Launch of the Stanford StorageX Initiative

BRIDGING GAPS BETWEEN SCIENCE, TECHNOLOGY, AND ECONOMICS IN ENERGY STORAGE

Stanford University

OCTOBER 17, 2019, 8:30AM - 6:00PM
The Nobel Prize in Chemistry 2019 was awarded jointly to John B. Goodenough, M. Stanley Whittingham and Akira Yoshino "for the development of lithium-ion batteries."
Stanford’s History on Energy Storage Research

1960’s-1980’s
Prof. Bob Huggins

Stanley Whittingham
Michel Armand
"Energy storage is critical to sustainability of the world, enabling consumer electronics, electric vehicles and grid-scale storage. I am very glad that Stanford is kicking off a major initiative in this area. Congratulations!"

M. Stanley Whittingham, co-recipient of the 2019 Nobel Prize in Chemistry
Energy Storage Industry to Grow by 10-20x to $1 Trillion Over Next 20 Years
Critical Mass at Stanford: 20+ faculty, 150+ students

Materials

Devices

Systems

years

hours

sec

ms

ns

ps

MSE, ME, ChemE, AA, CE, CS, ERE, Chem, Phys

Stanford | ENERGY
StorageX Initiative
We Need a Highly Visible Initiative at Stanford: StorageX

1) Build strong partnerships between university, industry and government.

2) Recruit the best students to Stanford.

3) Enhance Stanford-internal collaboration to identify and tackle grand challenges.

4) Build multi-PI facilities, including translational capabilities.
StorageX Planning Team

Co-Director
Prof. Yi Cui

Co-Director
Prof. William Chueh

Prof. Simona Onori

Prof. Fuo-Kuo Chang

Jimmy Chen

Will Gent

Hansen Wang

Miki Yu

Tracy Turner

Stanford ENERGY
StorageX Initiative
Brought to you by Stanford StorageX Initiative
Launch Sponsors:

Stanford | Precourt Institute for Energy

Stanford | SCHOOL OF EARTH, ENERGY & ENVIRONMENTAL SCIENCES

Stanford | ENGINEERING

Stanford | School of Humanities and Sciences
Brought to you by Stanford StorageX Initiative Supporters:
Grand Challenges for Energy Storage

1) Sustain the cost learning curve of batteries

2) Identify pathway to energy dense, high power, safe and long lasting batteries

3) Solve scientific challenges in scale up & manufacturing

4) Enable circular economy through re-use, recycling and regeneration

5) Leverage informatics and artificial intelligence to accelerate the pace of R&D
StorageX Initiative: From Fundamental to Translational Energy Research

**Academic research**
- Fundamental understanding
- Materials design/synthesis
- “Big science” facilities
- New directions (e.g., ML)

**Students, postdocs, staff & faculty**

**Industrial development**
- Prototyping & scale up
- Exhaustive optimization
- System integration
- Cost, life cycle, business model

Pre-competitive R&D

De-risk technology for commercialization
Selected Research Highlights: Fundamental Understanding

1st atom scale image of Li metal
Y. Cui Science 358, 506, 2017

1st atom scale image of SEI

W. Chueh, Science 353, 566, 2016

Kalirai & Weker

State of Charge

State of Charge
Materials design and new chemistries

Silicon anodes

Thin and flexible solid electrolyte

J. Qin, Y. Cui *Nature Nanotech*. 2019

Self-healing polymer
Y. Cui, Z. Bao *Nature Chemistry* 5, 1042 (2013)

Li metal anodes: host and interface
Machine Learning-Assisted Discovery

Conventional DFT approach

### Conventional DFT approach

- **Atomistic structure**
- **Electronic structure**
- **Physical parameters**
  - \( \sigma = \frac{f a^2 v_0 e^{\frac{\sigma}{k_B T}}}{k_B T} \)
- **Superionic?**

Our machine learning approach

### Our machine learning approach

- **Known structures**
- **Known conductivities**
  - \( \sigma_1, \sigma_2, \ldots, \sigma_n \)
- **Superionic?**

- **\( \sigma \)**
- **\(~4\) weeks/prediction**
- **<1 second/prediction**
- **50% F1 score to DFT results**

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Extreme Fast Charging: Passenger, Freight & Aviation

100 kWh pack in 5 mins = 1.2 MW

Charging Station \(\rightarrow\) Vehicle \(\rightarrow\) Pack \(\rightarrow\) Cell \(\rightarrow\) Material

Grid management

Charging electronics

Modelling & Data Science:
- Charging profile optimization

System engineering:
- Supercapacitor, thermal management, sensors

Device engineering:
- Electrode morphology, electrolyte formulation

Material
- New compositions, nanostructuring

Alternatives: battery swapping

AP Photo/Vincent Yu
Battery Reuse, Recycling, & Regeneration

First Life Use

Reuse or Recycle?

Second and Later Life Use

Reuse/Regeneration

Recycling

Life Cycle Valuation & Cost Model

Data Science
- Performance/degradation beyond first life
- Uncertainty in prediction

Systems Engineering
- Pack and cell designs to lower cost of recycling
- Pack-level rejuvenation

Materials & Processing
- Lower the cost of recycling
- Rejuvenation strategies to recover performance
An Ecosystem of Energy Research, Education and Impact at Stanford

STANFORD CAMPUS
- 200 out of 1700 faculty members
- 22 departments, all 7 schools
- Former US Secretary of Energy
- 2 Nobel Laureates

FORMER U.S. SECRETARIES

CORPORATE ENGAGEMENT
- Global Climate & Energy Project (2003-2018)
  - 15 years of partnership; $200M
- Strategic Energy Alliance (2018-...)
- ExxonMobil, Bank of America, Total, Shell
- Energy Initiatives
  - ~40-50 corporations
The Stanford Natural Gas Initiative

Focal areas
- Methane conversion
- Methane leakage

Focus areas in development
- Improving production
- Global natural gas markets
- (Future) Energy poverty

CONTRIBUTING MEMBERS

BASIC MEMBER
Leede Operating Company

SUSTAINING MEMBERS

CORPORATE MEMBERS

SUPPORTING ORGANIZATIONS

Bits and Watts
INNOVATION FOR THE 21ST CENTURY ELECTRIC GRID

20th Century
- Large centralized generation
- One way power flow
- Continuous generation follows uncontrolled load

21st Century
- Deep Decarbonization
- Distributed Energy Resources

Stanford Bits and Watts Initiative
- Technology, Markets, Business Models, Finance, Policy
- 18 faculty & research staff
- 5 schools & Hoover
The Sustainable Finance Initiative works with public, private and development institutions to engage Stanford researchers in developing the finance and policy tools needed for the transition toward a decarbonized and climate-resilient global economy.
Stanford related Sustainable Energy Companies
TomKat Center Innovation Transfer Program

CULTURE OF INNOVATION

SILICON VALLEY

CALIFORNIA

TomKat Teams

Halo Industries, Inc.
Choose the WiFi network: Stanford Visitor
No username/password necessary

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