\right)x}_{\text{EV Costs}} + \underbrace{\left(P_{AI}(K-x) - S_I + C_{MI} + C_{OI}\right)(K-x)}_{\text{ICE Costs}}$$

$P_{Av}(z) =$ Per vehicle lease price, $v \in \{E, I\}$ when z vehicles are leased

$S_v =$ Present value of salvage/resale value at end of lease, $v \in \{E, I\}$

$C_{Mv} =$ Present value of maintenance and non-fuel operating costs, $v \in \{E, I\}$

$C_{Ov} = \Delta P_{Fv} =$ Present value of fuel/electricity cost over vehicle life, where P_{Fv} is the discounted average price of fuel/km

Auto Manufacturer Revenues and Costs

- Related Auto Manufacturer revenues are:

$$R_{AM}(x,y) = \underbrace{(P_{AE}(x) - S_E)x}_{\text{Revenue from EV sales}} + \underbrace{(P_{AI}(K-x) - S_i)(K-x)}_{\text{Revenue from ICE sales}}$$

- Related Auto Manufacturer costs are:

$$C_{AM}(x) = \underbrace{C_{AE}(D_{AE}+x)x}_{\text{EV manufacturing costs}} + \underbrace{C_{AI} * (K-x)}_{\text{ICE manufacturing costs}}$$

$C_{AE}(D_{AE}+x) =$ Average cost to produce each EV where D_{AE} represent EV sales to buyers other than the PO.

- Assume $C_{AE}(z)$ is decreasing in total output, z
- Assume $C_{AE}(z)z$ is increasing and concave

$C_{AI} =$ Average cost to produce each ICE

- Assumes scale economies have been exhausted

Electricity Supplier Revenues and Costs

- Related Electricity Supplier revenues are:

$$R_{ES}(x,y) = \underbrace{\Delta P_{FE}\,x}_{\text{Revenue from supplying power to EVs}} + \underbrace{A_{BE}\,y}_{\text{Avoided cost resulting from V2G}}$$

A_{BE} = Discounted value of per vehicle avoided cost resulting from batter reserves and contingent power provided to the grid

- Related Electricity Supplier costs are:

$$C_{ES}(x,y) = \underbrace{\Delta C_{FE}\,x}_{\text{Cost of supplying power to EVs}} + \underbrace{P_{BE}\,y}_{\text{Price paid to PO for V2G}} + \underbrace{F_{BE}(y)}_{\text{V2G connection costs for PO EVs}}$$

C_{FE} = Discounted cost of electric power/km for EVs over lease life

$F_{BE}(y)$ = Cost to ES of connecting y PO vehicles to the grid

- Assume that $F_{BE}(y)$ is increasing and convex in y

Cost-based Solution (assuming feasibility)

- The joint optimization problem for the stakeholders *N* is defined as:

$$\max\left\{\sum_{i\in N} B_i(x,y,P) \middle| (x,y,P\geq 0; y\leq x\leq K; B_i(x,y,P)\geq B_{i0}, i\in N)\right\}$$

$B_{i0} =$ Agent *i*'s alternative option (i.e., agents' rationality constraint)

$B_i(x,y,P) = R_i(x,y,P) - C_i(x,y,P), \quad i\in N$

$P =$ The price vector defined by $(P_{FE}; P_{BE}; P_v = P_{Av}(z) - S_v, v\in\{E,I\})$

- Noting that the solution is independent of the price vector, and assuming a constant cost per vehicle for attaching EVs to the grid, this yields:

$$[C_{BE} > A_{BE}] \Rightarrow [y^* = 0; x^* = K\chi(B(K,0) - B(0,0))]$$

$$[C_{BE} \leq A_{BE}] \Rightarrow [y^* = x^* = K\chi(B(K,K) - B(0,0))]$$

$\chi(z) =$ Indicator equal to 1 if $z\geq 0$ and 0 otherwise.

- Where there are potential benefits to V2G services (the second case above) then the indicated condition on whether $y^* = x^* = K$ (rather than 0) is:

$$[C_{AE}(D_{AE}+K) - C_{AI}] + [C_{BE} - A_{BE}] \leq P_C g_E \Delta + [(C_{MI} + \Delta P_{FI}) - (C_{ME} + C_{FE})]$$

Conclusions and Future Research

- Low-carbon fleet operations are pressing forward, with potential benefits for the major stakeholders
- Fleet operations could provide a catalyst for achieving necessary scale to make economic manufacturing of batteries and autos feasible
- Their some interesting tradeoffs involved, but fundamentally the problem is one of risk sharing among the major parties (possibily sweetened by public subsidies)
- Real options approach to model and resolve optimal intertemporal risk-sharing strategies is the approach we are currently pursuing.

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