Smart Charging for Electric Vehicles
International experience

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Promotion of Light Electric Vehicles in SAARC
17 March 2020
The Energy Transformation

Electrification of the transport sector

By 2050, potential storage capacity to provide grid services:

- ~ 14 TWh EV batteries vs ~ 9 TWh stationary batteries

Source: IRENA’s upcoming “Global Renewables Outlook: Energy Transformation 2050”
## Energy Transformation Benefits

| Reduced local air pollution and emissions and improved health | Energy independence and universal access to clean energy sources | Economic and sustainable development |

## Electrification of Transport Benefits

| Reduced air pollution and noise in cities | Reduced dependency on imported oil for transport sector | 2 and 3 wheel EV are better suited with the purchase power of people |

Source: IRENA’s upcoming "Global Renewables Outlook: Energy Transformation 2050"
Smart charging means adapting the charging cycle of EVs to both the conditions of the power system and the needs of vehicle users. This facilitates the integration of EVs while meeting mobility needs.

Source: IRENA (2019) Innovation Outlook: Smart charging for Electric Vehicles
Vehicle-to-grid Smart Charging

EV battery used for peak shaving

EV battery used as a back-up for the grid

Market structure and regulation that enables V2G charging
Impact of smart charging on grid infrastructure

Case study: EVs impact on Hamburg’s distribution grid

Stromnetz Hamburg assessment: 9% EV share (60,000 EVs) would cause bottlenecks in 15% of the feeders in city’s distribution network

Option A: Grid reinforcement solution
- Reinforcing ~ 10,000 km of 0.4 kV cable lines, replacing transformers
- Construction works for many months, closing of roads
- Estimated investment: 20 million EUR

Option B: Smart digital solution
- Decrease the simultaneity. All charging points need to be visible by the DSO
- A real-time communication system enables DSO to reduce charging points loads.
- Estimated Investment: 2 million EUR

Source: IRENA (2019) Innovation Outlook: Smart charging for Electric Vehicles
Charging infrastructure

How?

• Slow charging - better for smart charging
• Fast and ultra fast charging - priority for mobility sector
• But, Fast charging increasing stress on local grids - Battery swapping, charging stations with buffer storage might be necessary

<table>
<thead>
<tr>
<th></th>
<th>Electricity demand</th>
<th>Peak demand</th>
<th>Distribution grids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow charging, uncontrolled</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Slow charging + smart charging</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Fast charging</td>
<td>+</td>
<td>++</td>
<td>++</td>
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<tr>
<td>Fast charging with batteries</td>
<td>+</td>
<td>+</td>
<td>+</td>
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</tbody>
</table>

Where?

• Location of slow charging points - at home/workplace to be considered at planning
Transport patterns in cities determine EV infrastructure development.

Two-wheelers dominate India’s electric vehicle market.

Public charging for 2/3 wheelers, Hubs for buses,

Charging Hubs, fast charging private cars – shared mobility

Home charging, private cars
Innovative charging stations business models

India gov has approved a program for establishing 2 636 charging stations for EVs throughout the country - 62 cities

Kiara Charzer Start-up in India:

- station costs just Rs 10,000 (USD $ 135)
- owners will set their own prices through the app and receive 100% of the revenue from their charging stations
- Up to 2h charging time for scooters
- Solar connection is planned
- 470 charging stations ordered in the pilot stage

Source: pv magazine India(2020) and http://charzer.com/
Battery swapping

Battery-swapping stations already exist for buses (mostly in China and South Korea) and two-wheelers.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Drawbacks</th>
</tr>
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<tbody>
<tr>
<td>· Very fast refuelling time, whatever the battery size (typically 5-10 minutes)</td>
<td>· No standardised batteries: heavy logistics for cars</td>
</tr>
<tr>
<td>· Batteries stored in the swap hubs can be used to balance the grid</td>
<td>· Battery swap network must be deployed at once: high capital expenditure</td>
</tr>
<tr>
<td></td>
<td>· Cars still need conductive charging “just in case”: more complexity, more parts</td>
</tr>
</tbody>
</table>

In Taiwan, Gogoro Smartscooter’s Swaping stations GoStations run on solar power.
Guidelines for policy makers

1. Set ambitious targets
2. Support charging infrastructure
3. Keep or introduce temporary incentives for cars
4. Deploy more renewables

5. Standardise and ensure interoperability
6. Implement on islands and in areas with high shares of renewable energy
7. Design smart charging strategy to fit the power mix
8. Choose optimal locations for charging
9. Market design should allow for smart charging, adjust regulation
10. Complement grid charging with storage at charging points or battery swapping

- Promote renewable energy to decarbonise power system
- Promote EVs to decarbonise transport

- Focus on smart charging
- Create incentives to tap large incremental benefits, especially from solar use

- Study impact of long-term evolution of mobility on smart charging
- Support battery and charging R&D considering both mobility and grid needs
- Study implications of mobility-as-a-service for EV flexibility
- Integrated planning of power and transport sector
Further reading

IRENA (2019), Innovation Outlook smart charging for Electric Vehicles: Link

IRENA (2019), Innovation Landscape for a renewable-powered future: Solutions to integrate variable renewables: Link

IRENA (2019), Innovation Landscape Brief: Electric-Vehicle Smart Charging: Link
Tuesday, 17 March 2020, 10:00–10:30 CET

Innovations for 100% renewable power: a systemic approach

Registration:
Save-the-date

IRENA INNOVATION WEEK 2020

8-10 September 2020
Bonn, Germany

https://www.irena.org/events/2020/Sep/IRENA-Innovation-Week-2020
Thank you for your attention!

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Impact of smart charging and next steps

**Study**
- **IRENA**
  - 50% penetration in an isolated system with 27% solar share
  - Uncontrolled charging: ↑9% increase in peak load, 0.5% solar curtailment
  - Smart charging: ↑5% increase in peak load (V2G), Down to 0% curtailment

- **RMI, 2016**
  - 23% penetration US (California, Hawaii, Minnesota, New York, Texas)
  - Uncontrolled charging: ↑11% increase in peak load
  - Smart charging: ↑1.3% increase in peak load (V1G)

- **Taljegard, 2017**
  - 100% penetration Denmark, Germany, Norway & Sweden
  - Uncontrolled charging: ↑20% increase in peak load
  - Smart charging: ↓7% decrease in peak load (V2G)

- **McKenzie, 2016**
  - 50% penetration in Island of Oahu, Hawaii, US 23% VRE share
  - Uncontrolled charging: 10-23% VRE curtailment without EVs
  - Smart charging: 8-13% VRE curtailment with smart charging EVs

- **Chen and Wu, 2018**
  - 1 MILLION EVs in Guangzhou region, China
  - Uncontrolled charging: ↑15% increase in peak load
  - Smart charging: ↓43-50% reduction in valley/peak difference

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**KEY ENABLING FACTORS**

- Charging infrastructure development and deployment
- ICT control and communication protocols
- Define roles and responsibilities of stakeholders
- Design regulation for vehicle-grid integration
- Big data and artificial intelligence for smart charging
Policies driven by air-pollution and friendly-transport for citizens. GHG mitigation is becoming a more prominent issue.

### Government / City level al targets

<table>
<thead>
<tr>
<th>Country</th>
<th>Target</th>
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<tbody>
<tr>
<td>California</td>
<td>Aims to reach 5 million zero-emission vehicles by 2030</td>
</tr>
<tr>
<td>UK</td>
<td>Set an ambition for at least 50% - and as many as 70% - of new car sales to be ultra-low emissions by 2030, alongside up to 40% new vans.</td>
</tr>
<tr>
<td>China</td>
<td>Sets target of 25% of new car sold by 2025 to be electrified</td>
</tr>
<tr>
<td>The city of Amsterdam</td>
<td>Aims to ban all petrol and diesel vehicles from town by 2030</td>
</tr>
</tbody>
</table>

### Examples of incentives for EV Chargers

- In **Amsterdam**, there are 912 public charging stations. EV owners can request **free installation** of public charging points. Total will install and operate up to 20,000 new public charging points in the Netherlands.

- **UK** government provides **grant schemes** to local authorities, private or residential customers to cover part of the cost associated to the installation of **EV Smart Chargers**.

- India will spend **$1.4 billion** to subsidize sales of electric and hybrid vehicles as part of efforts to curb pollution and reduce dependency on fossil fuels.

- In the state of **California**, ~15 programs implemented by utilities or municipalities **incentivise** the installation of charging stations.

*Status in mid 2018

Source: IRENA (2019) Innovation Outlook: Smart charging for Electric Vehicles
Impact of smart charging on solar PV and wind integration

- Smart charging cuts peak load, reduces curtailment and allows higher shares of low-cost PV electricity.
- This can help to displace more expensive generation and lower electricity prices.
- Higher impact on PV than wind due to generation profiles.

Source: IRENA (2019) Innovation Outlook: Smart charging for Electric Vehicles
Possible evolution of EV flexibility by 2030 and 2050

<table>
<thead>
<tr>
<th>Today</th>
<th>2030</th>
<th>2050</th>
</tr>
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<tbody>
<tr>
<td>Low penetration</td>
<td>High penetration</td>
<td>High penetration</td>
</tr>
<tr>
<td>Small batteries (30-60kWh)</td>
<td>Large batteries (90-200kWh)</td>
<td>Large batteries (90-200kWh)</td>
</tr>
<tr>
<td>→ Low driving range (150-300km)</td>
<td>→ High driving range (600-1000km) (?)</td>
<td>→ High driving range (600-1000km)</td>
</tr>
<tr>
<td>Standing still 90% of time</td>
<td>Still high parking time</td>
<td>Reduced parking time</td>
</tr>
<tr>
<td>Home &amp; office charging</td>
<td>Still mostly home &amp; office charging</td>
<td>Hubs in city suburbs (mostly night)</td>
</tr>
<tr>
<td>Smart charging in testing phase</td>
<td>Only ToU more common</td>
<td>Smart charging implemented, market-dependent potential</td>
</tr>
</tbody>
</table>

Positive for EV flexibility ▶ Negative for EV flexibility ▶ Less positive impact than in 2030