IHS TECHNOLOGY

Presentation

Opportunities and Challenges for Energy Storage in PV – On and Off the Grid.

10th March 2015

ihs.com

Sam Wilkinson

Research Manager, Energy Storage & Solar, IHS Technology

+44 1933 40 22 55, Sam.Wilkinson@ihs.com

Introduction to IHS

- IHS provides information, analytics and expertise to leading businesses around the world.
- It provides unrivalled coverage of the energy, technology and other industries.

IHS serves:

Corporations and governments in **165+** countries

Small businesses to **Fortune 500**

75+% of the Global Fortune 500

70+% of the Fortune 1000

Energy Storage in PV Report – 2014

- The majority of the analysis included in this presentation is taken from:

"The Role of Energy Storage in the PV Industry – 2015"

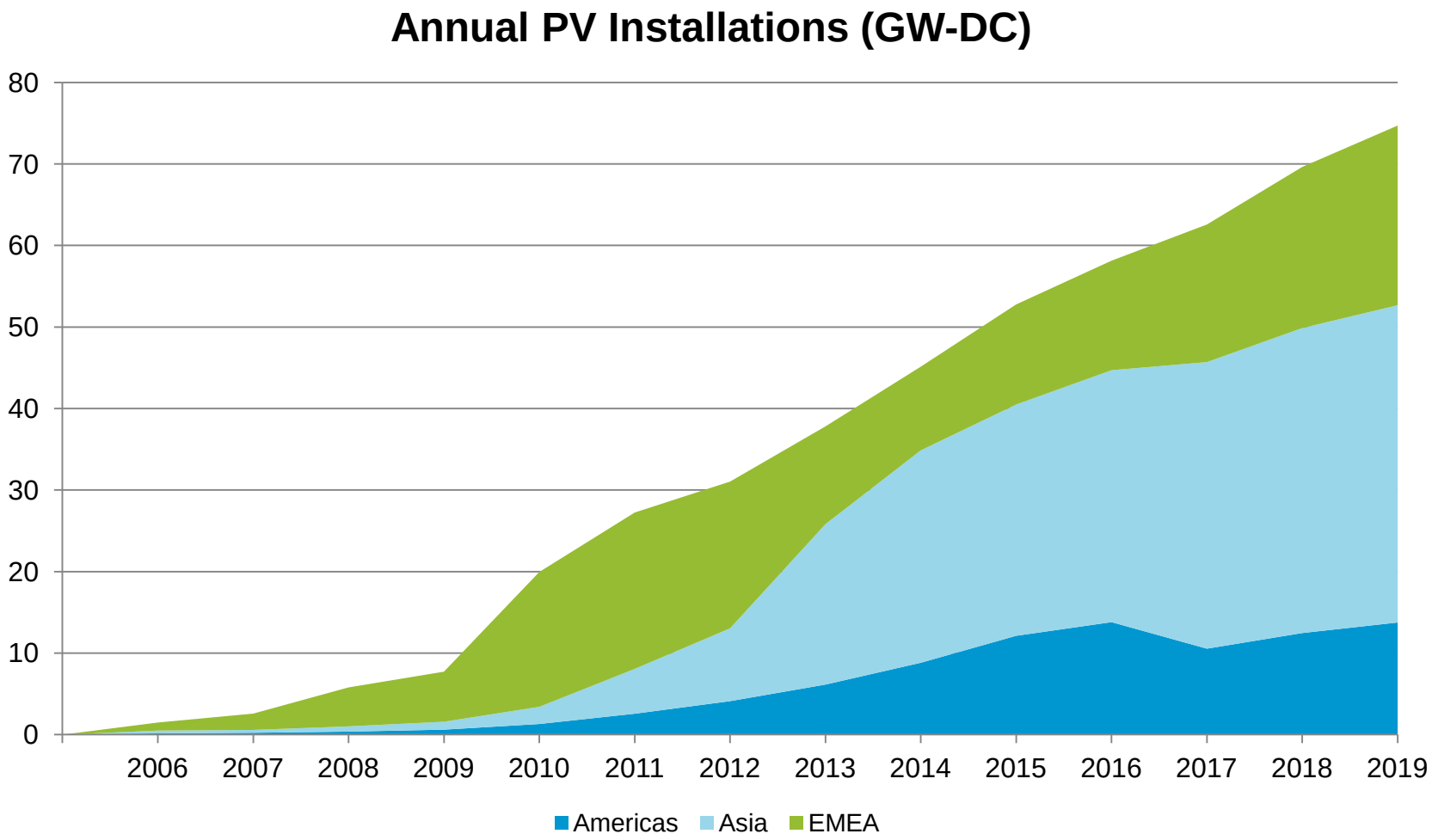
- Published in October 2014, following 6 months of research and interviews.
- Includes detailed industry forecasts for all key applications and regions.
- More information: Sam.Wilkinson@IHS.com

- ~30 minute presentation, followed by 10-15 minutes for Q&A.

Key questions

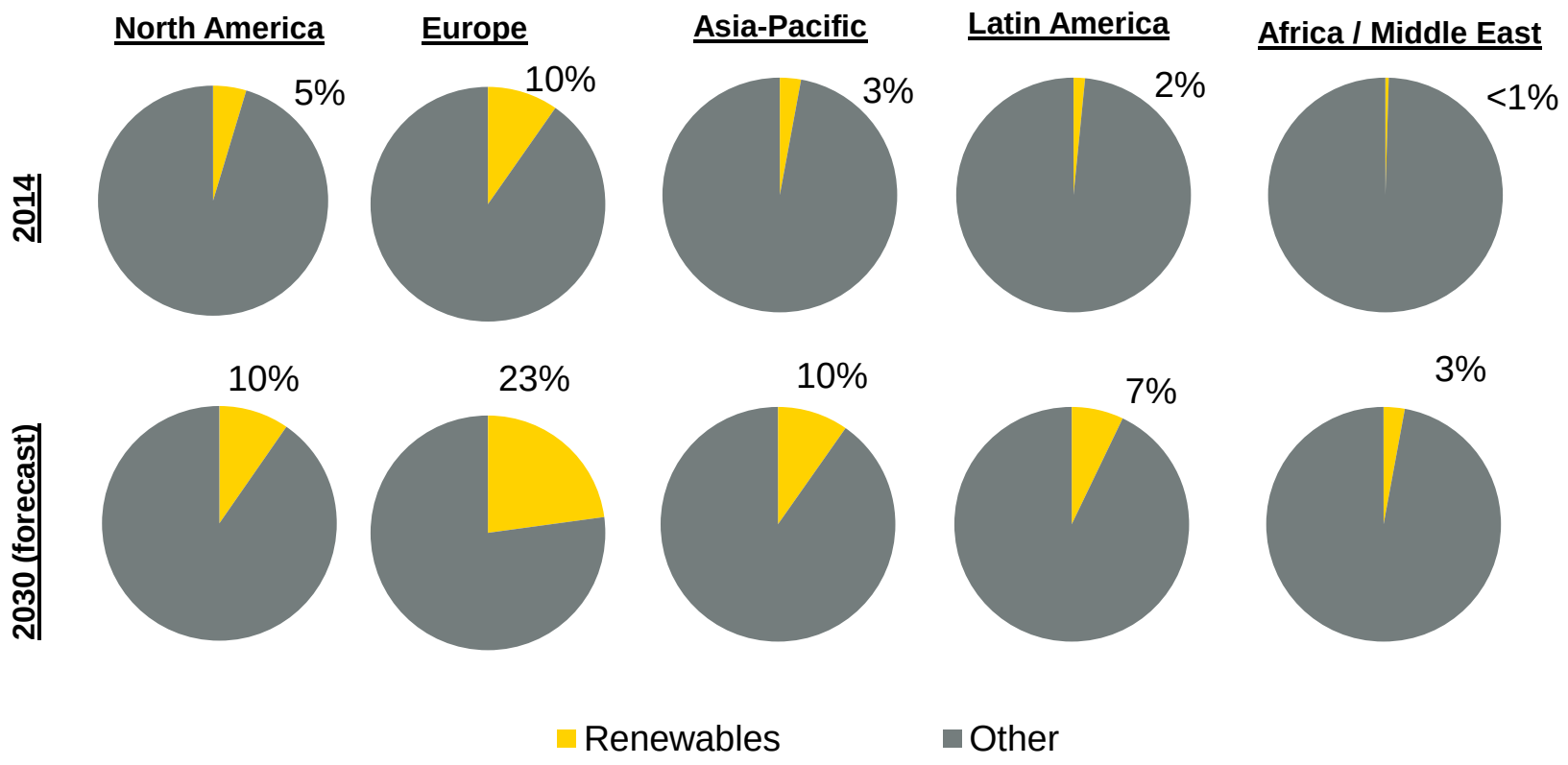
- What are the applications, and where are the biggest opportunities for energy storage in grid-connected and off-grid PV systems?
- How much PV will be installed with energy storage in the coming years?
- What are the challenges and market barriers for PV energy storage?

Why is energy storage becoming such a hot topic?



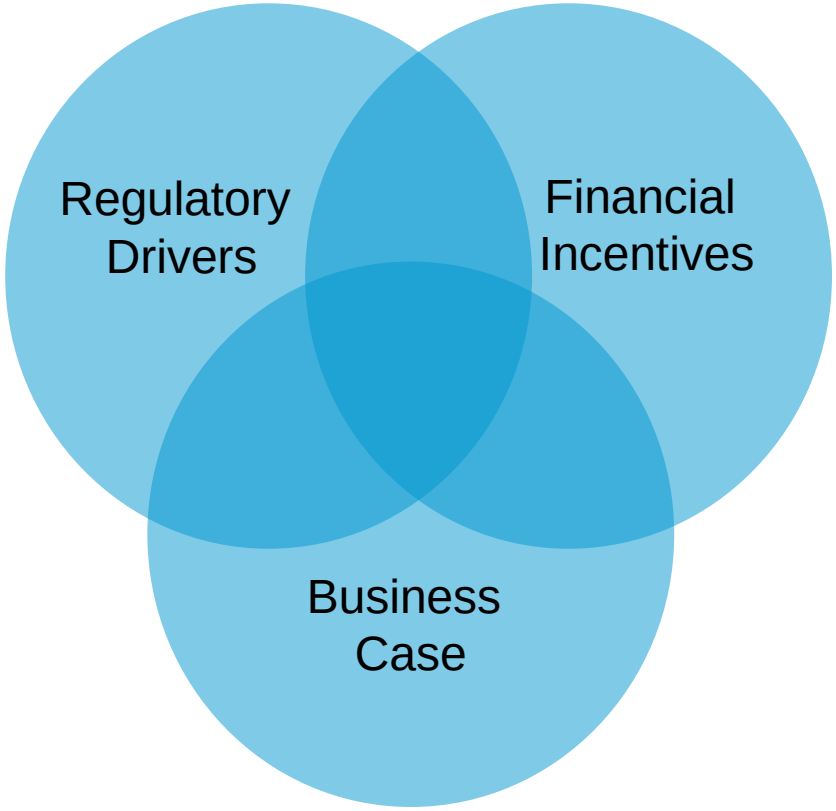
Why is energy storage becoming such a hot topic?

Grid penetration of wind and solar energy (2014-2030)



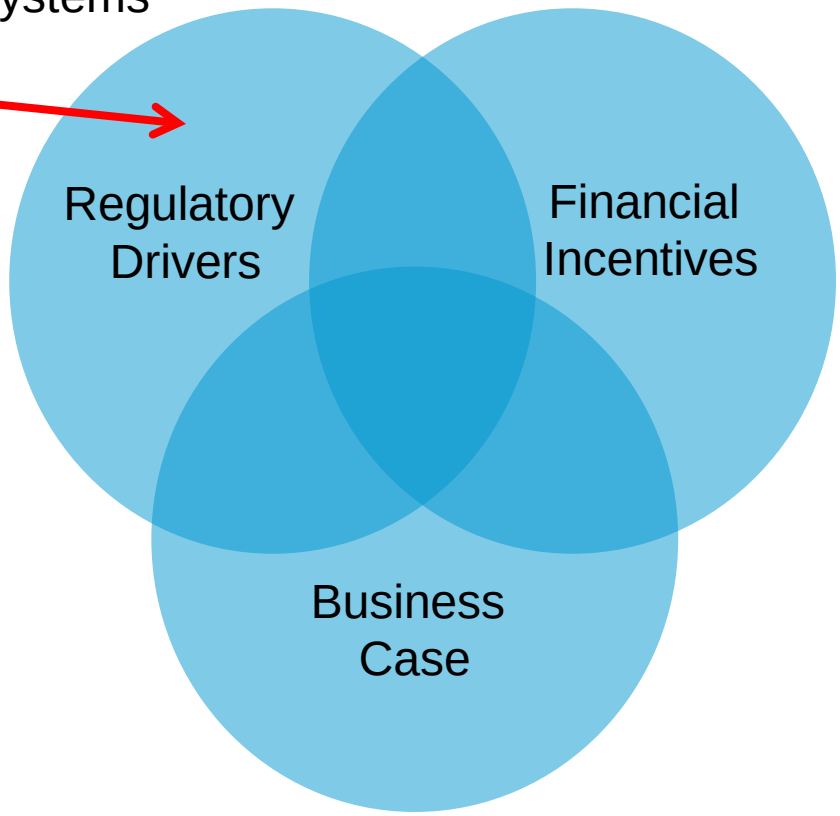
Source: IHS Global Energy Scenarios

Energy storage market drivers



Energy storage market drivers

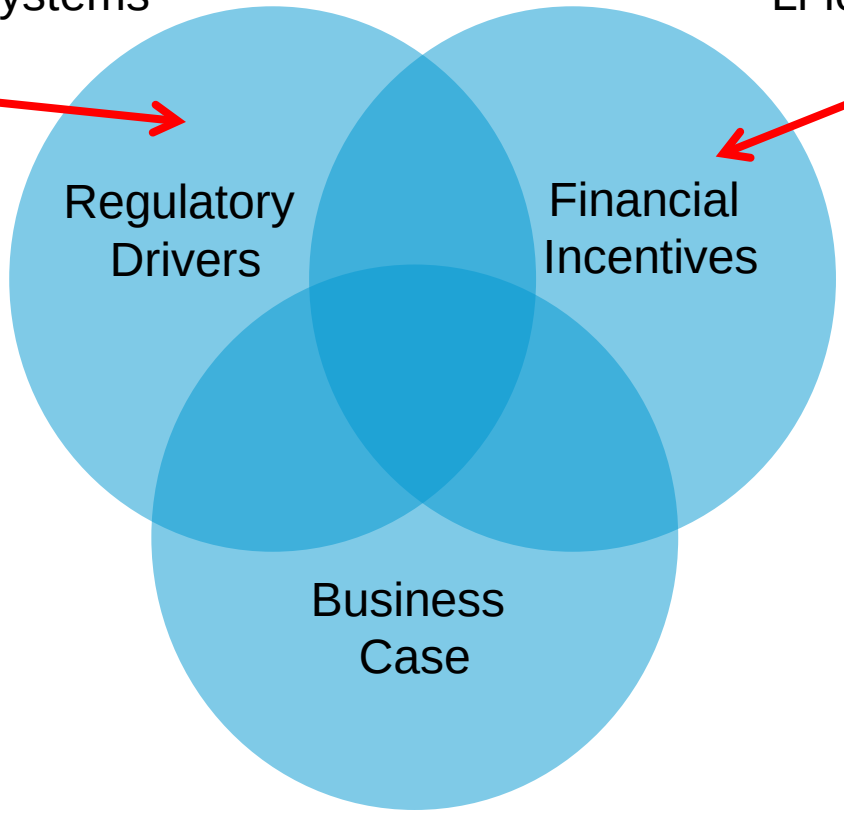
e.g. Ramp-rate control restrictions on PV systems in Puerto Rico



Energy storage market drivers

e.g. Ramp-rate control restrictions on PV systems in Puerto Rico

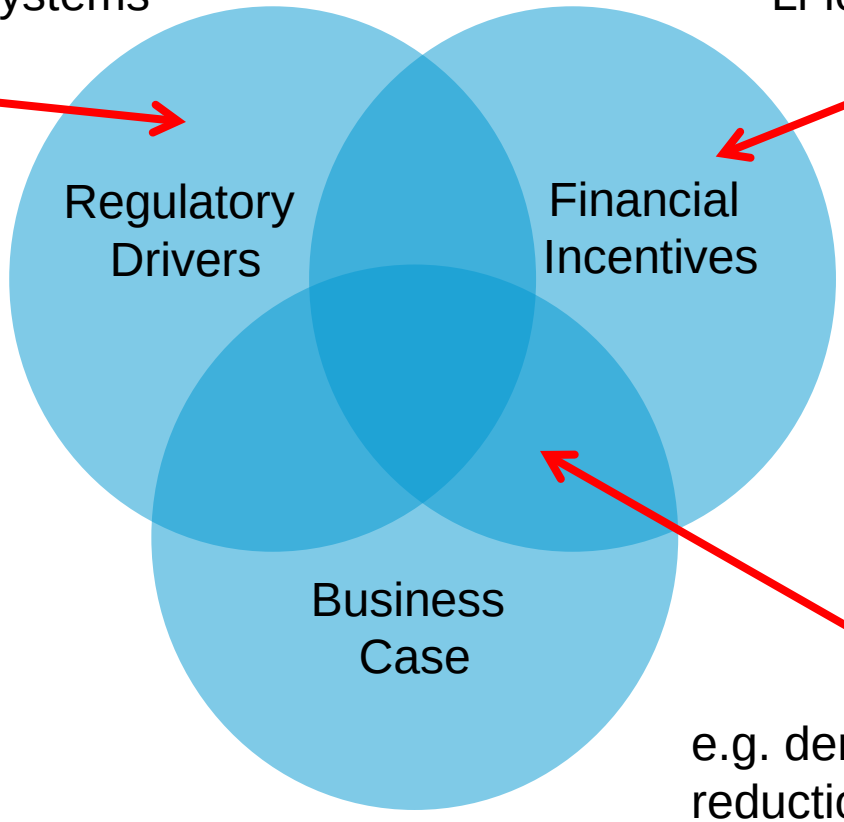
e.g. Behind-the-meter Li-ion subsidy in Japan



Energy storage market drivers

e.g. Ramp-rate control restrictions on PV systems in Puerto Rico

e.g. Behind-the-meter Li-ion subsidy in Japan



e.g. demand charge reduction in USA with SGIP incentive

Market drivers vary significantly by system type

Driver	Grid-connected			Off-grid
	Residential	Commercial	Utility-scale	
Self-consumption	Major	Minor		
Continuous power from PV				Major
PV is cheaper than diesel generation				Major
Back-up	Minor	Minor		
Peak demand charges	Minor	Major		
Ramp-rate control			Major	
Providing services to the grid	Minor	Minor	Minor	
Defer T&D upgrades	Minor	Minor	Minor	Minor
Manage variable electricity rates	Minor	Minor		
Financial incentives/subsidies	Major	Major		

Source: IHS

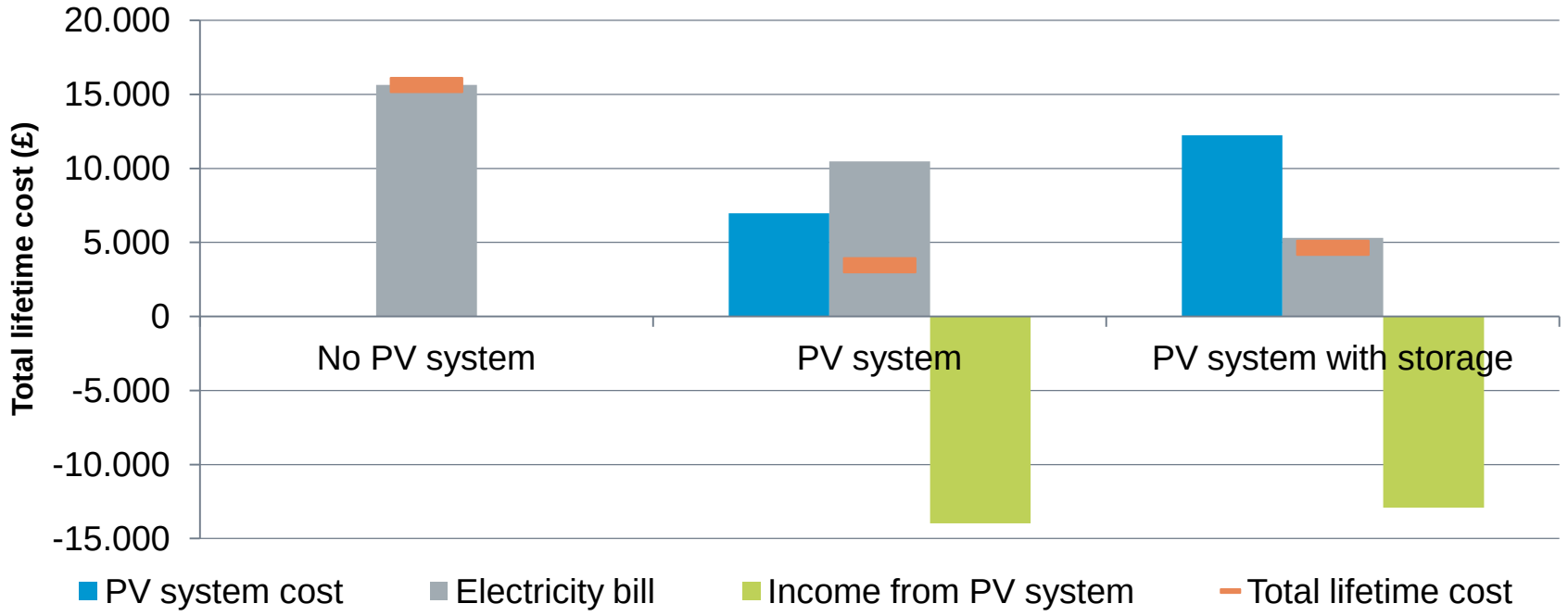
Market drivers vary significantly by system type

Driver	Grid-connected			Off-grid
	Residential	Commercial	Utility-scale	
Self-consumption	Major	Minor		
Continuous power from PV				Major
PV is cheaper than diesel generation				Major
Back-up	Minor	Minor		
Peak demand charges	Minor	Major		
Ramp-rate control			Major	
Providing services to the grid	Minor	Minor	Minor	
Defer T&D upgrades	Minor	Minor	Minor	Minor
Manage variable electricity rates	Minor	Minor		
Financial incentives/subsidies	Major	Major		

Source: IHS

Residential PV energy storage – UK case study

Economics of PV self-generation with energy storage in the UK

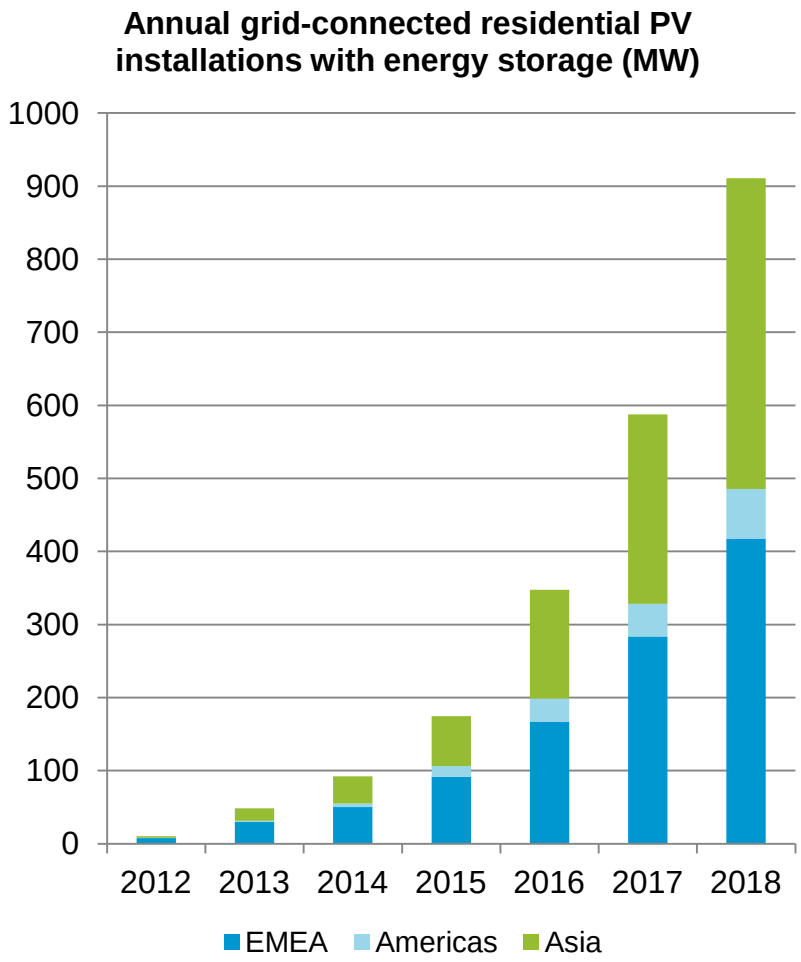


Source: IHS

Assumptions

Typical UK household: Annual electricity consumption = 3500 kWh; Electricity price = £015/kWh (4% inflation)
PV system: PV system size = 4 kW; capacity factor = 0.11; FIT rate = £0,149/kWh (generation); FIT 'export bonus' = £0.046/kWh
Energy storage: 3 kWh L-ion battery; self-consumption without storage = 30%; self-consumption with storage = 60%
Cost of finance/capital is not considered. Simple total lifetime cost calculation.

Residential PV energy storage installations to reach 900 MW in 2018



- EMEA installations driven by Germany and UK
- Americas limited due to no little incentive for self-consumption.
  - Very difficult to sell energy storage purely for backup in the residential sector.
- Asia largely driven by Japan and Australia.

Market drivers vary significantly by system type

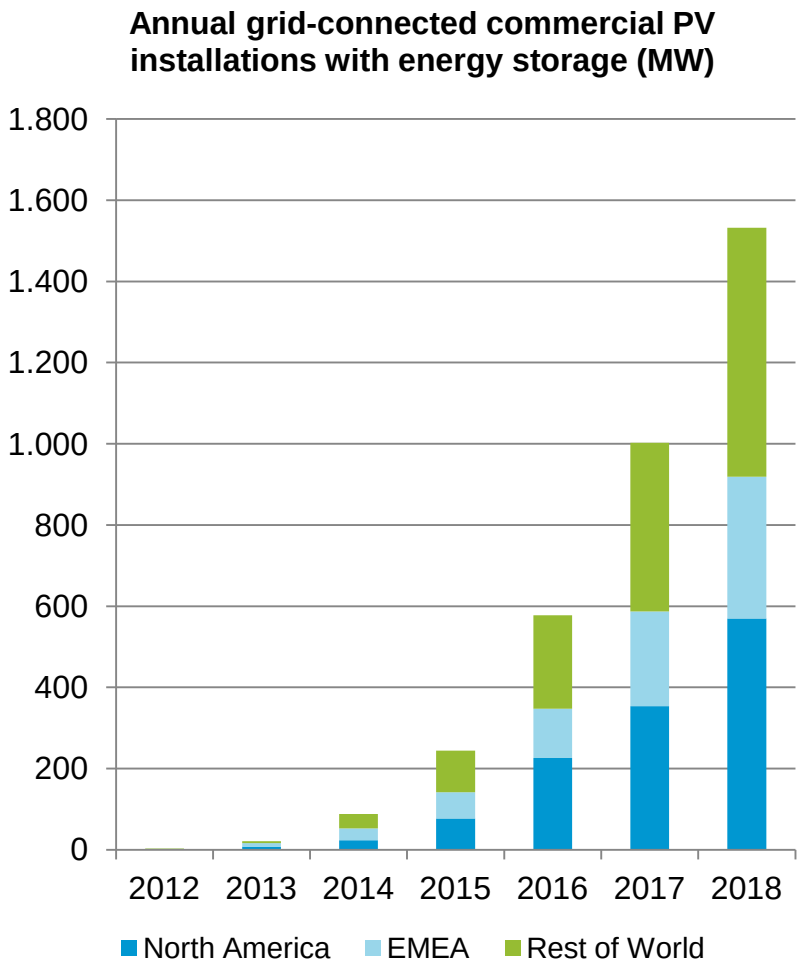
Driver	Grid-connected			Off-grid
	Residential	Commercial	Utility-scale	
Self-consumption	Major	Minor		
Continuous power from PV				Major
PV is cheaper than diesel generation				Major
Back-up	Minor	Minor		
Peak demand charges	Minor	Major		
Ramp-rate control			Major	
Providing services to the grid	Minor	Minor	Minor	
Defer T&D upgrades	Minor	Minor	Minor	Minor
Manage variable electricity rates	Minor	Minor		
Financial incentives/subsidies	Major	Major		

Source: IHS

Explanation of peak demand charge reduction

- Commercial electricity tariffs are generally made up of a ‘per kWh’ element and a ‘per kW’ element in USA.
- The ‘demand charge’ portion can represent a significant proportion of the total electricity bill each period.
- Significant savings can be made by reducing spikes in a building’s load profile.
- Business model is not reliant on PV, but economics are often improved by the addition of a PV system.
- Several companies offering ‘no money down’ models to customers in USA. E.g. Stem, Green Charge Networks.

USA and Japan drive commercial PV energy storage market



- Market dominated by North America due to significant ‘peak demand charges’ in commercial sector.
- Subsidy for Li-ion batteries in commercial buildings in Japan driving market in Asia.

Market drivers vary significantly by system type

Driver	Grid-connected			Off-grid
	Residential	Commercial	Utility-scale	
Self-consumption	Major	Minor		
Continuous power from PV				Major
PV is cheaper than diesel generation				Major
Back-up	Minor	Minor		
Peak demand charges	Minor	Major		
Ramp-rate control			Major	
Providing services to the grid	Minor	Minor	Minor	
Defer T&D upgrades	Minor	Minor	Minor	Minor
Manage variable electricity rates	Minor	Minor		
Financial incentives/subsidies	Major	Major		

Source: IHS

Case Study: 5MW plant in French Guiana

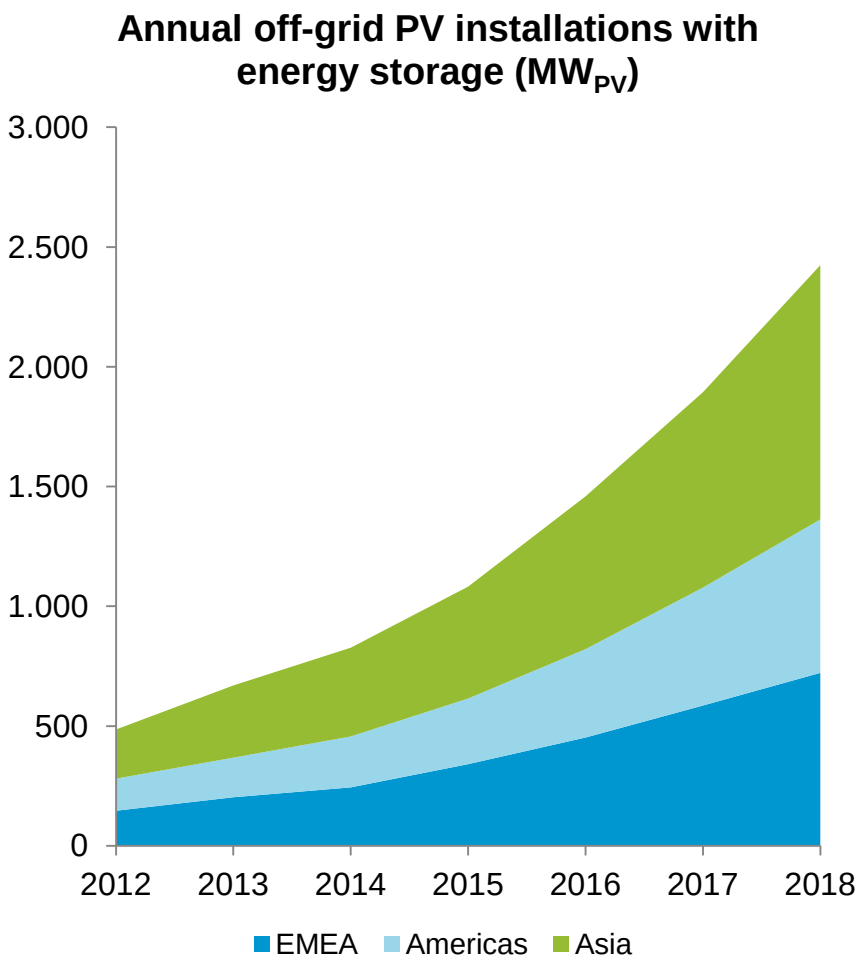
- EDF commissioned ‘Toucan PV Plant’ in French Guiana in Jan 2015.
- Energy storage improves integration into the unstable grid by smoothing the system’s output.
- Timeshifts PV energy to feed it in at night when required
- The PV system includes a relatively long duration 1.5 MW / 4.5 MWh sodium nickel chloride battery, provided by Italian battery manufacturer FIAMM.
- Other installations have been completed elsewhere, with some providing grid services such as primary reserves

Market drivers vary significantly by system type

Driver	Grid-connected			Off-grid
	Residential	Commercial	Utility-scale	
Self-consumption	Major	Minor		
Continuous power from PV				Major
PV is cheaper than diesel generation				Major
Back-up	Minor	Minor		
Peak demand charges	Minor	Major		
Ramp-rate control			Major	
Providing services to the grid	Minor	Minor	Minor	
Defer T&D upgrades	Minor	Minor	Minor	Minor
Manage variable electricity rates	Minor	Minor		
Financial incentives/subsidies	Major	Major		

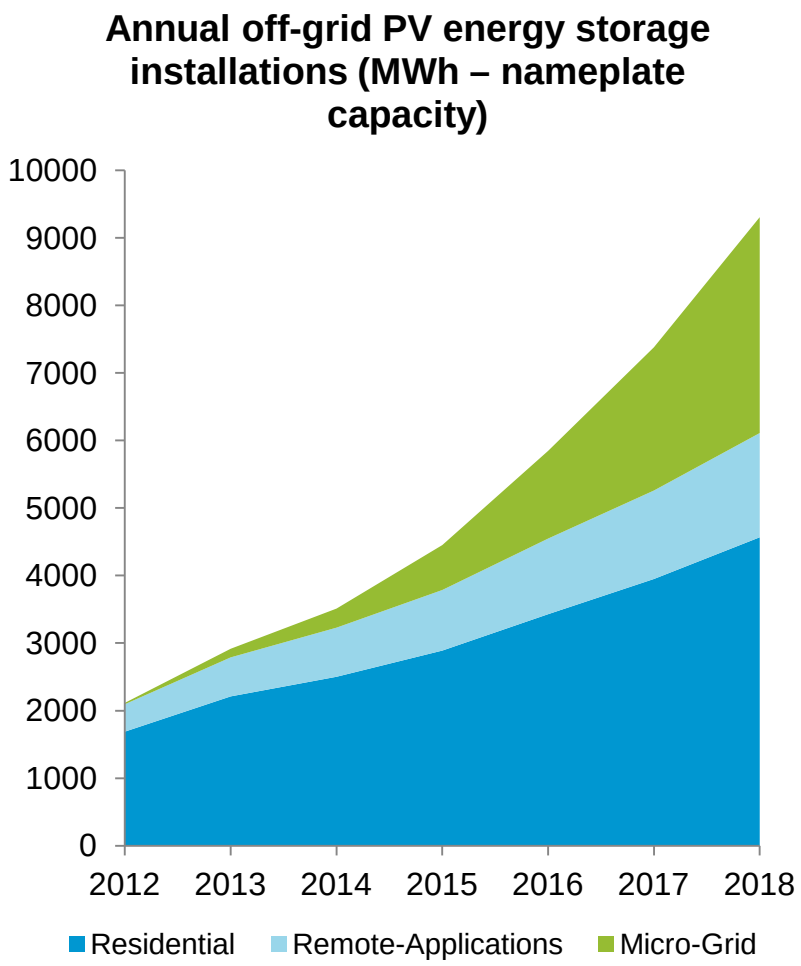
Source: IHS

Rapid growth predicted for off-grid solar



- Off-grid PV installations to grow three-fold from 2014 to 2018
- Increasing opportunities due to renewables being competitive and attractive solutions to compete with diesel generation, or provide remote electrification.

Off-grid PV energy storage applications



- Robust growth for residential off-grid systems to provide power to homes in remote areas.
- ‘Remote applications’ includes telecoms, mines etc.
- Microgrids predicted to be fastest growing segment. Growing interest in island grids.

Why hasn't energy storage in PV taken off yet?

Key energy storage PV markets have slowed

Outlook for major European residential markets cut heavily

Lack of clear policy around energy storage in the grid

How can storage provide services as an asset in the grid?

Lack of incentives to 'kick start' the industry

Policies and mandates are slowly being introduced

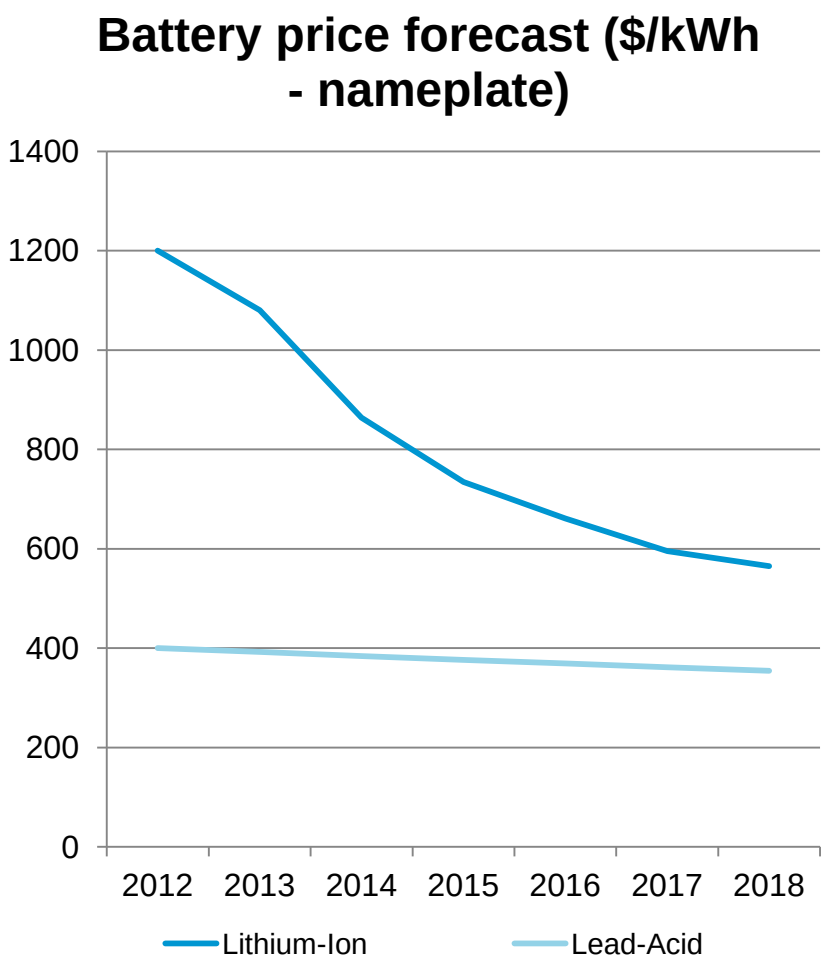
Industry momentum toward centralised storage solutions

ESS 'in-the-grid' to tackle challenges at a grid-level

High price of batteries

When will this change?

Rapid price reductions making Li-ion the technology to beat

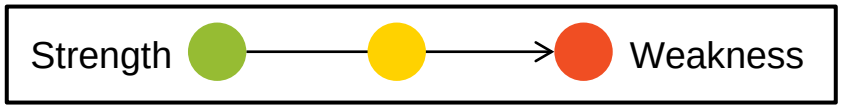


- Advantages of Li-ion:
  - Greater depth-of-discharge – more usable capacity
  - Longer lifetime / increased lifecycles.
  - Greater energy density

Other storage technologies? – key considerations

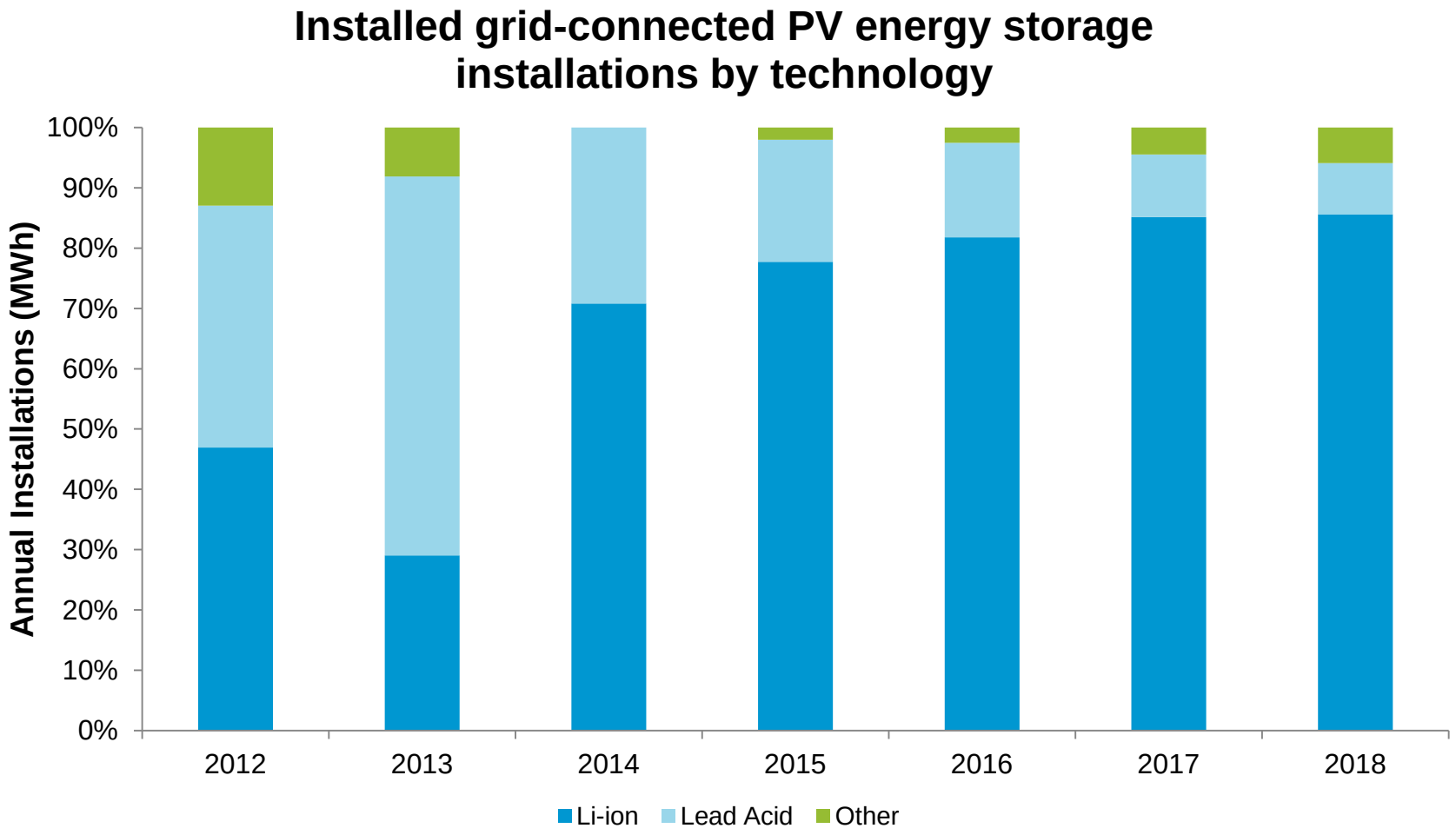
Grid-connected battery technology comparison

Battery technology	Current lifetime cost	Potential for cost declines	Energy density	Round-trip efficiency	Safety concerns
Lithium-ion	Weakness	Strength	Strength	Strength	Intermediate
NaS	Strength	Weakness	Intermediate	Intermediate	Weakness
Lead-acid (advanced)	Weakness	Weakness	Intermediate	Intermediate	Weakness
Flow	Intermediate	Intermediate	Weakness	Weakness	Intermediate
NaNiCl	Intermediate	Intermediate	Intermediate	Intermediate	Strength



Source: IHS

Li-ion to dominate grid-connected PV energy storage market



Conclusions:

- Growing demand for electricity and increasing renewable penetration is driving a need for energy storage
- Drivers for the adoption of storage vary across all system types
- Currently, the most significant barrier to wide-scale deployment is high battery prices. Significant cost reductions are predicted for the future.
- Li-ion is currently the “technology to beat”, and will account for the majority of the grid-connected PV energy storage market.

Questions?

For more information about the content of this presentation:

Sam Wilkinson

Research Manager, Energy Storage & Solar, IHS Technology
+44 19 33 402255 – Sam.Wilkinson@IHS.com

IHS Customer Care:

- **Americas:** +1 800 IHS CARE (+1 800 447 2273); CustomerCare@ihs.com
- **Europe, Middle East, and Africa:** +44 (0) 1344 328 300; Customer.Support@ihs.com
- **Asia and the Pacific Rim:** +604 291 3600; SupportAPAC@ihs.com