Energy Storage in China

deployment and innovation

Mockup of Tesla Gigafactory in Shanghai free trade zone

BYD-State Grid Battery ES Array in Zhangbei

Joanna Lewis
Georgetown University

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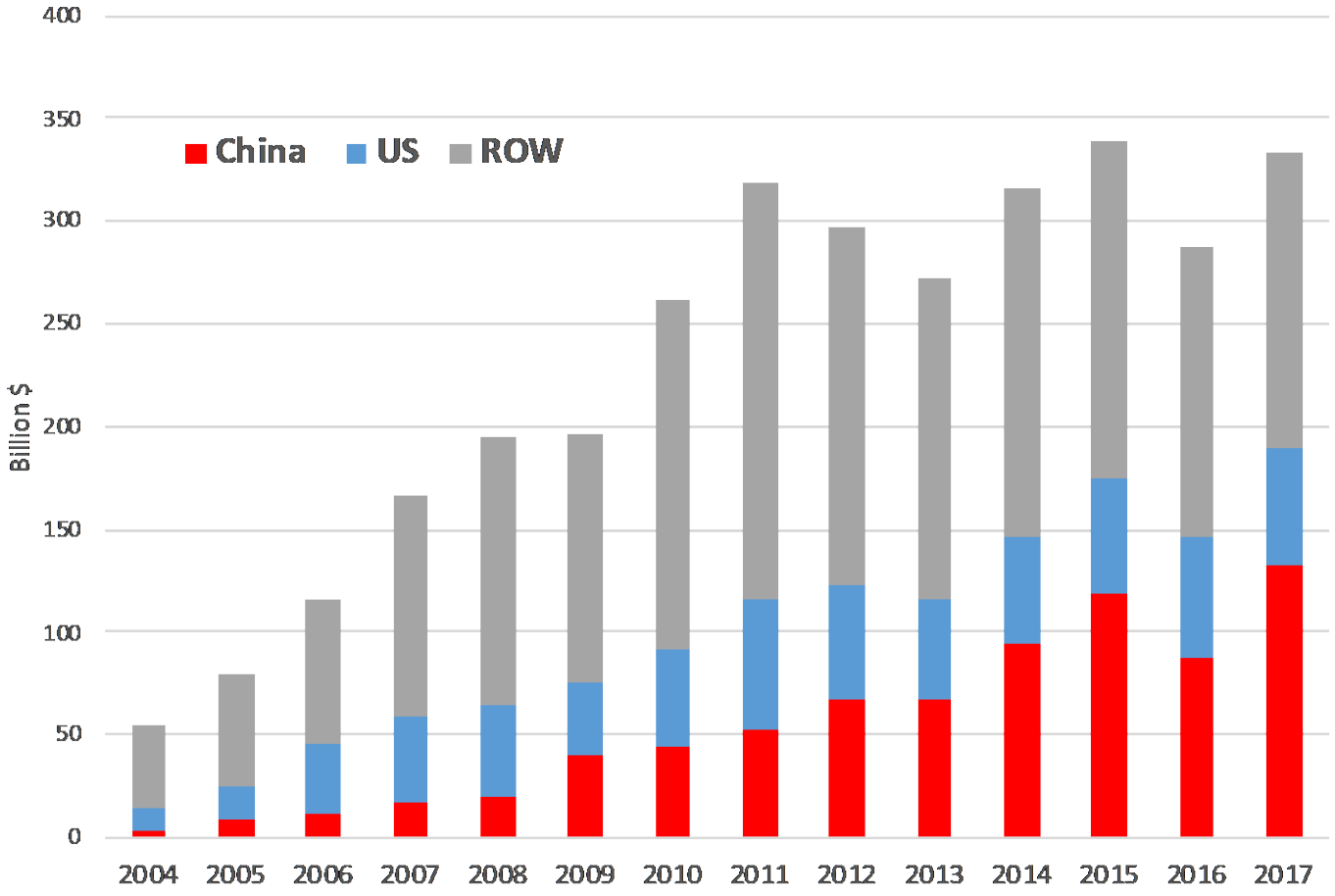
Overview

- China is late to the game in developing energy storage (ES) technologies-but has been ramping up very quickly over past ~2 years and is on track to surpass current leaders
- Recent push is supported by many new government policies targeting both innovation and deployment in ES technologies
- Li-ion is the fastest growing electrochemical ES tech in China targeting both grid scale and EV storage markets; but the vast majority of ES currently used in China is pumped hydro
- Li-ion storage increasingly directed at RE integration challenges (wind, PV CSP); lead acid primary used for DG and microgrids

China leads a $300+ billion per year global clean energy industry

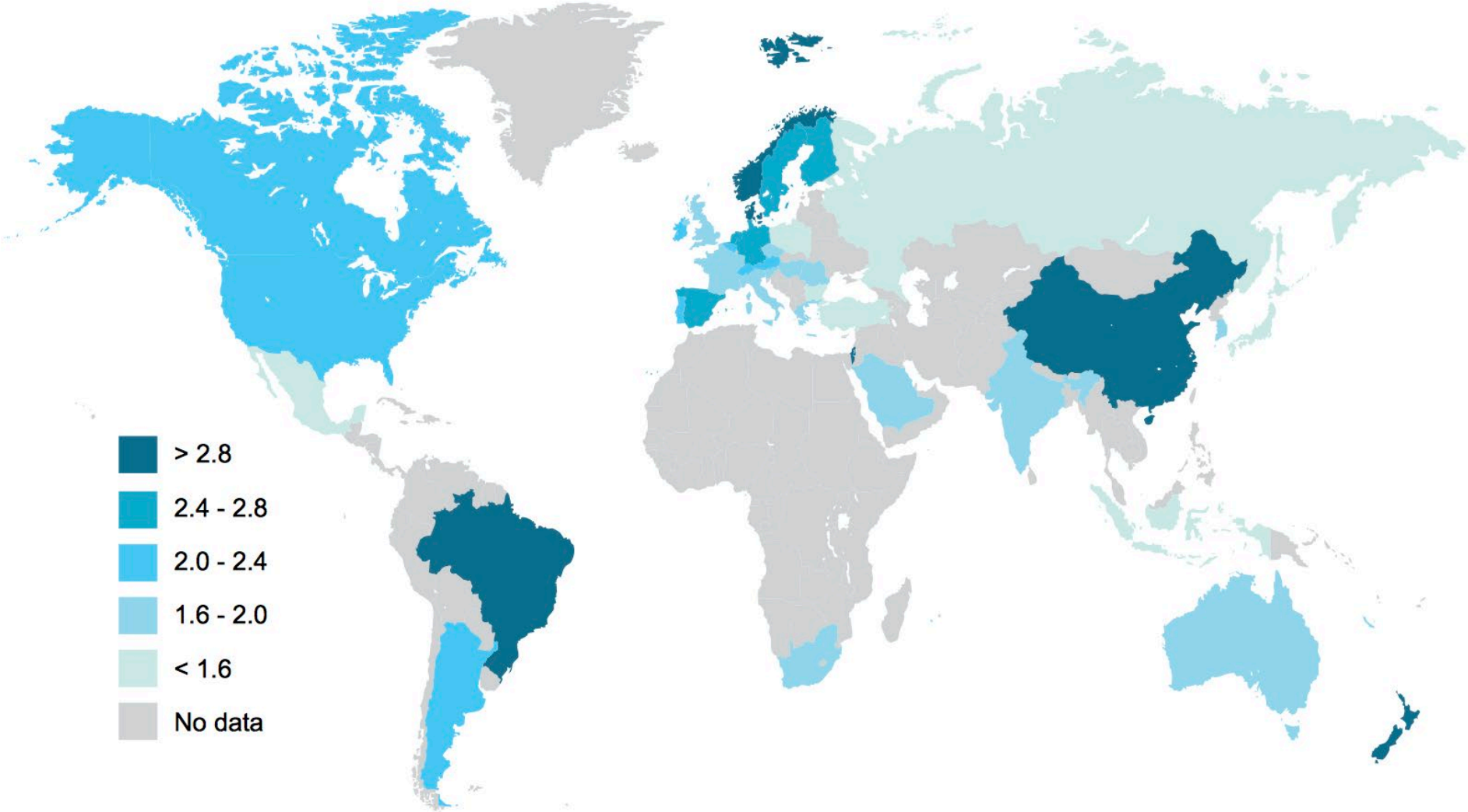


For 2018: China wind and solar investments are slowing and EV investment is increasing

In Q3 There was a $1 billion initial public offering by NIO, a $585 million Series C venture capital round by Guangzhou Xiaopeng Motors and a $294 million pre-IPO round by Zhejiang Dianka Automobile.

Data from BNEF 2017

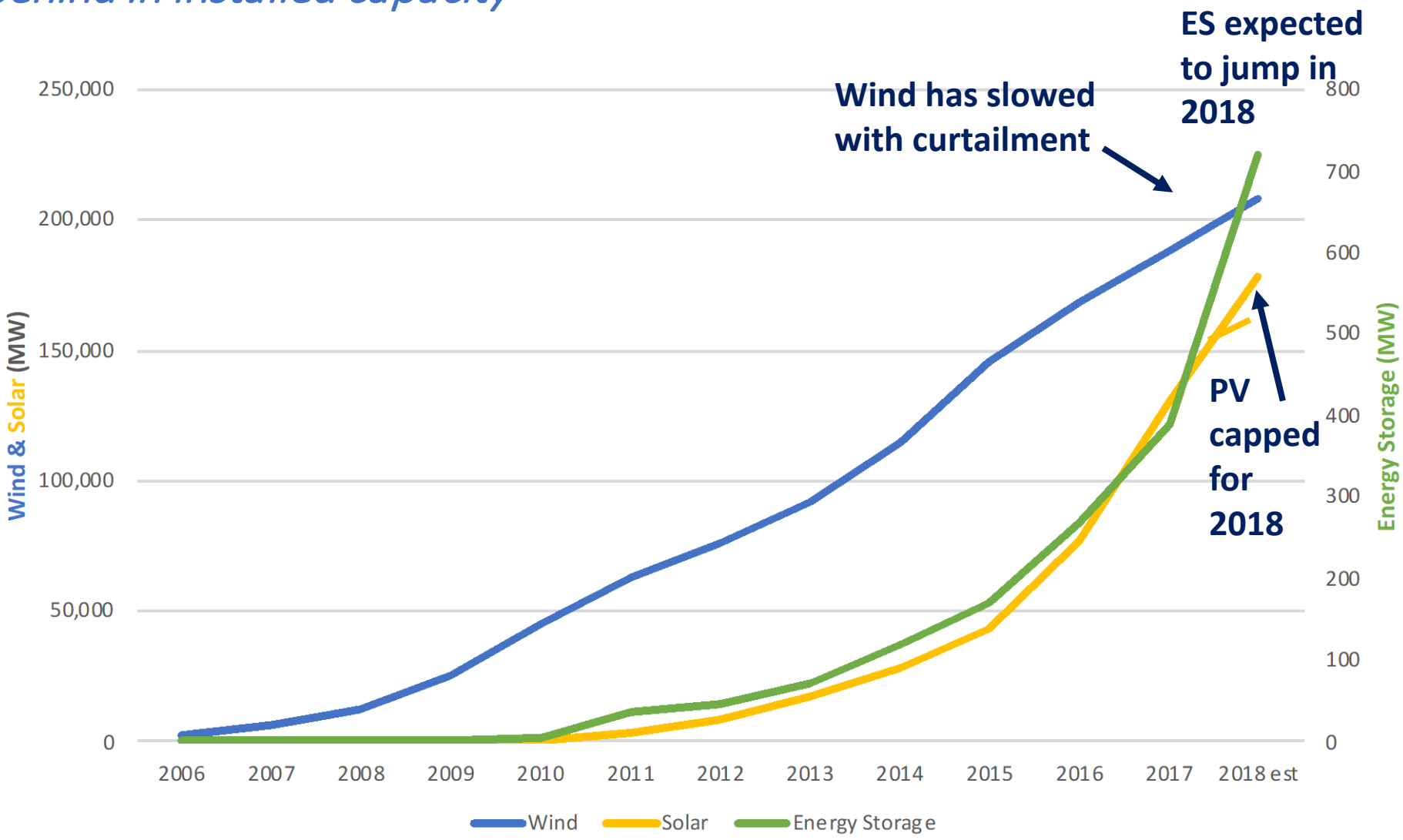
China is particularly strong in scaling-up and commercializing cleantech innovations



Commercialized clean tech innovation scores: Includes cleantech manufacturing value-added; cleantech company revenues; renewable energy consumption data; cleantech late-stage private investment, M&A's and IPOs; and the number of publicly traded cleantech companies

Wind, solar and storage trends

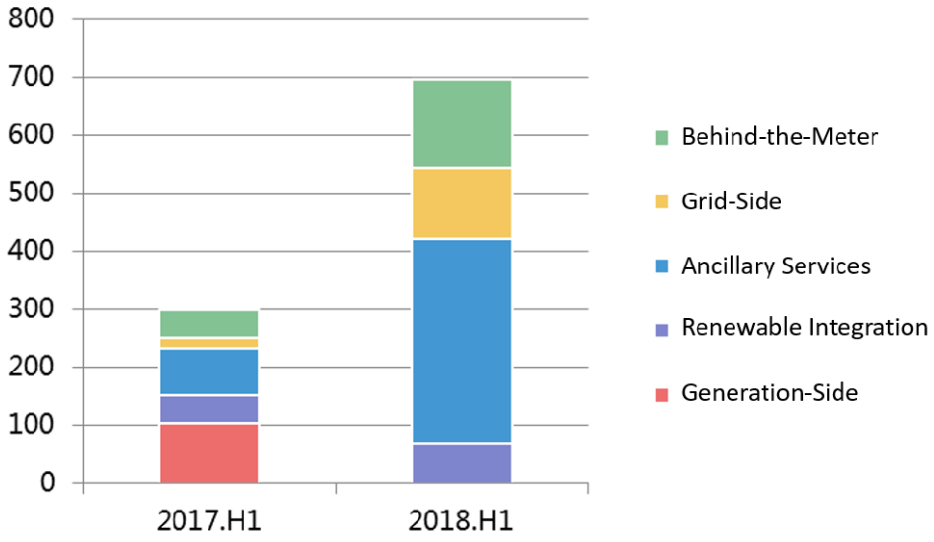
batteries on a similar growth curve as wind and solar though far behind in installed capacity



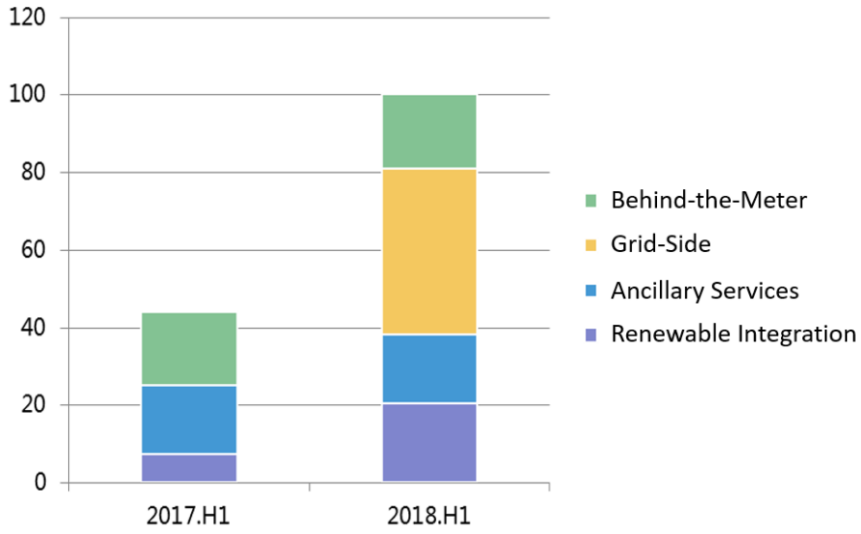
Electrochemical ES only. 2018 estimates from BNEF, CESA

Battery storage by application

Global



China



- RE integration and ancillary services identified as key areas for ES expansion in China

Regulatory frameworks for ES in China

Innovation and Industrial Policies

- Mentioned in 13th FYP as among the top 100 most important national strategic projects
- Identified as "strategic emerging industry "
- Specific RD&D goals for ES technologies:
  - Energy Development 13th Five-Year Plan
  - Made in China 2025 – Energy Equipment Implementation Plan
  - Energy Technology Revolution Innovation Action Plan (2016-2030)

Power Sector Reforms

- Tariff reforms towards market based prices
- Allowing for pricing of ancillary services including provided by ES

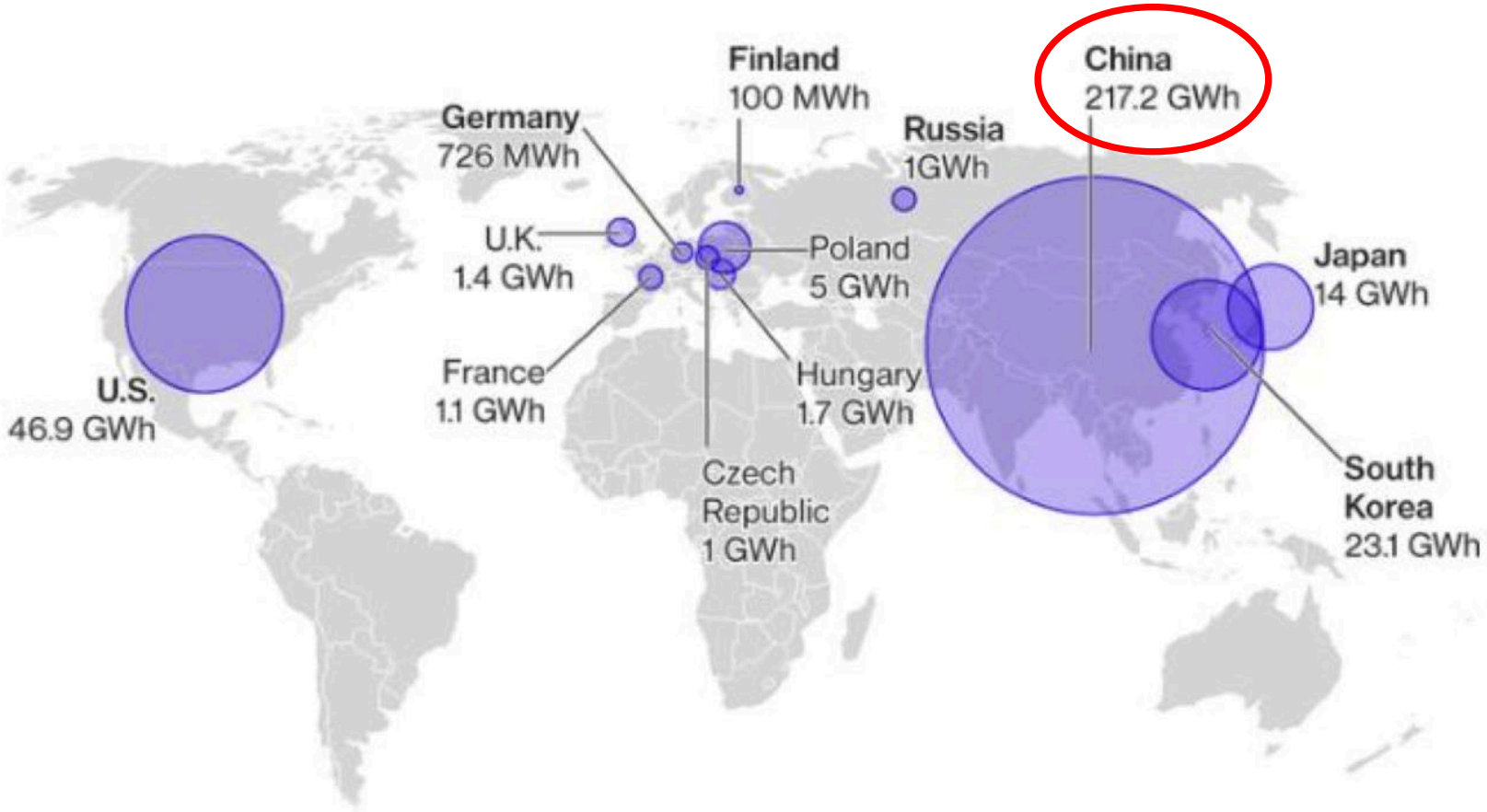
Broader Energy Sector Goals

- RE quota and guarantee mechanism; RE integration and curtailment targets
- Microgrid policies and demos
- New energy vehicles policies (20 percent of total vehicle production and sales by 2025 est. at 35 million) including foreign-owned models
- Internet of energy & smart energy development

Regulations Targeting ES

- 2017 Document 1701, "Guidance on the Promotion of Energy Storage Technology and Industry Development" (NDRC and NEA with MOF, MOST, MIIT)
- 2017 Improving ancillary services compensation mechanism workplan
- 2017 Notice on the development of distributed generation market pilot projects
- *Others expected to follow*

Planned battery cell production capacity



BNEF in Hart et al 2018

Chinese battery “gigafactories”

Innovation and IP

- Goal is to “promote a number of energy storage technologies and products with independent intellectual property rights”
- Several Chinese battery manufacturers benefiting from industrial policies (and indirect subsidies) as well as government procurement
- China has said it would remove foreign ownership caps for companies making PHEV and EVs in 2018, for makers of commercial vehicles in 2020, and the wider car market by 2022

International technology partnerships & transfers

- BYD 比亚迪汽车 & Daimler (Germany), ABB (Switzerland)
- Narada 南都电源 & Leclanche (Switzerland)
- Sungrow 阳光电源 & Samsung SDI (Korea)
- Shoto 双登 & Oorja (USA)
- Shenzhou Clou 科陆电子& LG Chem (Korea)
- CATL 宁德时代 & BMW, Volkswagen (Germany)

Outlook

- China poised to become the center of battery manufacturing
- Chinese companies playing an increasingly important role but many rely on international partnerships (EV companies)
- Policy focus on ES in China increasingly targeting RE integration, grid stability/ancillary services, as well as expanded DG and microgrids, but tied to broader power sector reforms
- Obstacles still remain (including cost) but many signs that ES will repeat China's success in rapidly expanding the wind and solar industries

Joanna Lewis
Associate Professor

Science, Technology and International Affairs Program
Edmund A. Walsh School of Foreign Service
Georgetown University
ICC 510, 3700 O Street NW, Washington, DC 20057
phone: + 1 202 687 7284
email: Joanna.Lewis@Georgetown.edu
web: https://blogs.commons.georgetown.edu/jil9/