Aalto University
School of Science
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SIMBe!

Electric Mobility Needs Smart Infrastructures

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Introduction

- Sustainable communities – including sustainable mobility?
- Most promising option:
  - Electric vehicles (EVs) and
  - plug-in hybrid electric vehicles (PHEVs)

- Are they clean and sustainable, and will they be affordable?

- **Yes**, if…
  1. **EVs smartly integrated into grid**
  2. **charging infrastructure available and smart**
  3. **urban and environmental impact balanced**
  4. **e-mobility value network in place**

An interims status of the Tekes Sustainable Community project
SIMBe: Smart Infrastructures for Electric Mobility in Built Environments

Thousands of Buffer Batteries

- Disruptive paradigm change: **cars can provide clean energy**
  - Grid becomes smart – and electric vehicles play active role
  - electrical, renewable energy can be **buffered**
  - thus local and distributed energy production is **welcome at any time**

- Smart grid project examples
  - International: Pecan Street Project (http://pecanstreetproject.org)
  - Helsinki: Kalasatama (https://www.helen.fi/pdf/Suvi10_hyvarinen.pdf)

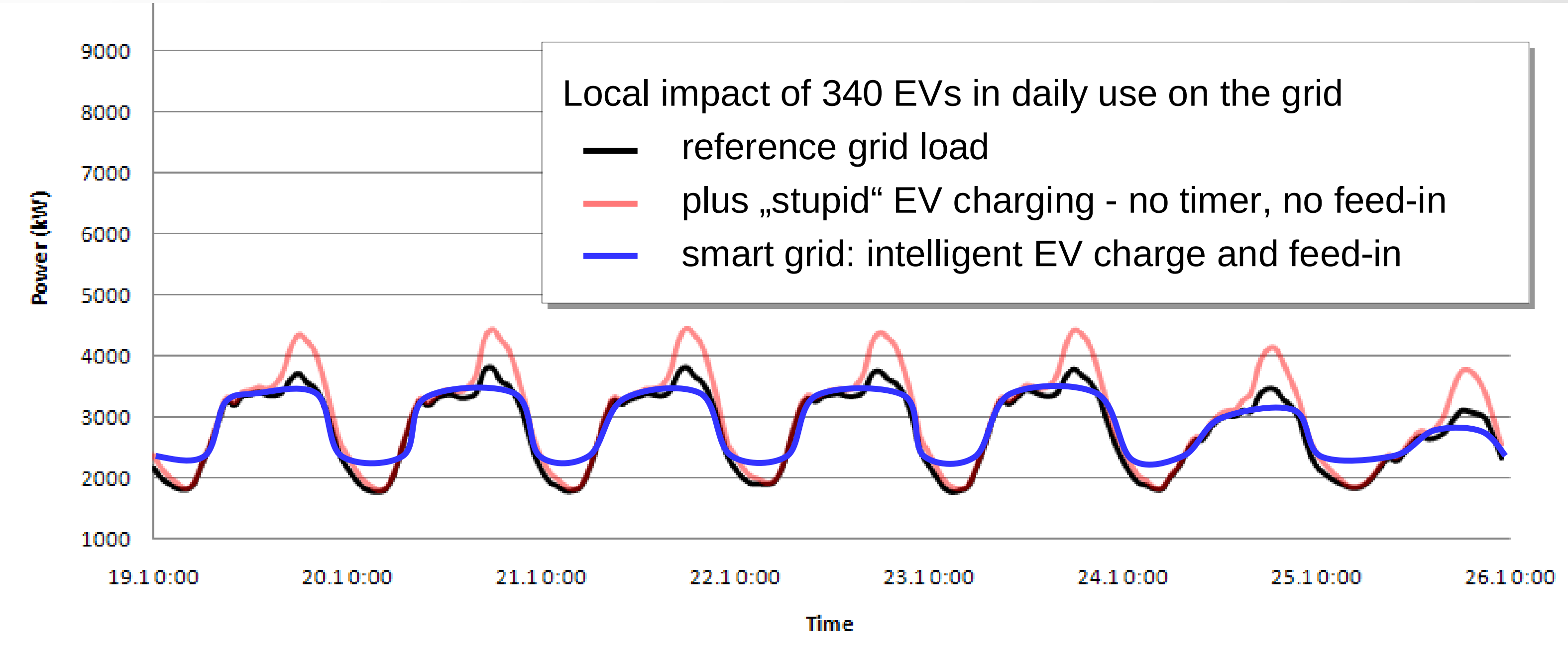
Less Peaks and Cleaner

Target

- Reduce peak loads: less CO_2 emission
- Use **renewable** energy when available
- Consume unused energy: especially nuclear power

Study impact on power supply grid

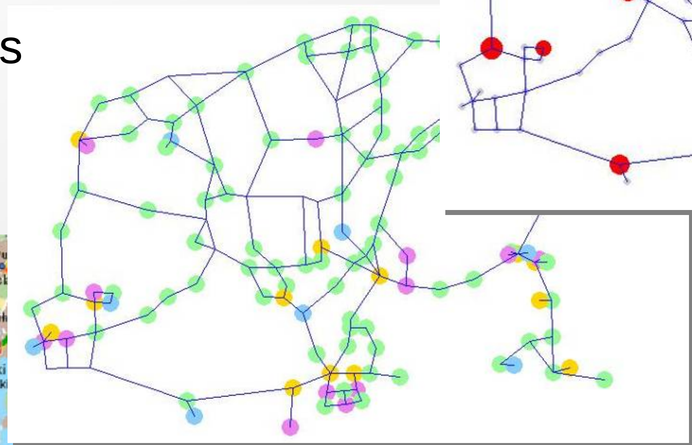
- Suburban areas (individual view and medium voltage feeder)
- Downtown areas



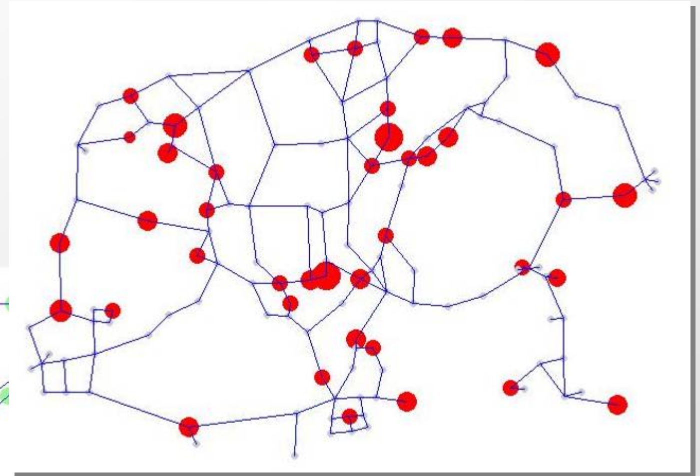
Helsinki Simulations

Research dimensions

- EV population/battery density
- Charging distribution
- EV charging loads
- Feed-in



Charging types



Charging loads

Charging Infrastructure

Research on individual EVs

- Slow/fast charging and its effects on grid & battery
- Charging in garages, parking lots, park-and-ride, **kerbside**, home and work
- Billing and metering and means of payment
- **Smart charging and feed-in** rewards

IEC 61851-1 charging modes

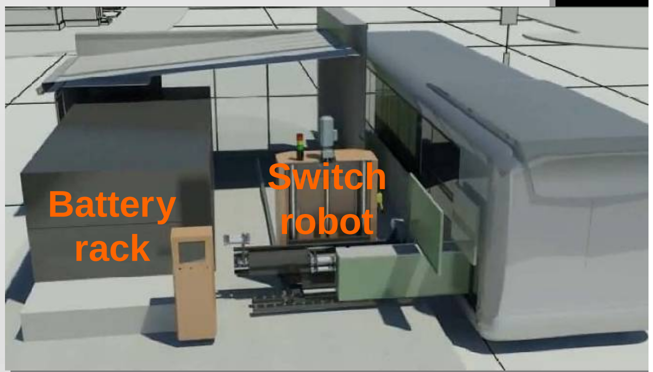
1.	230-400V	16A	3.7-11kW
2.	400V	32A	13-22kW
3.	690V	32-250A	22-300kW
4.	1000V DC	400A	400kW

Research on public and delivery transport

- Trolley and battery (combined) buses
- Battery powered delivery vehicles

Battery switching

- Benefit: recharging time = today's refueling time
- Attractive for large EVs with batteries >100kWh
- "Battery rack" allows fast charging for standard EVs
- Car manufacturers show **little interest** in switching



Power Source Evaluation

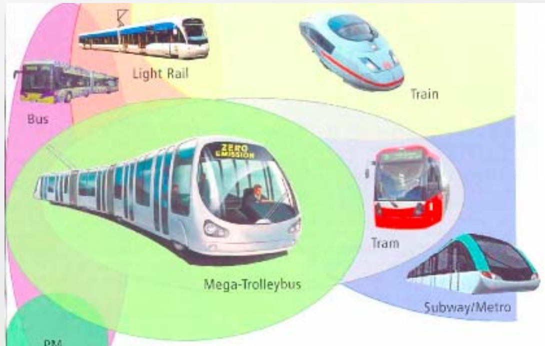
Reference = Diesel bus (4.5-5kWh/km), 250-300k€	Transport fuel/power source versus Diesel alternative		
	Overhead (trolley)	**Hydrogen**	**Battery**
Energy balance (consumption in kWh/km)	+ (1.8-2.5)	-- (3.9-6.4 - fuel cell)	++ (1.0-1.2)
Volumetric storage density	++ (no special storage needed)	+	--
Technological availability	**o**	-	-
Range	++ (unlimited; restricted routes)	**o** (similar distances to diesel)	-- (very limited)
Additional infrastructure	- (overhead lines etc.)	- (storage; dispending)	- (recharging; battery swapping)
Unit costs (x1000€)	- 450–750	-- 805–2 410	- 383 (hybrid)
Working as power resource	Not possible	Not considered	+ (supporting smart grid)
Comfort and attractiveness			
Environmental issues			

-- Major disadvantage; - Disadvantage; **o** Neutral; + Advantage; ++ Major advantage

Urban and Environmental Impact

Research on future urban mobility

- Why do humans yearn for mobility?
- Future role of the (individual) car?
- Emerging EVs and concepts?
- E-mobility effects on people's mobility…
- …and on selection of transport means?



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Environmental assessment

- over whole EV life cycle, including
- emission view on electric energy creation

Research on traffic and transport integration

- Urban traffic flows and travelling behaviour
- Data from Helsinki metropolitan area traffic survey
- Various scenarios for penetration speed of EVs
- Output: blueprint for local charging network

Industrial e-Mobility Value Chain

BIT RESEARCH CENTRE

Maintenance
and Life Cycle Services

Energy supplier

Energy distributor

Electricity market operator

Operative system integrator

Vehicle supplier

Nomadic charging SP*

End user application SP*

Charging infrastructure supplier

Battery supplier

Parking SP*

Charging information SP*

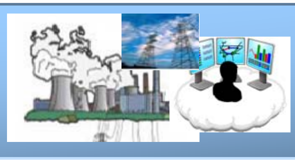
- Identification
- Metering
- Billing
- Battery information mediator

Mainly multi time earning

Mainly one time earning

*: SP = Service Provider

Ideal EV Management System*

	Context	System level	Optimisation aim	Number of EVs
	**Regional power system**	**Layer IV**	**Support Frequency Stability**	**Millions**
	**Distribution system**	**Layer III**	**Avoid peak loads**	**Thousands**
	**Local power system**	**Layer II**	**Support local power generation**	**Hundreds**
	**Fast charging station**	**Layer I**	**Provide safe and reliable charging**	**Tens**
	**User**	**Smart Control Terminal**	**Optimize charge and discharge schedule**	**One**

*: In agreement with CEPRI Electrical Engineering and New Material Department

Selected Business Opportunities

In the mid term, market will become end-user driven

- end-users ask for clean and smart mobility,
- and they will be ready to pay

Nomadic charging service provider

- fuel station network
- supermarkets, shopping centres

Parking service provider

- today's slow charging can be extended in volume and speed

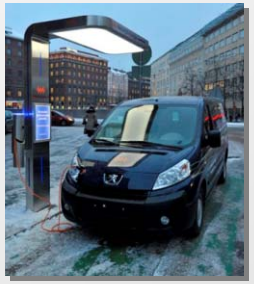
End user application service provider

- EVs most suitable for urban traffic (0 emissions)
- ideal for urban car sharing clubs and car rental agencies
- hotels and further real estate and utility providers will follow
- EVs ideal feeders for railway stations

Operative system integrator

- combines potentially strongest opportunities and risks

Conclusion: e-Mobility Needs Smart Infrastructures



EV batteries offer opportunities for grid and sustainable mobility

- with **intelligent, smart charging** solutions,
- sufficient charging and **feed-in** possibilities,
- also in work places and especially on **kerbsides.**
- Battery racks should be multi-use and multi-feed.

Opportunities for real estate, construction and facilities management industry

- urban car sharing clubs and rental agencies
- hotels and railway station operators
- most interesting: **operative system integrator**

When linking EVs to sustainable communities and building

- Think holistic and allow complexity
- Think big and international
- Listen to stakeholders
- Find the business perspective: visit www.SIMBe.fi