International Renewable Energy Agency

The impact of Electric Vehicles Deployment on Production Cost in a Caribbean Island Country

Emanuele Taibi and Carlos Fernandez del Valle
23 October 2017, Berlin

Agenda

» Introduction to IRENA

» Motivation

» Methodology

» Case Study: Barbados

» Results

» Conclusions

International Renewable Energy Agency (IRENA)

IRENA
International Renewable Energy Agency

MANDATE

- To promote the **widespread adoption** and sustainable use of all forms of **renewable energy worldwide**

OBJECTIVE

- To serve as a **network hub**, an **advisory resource** and an authoritative, unified, **global voice for renewable energy**

SCOPE

- **All renewable energy sources** produced in a sustainable manner

KEY FACTS

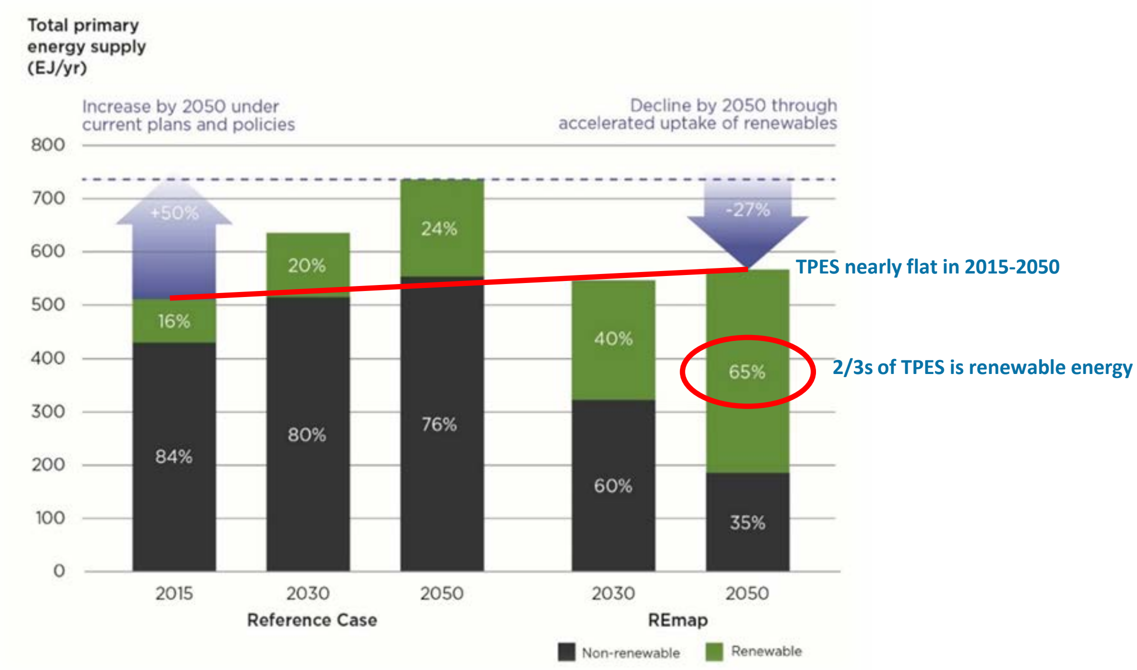
- Established in **2011**
- Headquarters in **Abu Dhabi, UAE**
- **IRENA Innovation and Technology Centre (IITC) – Bonn, Germany**
- Permanent Observer to the United Nations – New York

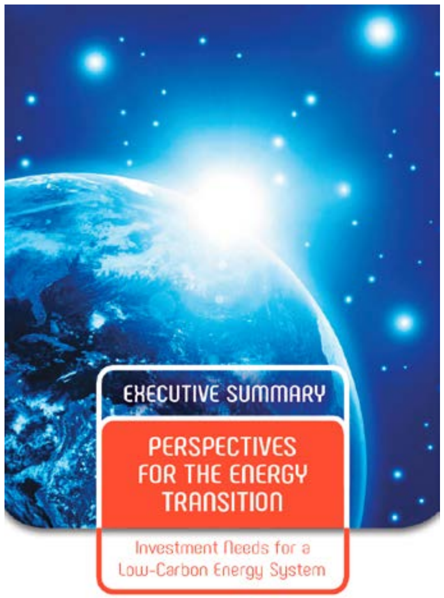
Mandate: Assist countries to accelerate renewable energy deployment

Decarbonisation as key driver

G20 Energy transition action agenda

- The comprehension analysis of the energy transition and its effects on climate change, air pollution and economic aspects.
- View to 2050, with joint IRENA-IEA report released in March, and IRENA reports on Innovation (June), Stranded Assets (July) and RE/EE Synergies (August)





- Reaching energy-related CO_2 emissions below 10 Gt/yr by 2050 will require an increase of about **1.2%/yr in renewables**' share between 2015-2050. This represents a **seven-fold growth** compared to 0.17%/yr in 2010-2015

Power Sector Transformation at IRENA

IRENA
International Renewable Energy Agency

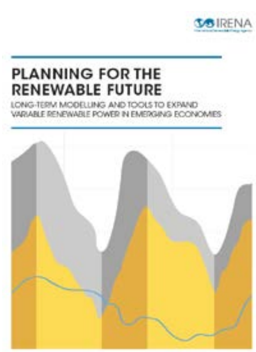
Find the optimal pathway for power sector transformation

Market design, regulation, business models

- ***Adapting electricity market design to high shares of VRE***
- Country regulatory advice
- **Power sector innovation landscape report** (Q4 2017)

Long term, least cost capacity expansion plan

- Best practices in long-term scenario-based modelling report, ***Planning for the renewable future***
- Recommendations discussed at a **Latin American regional workshop** in Buenos Aires



Unit commitment and economic dispatch

- Production cost modeling (using PLEXOS)
- Developing **flexibility assessment** methodology and optimization tool (**FlexTool**)
- Developing a **global storage valuation framework**, to assess the value of storage in different markets

Grid studies

- Technical network studies
- A guide for **VRE integration studies** is upcoming (2017 Q4)
- Technical assessments for larger systems

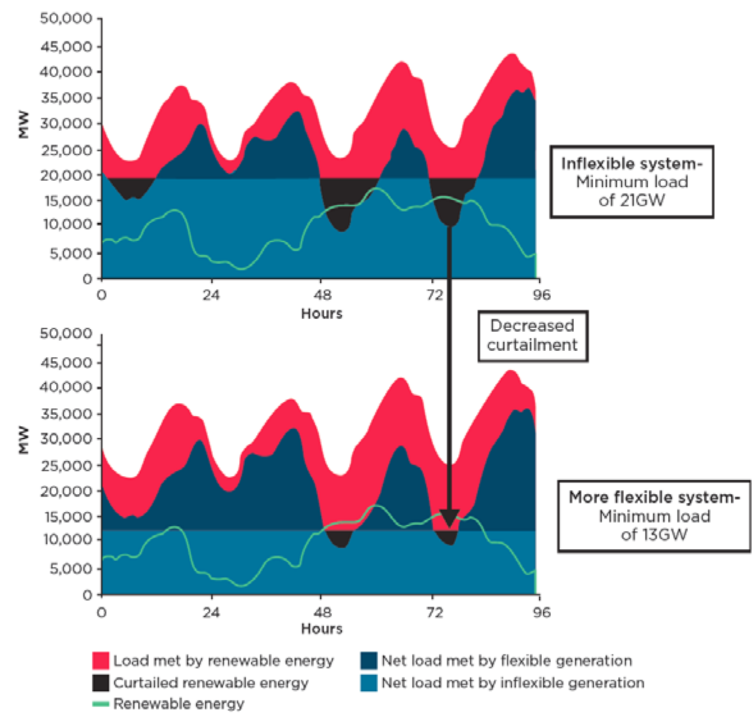
Flexibility as key enabler for VRE

IRENA
International Renewable Energy Agency

- Most of the acceleration in RE deployment took place in the power sector
  - Focus on variable renewable energy (VRE), solar and wind in particular
  - More VRE requires a more flexible power system
- An electric power system is flexible if it can:
  - Maintain the balance between generation and demand at all times
  - Dispatch all (or most) of the existing VRE on the system, avoiding curtailment

- Which aspects of flexibility to consider?
  - Ramp rates
  - Minimum load levels
  - Start-up times
  - Storage
  - Interconnectors
  - Demand response

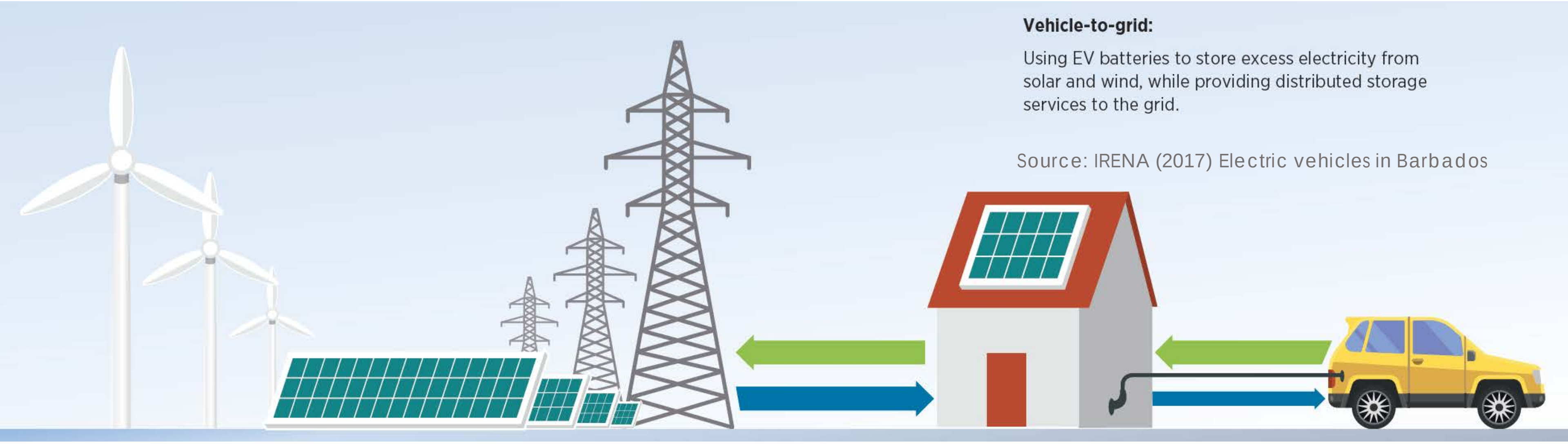
- IRENA FlexTool
  - Analyze the flexibility of the system
  - Dispatch + Capacity Expansion
  - Some Solutions:
    - Interconnection
    - Demand side management
    - Storage (hydro, batteries)
    - Electric Vehicles
    - Power-to-X



Source: Denholm, P., Hand, M. (2011)

Coupling transport and RE via electricity

Decarbonisation:
- EVs require a clean energy supply source
- Variable renewable power integration require system flexibility



Source: IRENA (2017) Electric vehicles in Barbados

Case Study: Barbados Energy Roadmap

» Land Area: 430 km^2

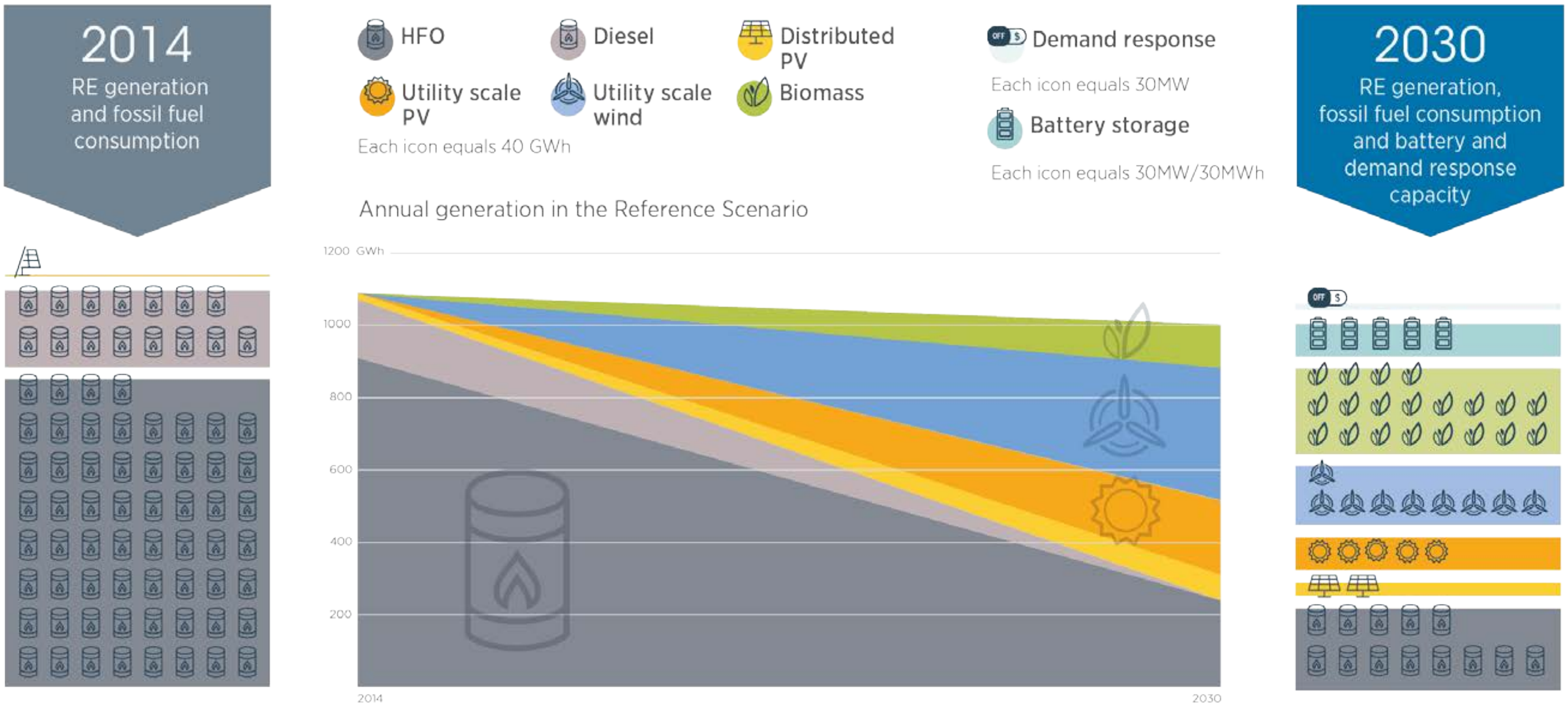
» Population: 284,800 in 2016

» Electricity Demand: 167.5MW

» Generation capacity (2016): 240 MW

IRENA Barbados Energy Roadmap

- Estimation of EVs expected in 2030
- Analysis of EV impact on the grid as static profile

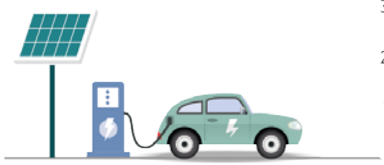


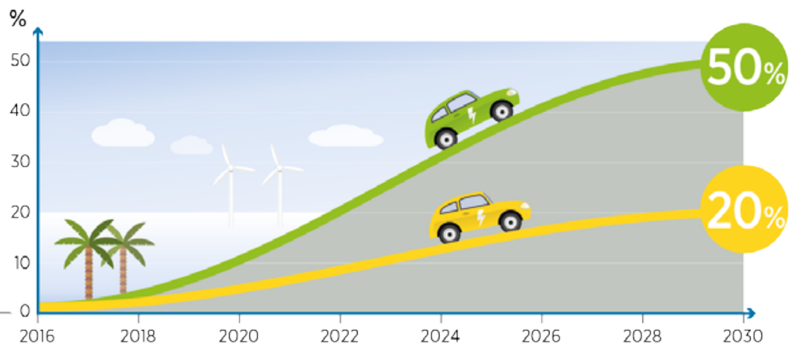
Case Study: EVs scenarios in the Roadmap

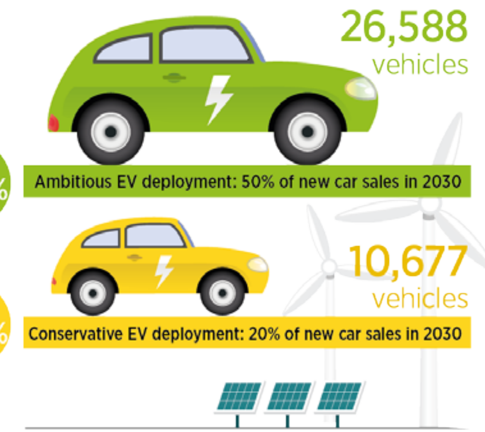
IRENA
International Renewable Energy Agency

EV PASSENGER CAR DEPLOYMENT

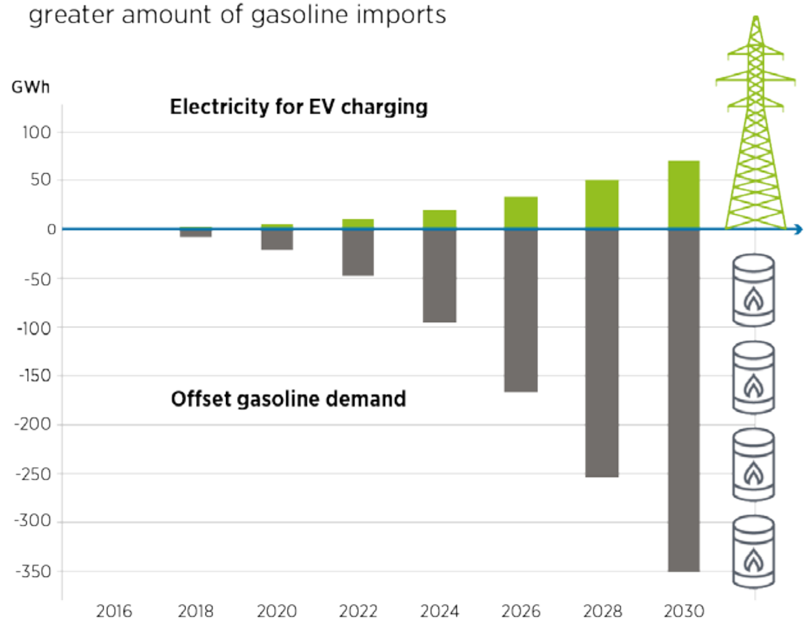
- EV deployment has started in Barbados: approx. 100 EVs on the road in 2016



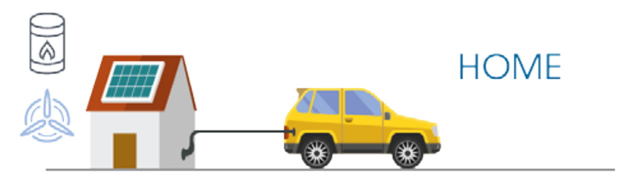




The increase in electricity demand for charging EV offsets a much greater amount of gasoline imports



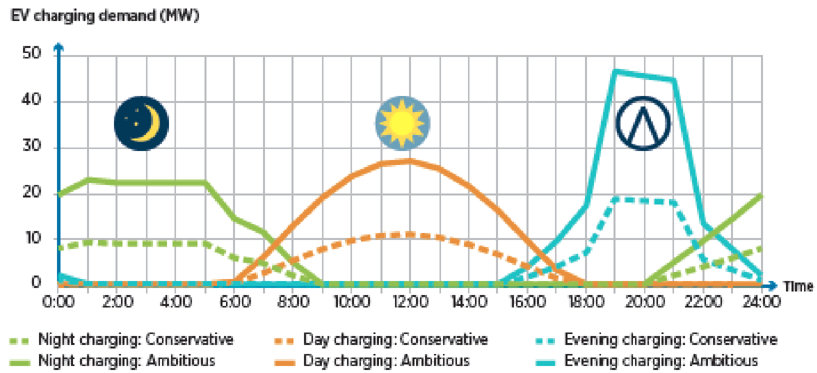
- Required for daytime charging, which maximize RE in EV charging
- Requires research to place charging stations in locations that support high usage
- Average commute only 40km EV, no need to charge each EV every day



- Time of use pricing / controls should be implemented to prevent charging at evening peak
- Best suited for allowing vehicles to be connected long enough to the grid to act as grid-connected battery storage and provide services to the grid in the future, maximizing value for vehicle owner and minimize cost of grid services

Source:

EVs as enabler for integration of VRE



EVENING PEAK

- EVs charged at home as people return from work
- Likely charging pattern with no policy intervention
- Reduces system reliability by adding to existing evening peak demand
- Should be discouraged with time of use pricing and availability of public charging stations

NIGHTTIME

- Requires pricing signals and smart grid technologies to delay / prolong charging away from evening peak
- Better option for home charging
- Opportunity for vehicle-to-grid in the future, with EVs providing remunerated services to the grid

DAYTIME

- Maximizes RE share in EV charging: 58-76%
- Significantly reduces RE curtailment from 14.5% to 9.3%
- Supports deployment of additional 12 MW of PV
- Requires investment in public charging infrastructure

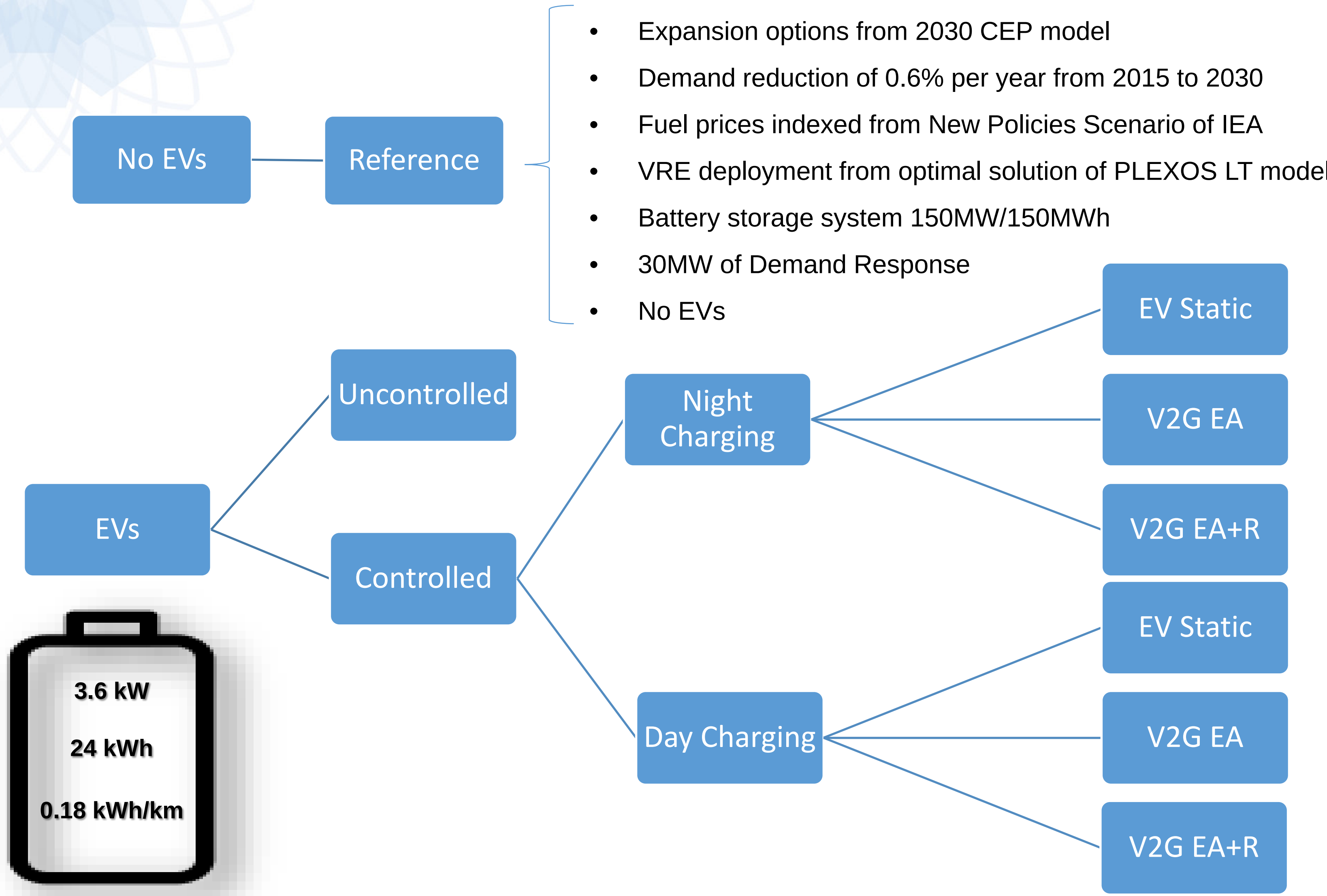
Higher VRE integration and improved system reliability

- Load management: peak shift, charge coincide with RE available
- EV as decentralized storage: Increased flexibility through V2G scenario
- EV can provide primary and secondary reserve to the system, ancillary services
- Minimize network reinforcement costs and decouple the electricity growth from peak load growth

…but a smart charging approach is critical

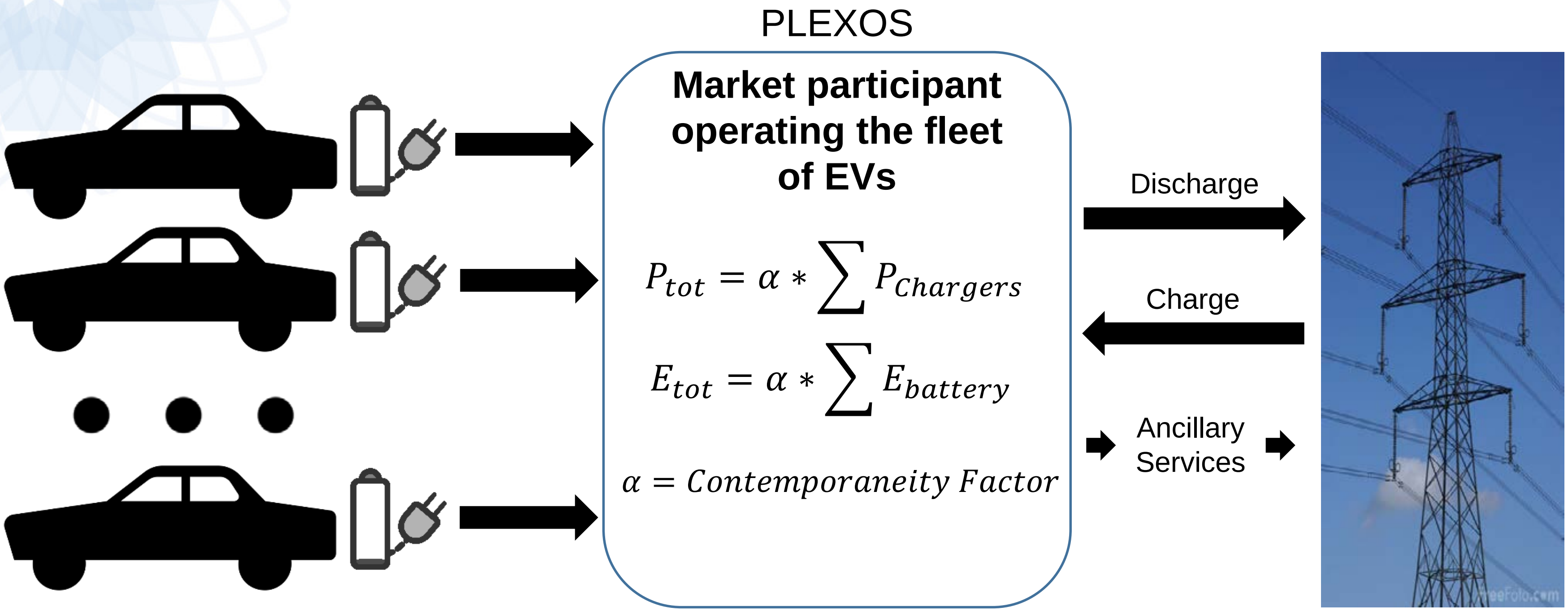
Source: IRENA (2017) Electric vehicles in Barbados

Scenarios



Source: Barbados Energy Roadmap

Vehicle-to-Grid (V2G)



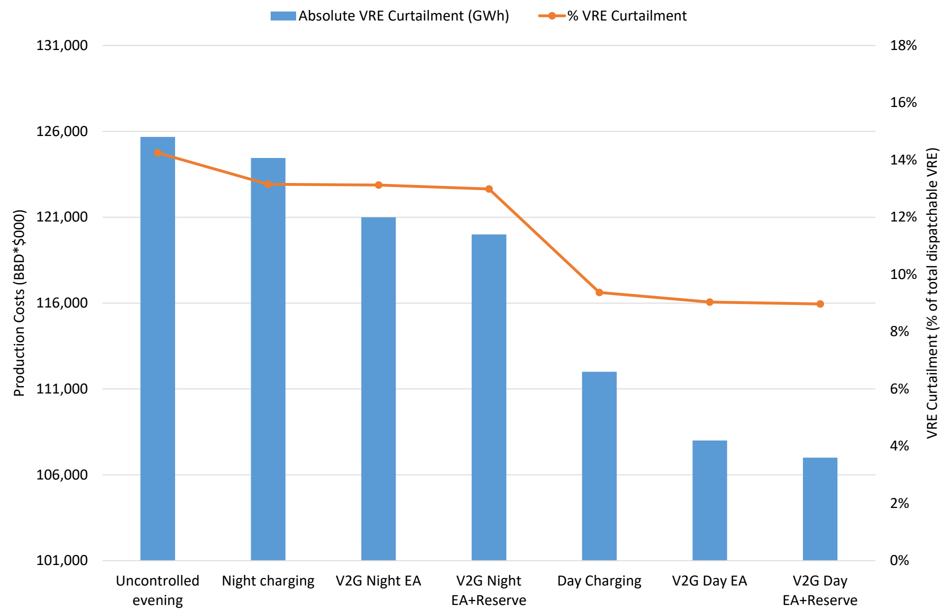
» Constraints

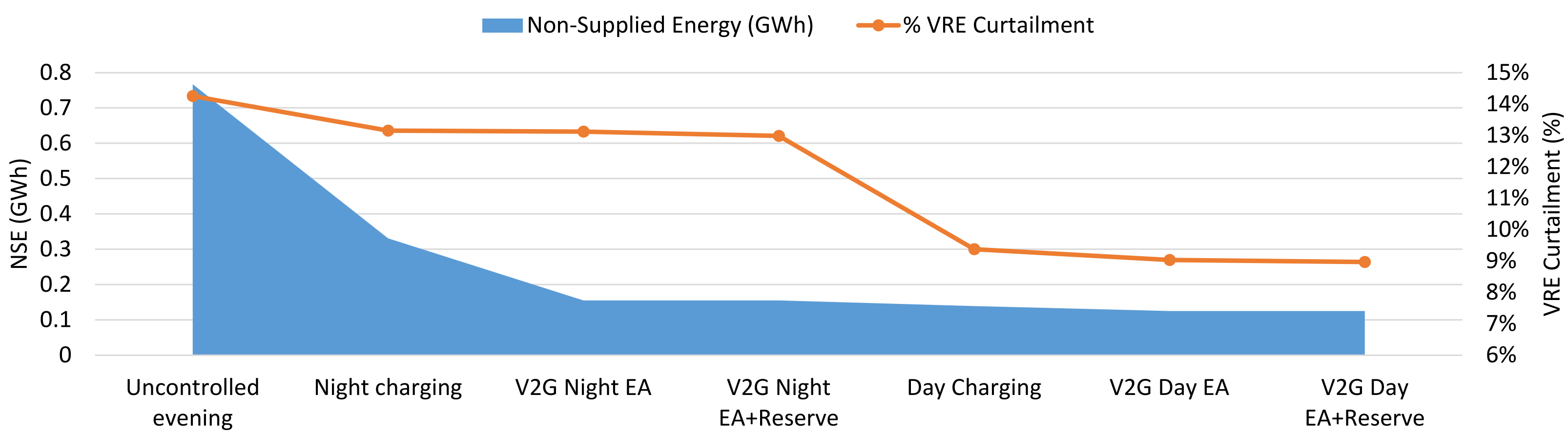
- » Set the hours in which EVs are connected to the grid depending on charging scenario
- » E-Mobility vehicle discharge: Negative Inflow profile that equals the energy discharged when vehicle is not connected
- » Contemporaneity factor set to 30% in day scenario and used to simulate progressive connection and disconnection of EVs
- » Ongoing follow-up work: add a degradation constraint

Impact on Production Costs

IRENA
International Renewable Energy Agency

» **Production Costs**
  - » EVs increase productions costs
  - » V2G could save up to an 85% w.r.t the uncontrolled charging
  - » Charging during the day is more advantageous
  - » Most of the reduction in production cost is due to the reduction in VRE curtailment



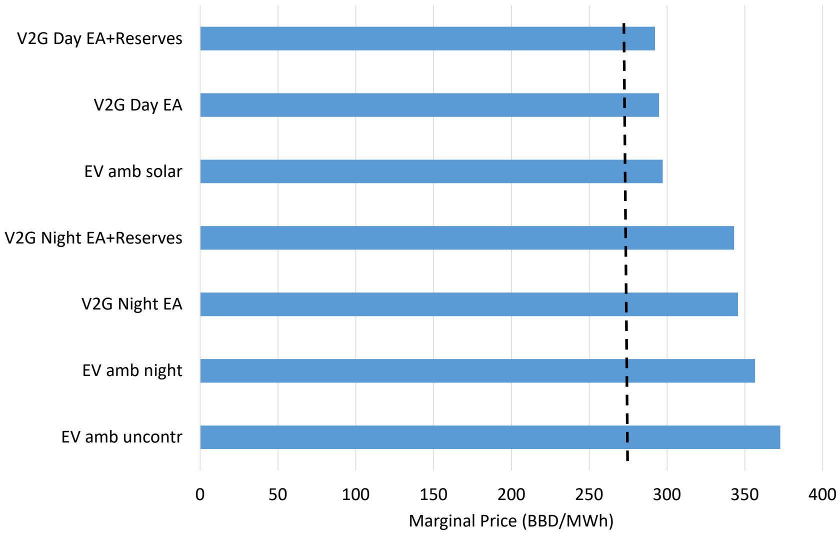


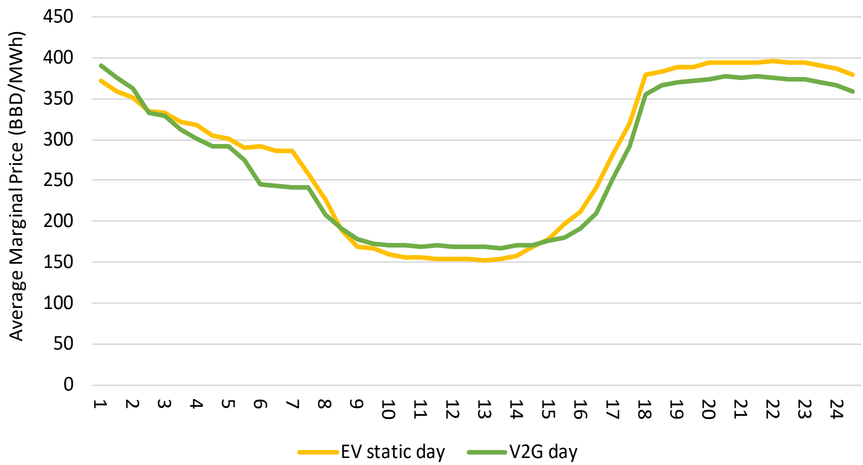
Source:

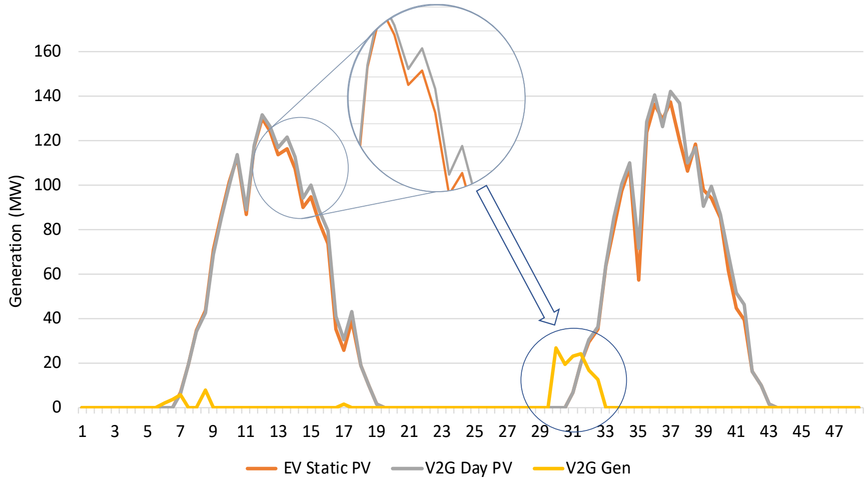
Impact on Daily Marginal Price Profile

» **Marginal Price**

- » V2G can reduce the marginal price of the system compared to unidirectional charging
- » V2G also affects the marginal price profile (due to energy arbitrage capabilities)







Source:

Reduced need for grid-connected storage capacity

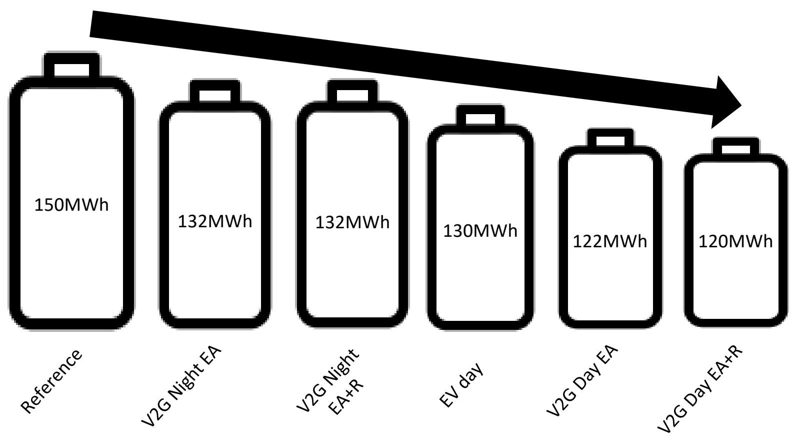
» Methodology

- » How much storage can I avoid while maintaining the same level of reliability?
- » Similar to ELCC calculation

1. Calculate the amount of non-supplied energy in each scenario, using reference as base
2. Identify the scenarios that reduce Non-Served Energy (NSE) compared to reference
3. Start reducing MWh of grid-connected energy storage progressively
4. Stop when the amount of NSE equals the one from reference scenario
5. Calculate amount of avoided grid-connected energy storage

» Results

- » All V2G scenarios reduce the amount of grid connected storage
- » EV Static day also reduces storage even more than night V2G
- » V2G can reduce it up to a 20%



Conclusions

- Main Findings
  - There are different ways to model EVs into the grid
  - V2G can significantly reduce the system cost of charging EVs
  - V2G reduce VRE curtailment increasing the integration of VRE
  - V2G can avoid grid-connected storage investment reducing system CAPEX
- Further Research
  - Modeling EV battery degradation due to V2G
  - Include total system costs assessment (CAPEX+OPEX)
  - Include impact on transmission or distribution grid
- Applicability
  - Methodology can be generalized to apply to other countries or regions considering how to best integrate EVs in the grid
  - Controlled day charging scenarios are ideal for systems with high share of PV
  - Controlled night scenarios are the most applicable to systems without much PV
- Key take away
  - EV integration has to be carefully planned:
    - if uncontrolled, the natural charging behavior is likely to negatively affect the power system in terms of reliability, required investments and production cost
    - If smartly integrated, it can positively affect the power system in terms of reliability, reduced need for investment in flexibility and limited increase in overall production cost, facilitating integration of VRE

IRENA

International Renewable Energy Agency

Emanuele Taibi
Etaibi@irena.org