

Towards a More Transformational Solar Energy R&D Portfolio



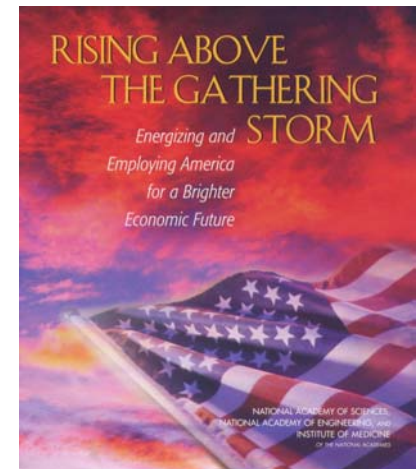
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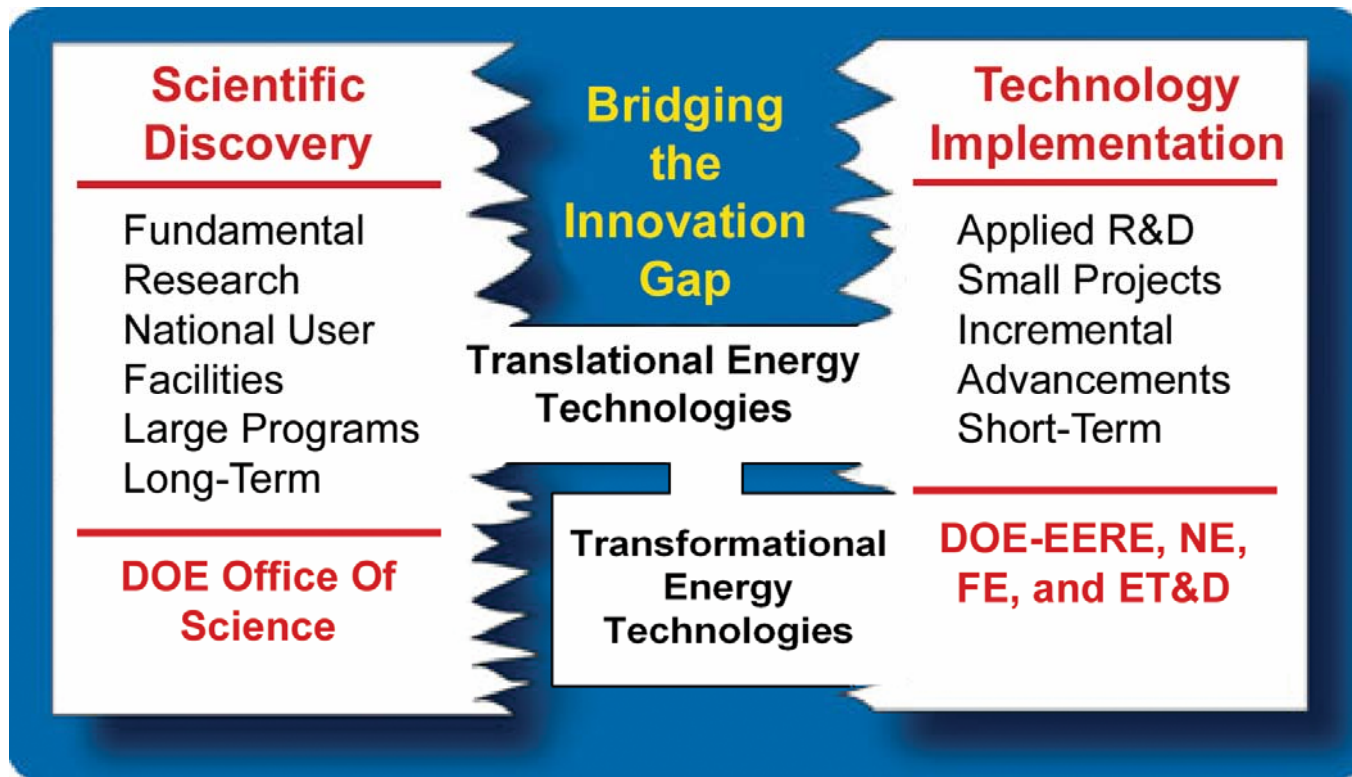
**Southeast Solar Summit
Oct. 2007**

There is growing interest in transforming America's energy R&D portfolio

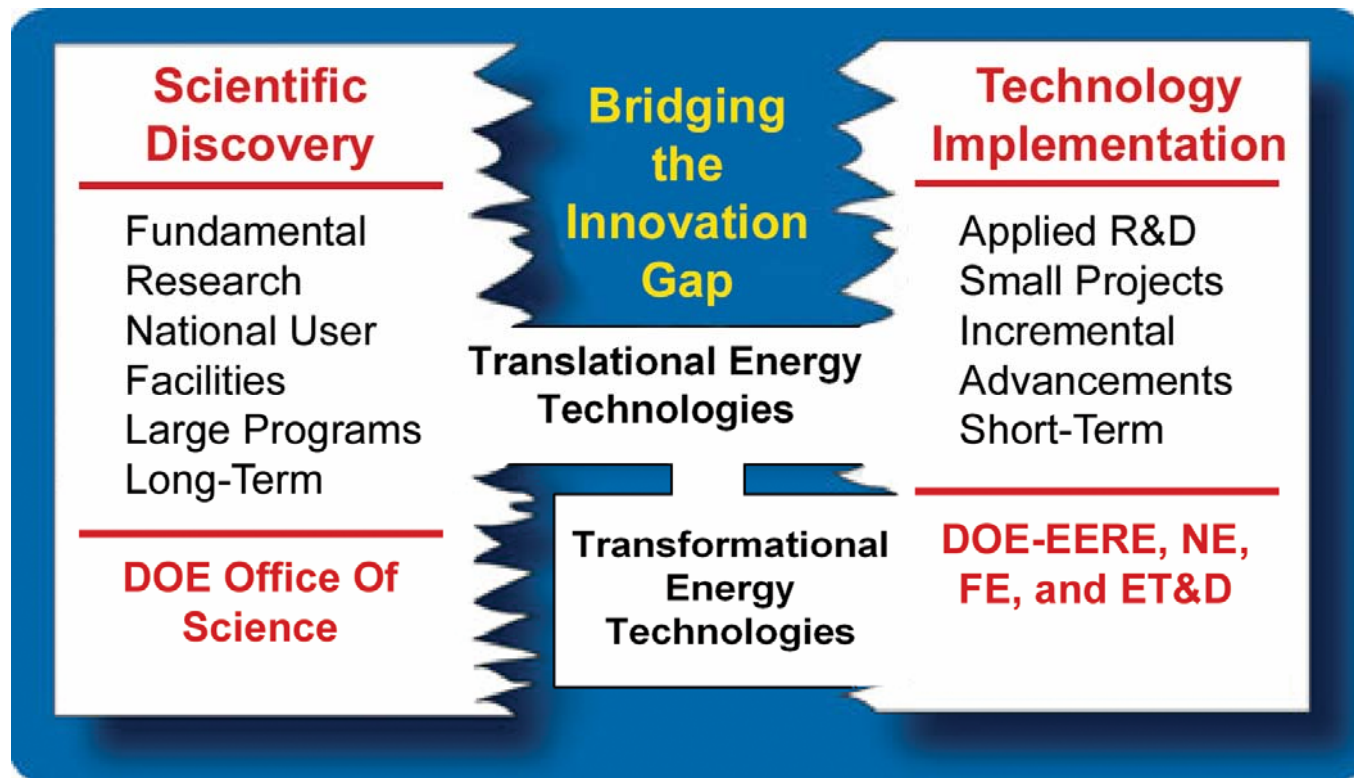
- **National Commission on Energy Policy:**
 - “shortcomings in energy innovation”
 - “recommend more risk-taking”
- **National Academies recommended creating a new agency within DOE for “out-of-the-box” transformational energy research**
- **America COMPETES Act**
- **Solar energy is area where transformational research could have big impact**



Bridging the innovation gap



Comparing Translation & Transformation



Webster's Dictionary Definitions:

Translation – to remove from one place or office to another

Transformation – the act of changing one configuration into another

Translational R&D

- Addresses known energy system needs and problems with new scientific knowledge, materials and processes. Examples:

Known Problem/Need	Translational R&D
We need electric lights that are more efficient	Solid State Lighting
We need more efficient and lower cost solar cells	Nano-structured photoelectric conversion devices
We need self-propelled vehicles that require less (or no) oil and don't pollute the air	Plug-in hybrids (Short-term) Hydrogen fuel cells (Long-term)

Translation & Transformation can occur at many different levels

Three Examples

Buildings ← Incremental
Translational
Transformational

Solar Energy ← Incremental
Translational
Transformational

Transport ← Incremental
Translational
Transformational

Lighting ← Incremental
Translational
Transformational

Energy Conversion ← Incremental
Translational
Transformational

Vehicles ← Incremental
Translational
Transformational

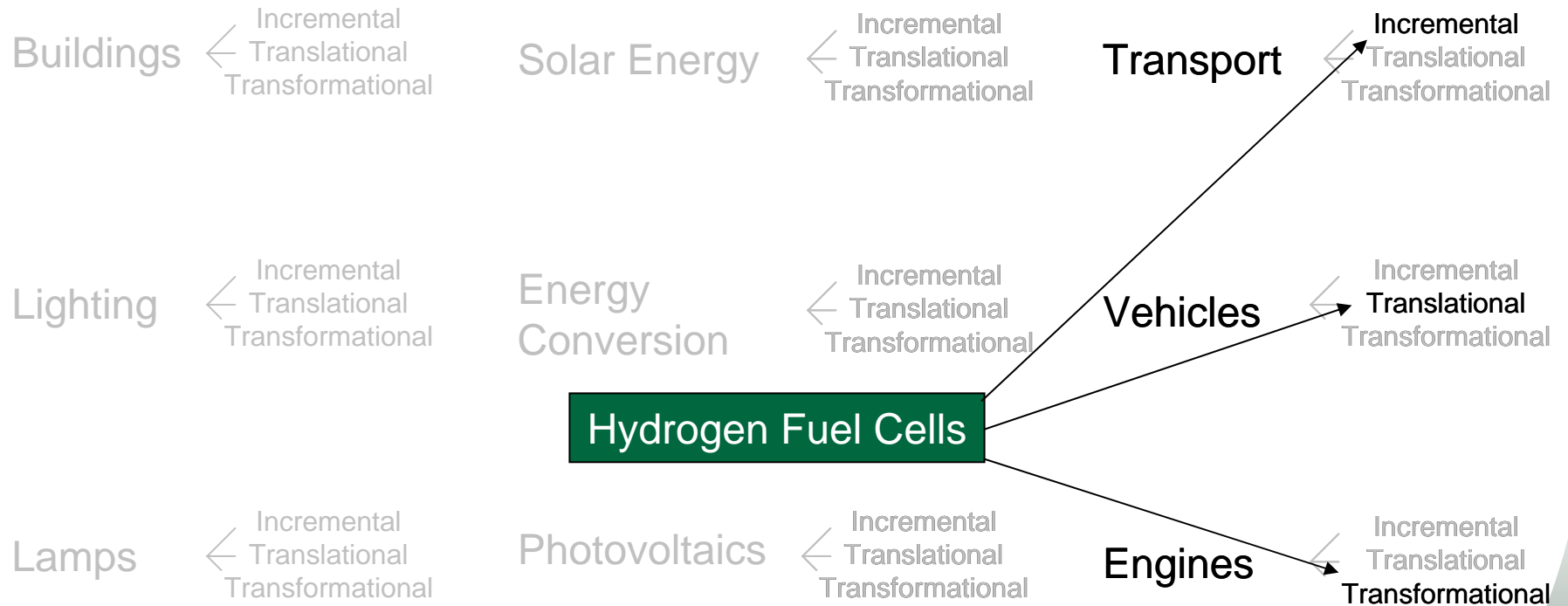
Lamps ← Incremental
Translational
Transformational

Photovoltaics ← Incremental
Translational
Transformational

Engines ← Incremental
Translational
Transformational

Translation & Transformation can occur at many different levels

Three Examples



Key Observation: Most transformational energy R&D is conducted at the component, process, or material level today rather than at the systems-level.

Three Examples

Buildings ← **Incremental**
Translational
Transformational

Solar Energy ← **Incremental**
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Transport ← **Incremental**
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↑
Solid-state devices

↑
Nanostructured materials

↑
Hydrogen fuel cells

Thinking transformationally requires looking outside the box

- **Look beyond today's known needs and requirements** by [envisioning what future energy systems might consist of](#) and pursue opportunities for bringing entirely new core capabilities to energy systems.
- **Create New Paradigms & R&D Market Space**
 - If we're already doing it, it's likely not transformational.
- **Fill the gap** between fundamental discoveries in science and existing energy technologies.
- **Accelerate development and lower risk** until ideas prove their promise or are eliminated.

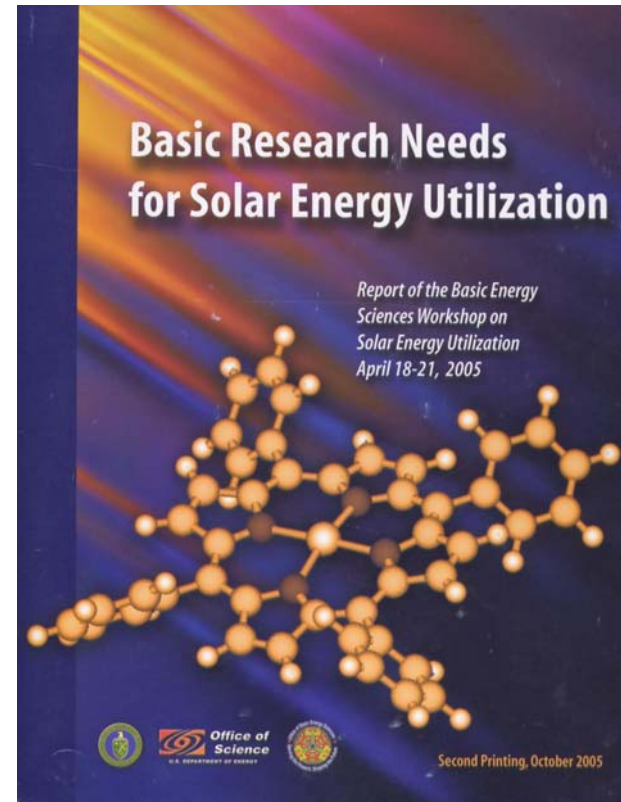
Steps in identifying transformational gaps

- Understand existing paradigms at each level
- Locate where existing R&D activities fit in the big picture
- Look outside-the-box for new high-impact areas of innovation

Today's paradigm

Steps to identify gaps:

- Understand existing systems-level paradigm
- Locate where existing R&D portfolio fits in the big picture
- Look outside-the-box for new high-impact areas of innovation



“All routes for utilizing solar energy exploit the functional steps of capture, conversion, and storage.”

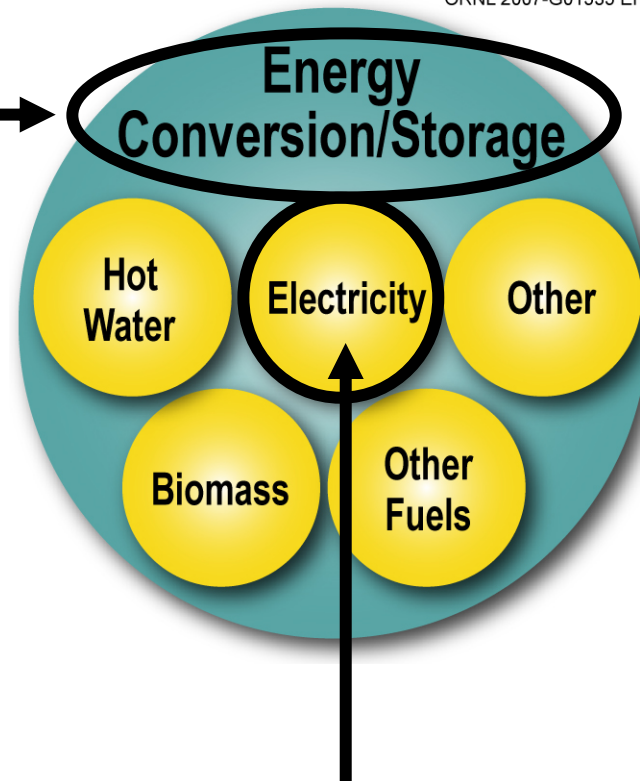
Report of the Basic Energy Sciences Workshop on Solar Energy Utilization; April 18–21, 2005; P. 3.

Today's federal solar R&D market space

ORNL 2007-G01535 EFG

Steps to identify gaps:

- Understand existing systems-level paradigm
- **Locate where existing R&D portfolio fits in the big picture**
- Look outside-the-box for new high-impact areas of innovation



“The mission of the Solar America Initiative is to help lower the cost of **solar electricity so that it is cost-competitive across all U.S. market sectors by 2015.”**

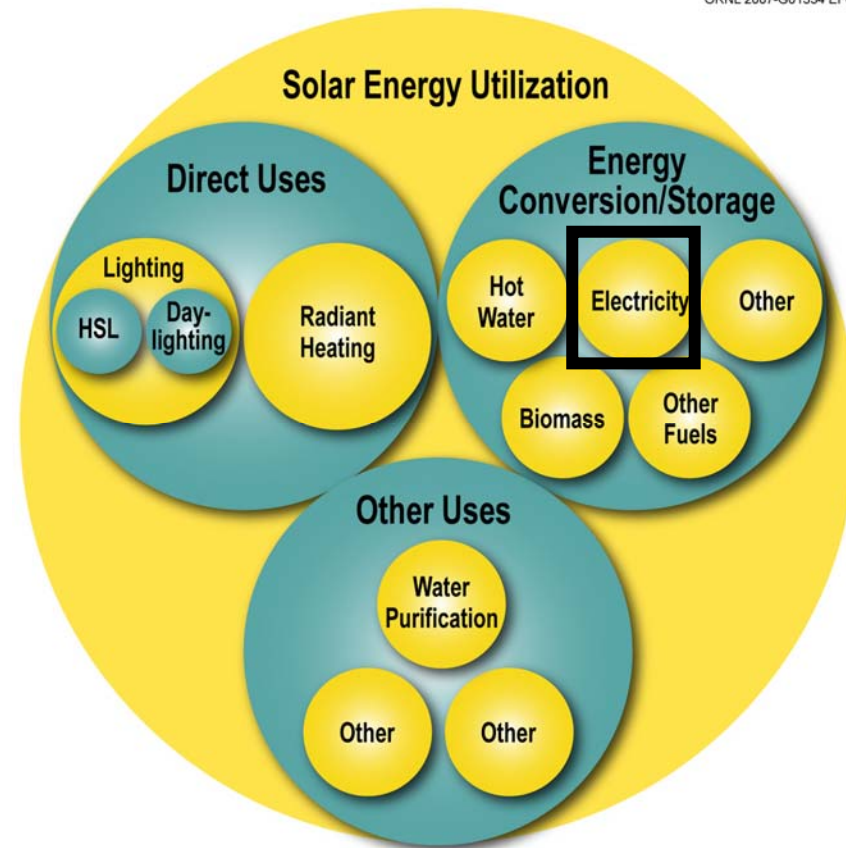
http://www1.eere.energy.gov/solar/solar_america/mission_approach.html

“Trolling” for transformational ideas

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Steps to identify gaps:

- Understand existing systems-level paradigm
- Locate where existing R&D portfolio fits in the big picture
- **Look outside-the-box for new high-impact areas of innovation**

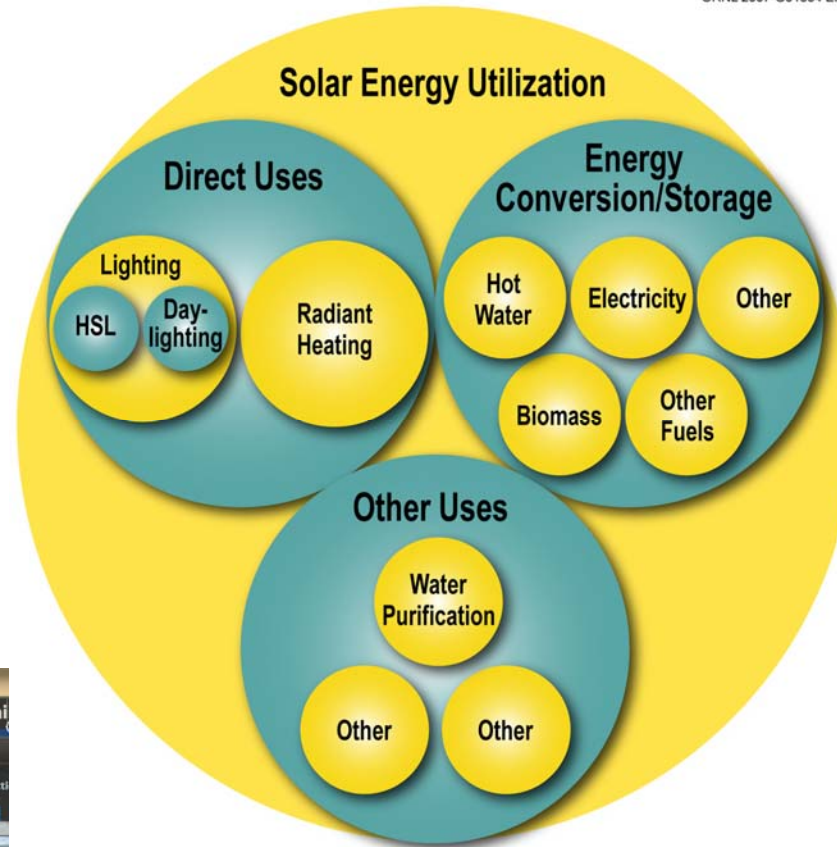


➔ **Innovation that falls outside of today’s paradigm & R&D market space.**

➔ **Innovation in other steps of the product delivery process beyond “capture, conversion, and storage.”**

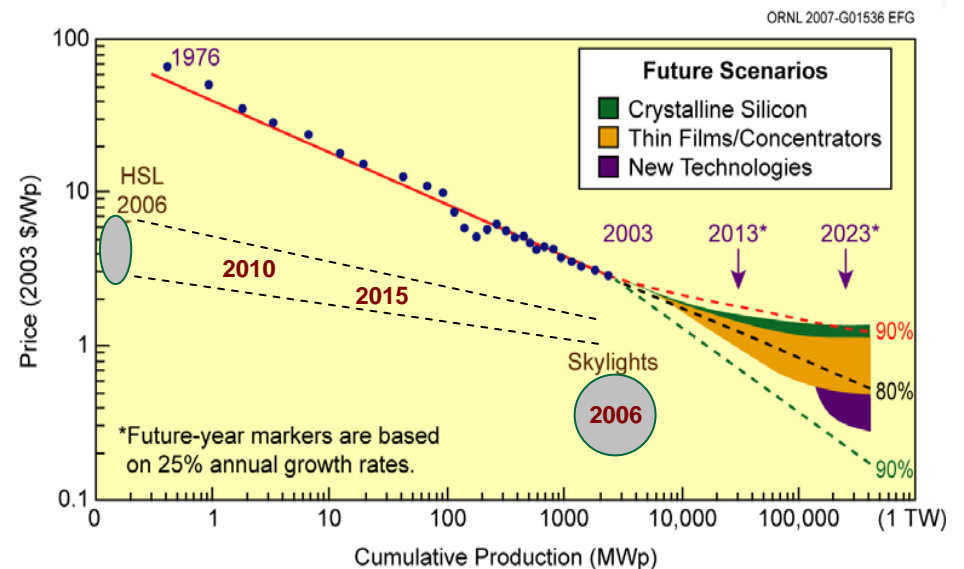
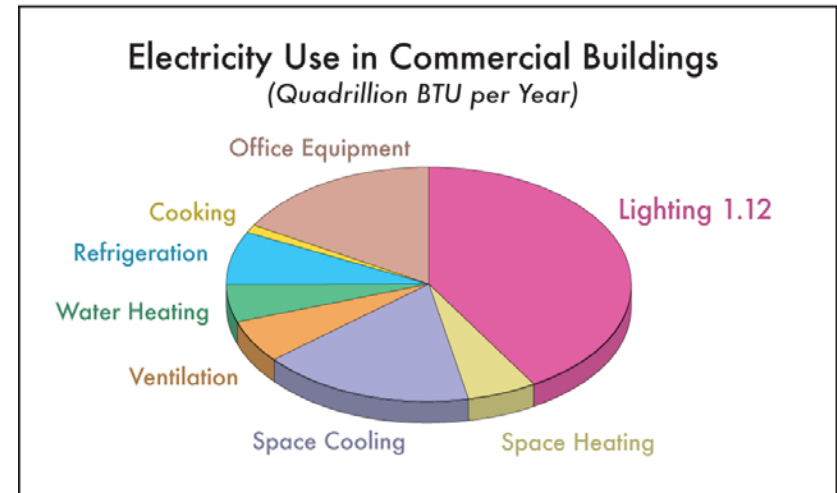
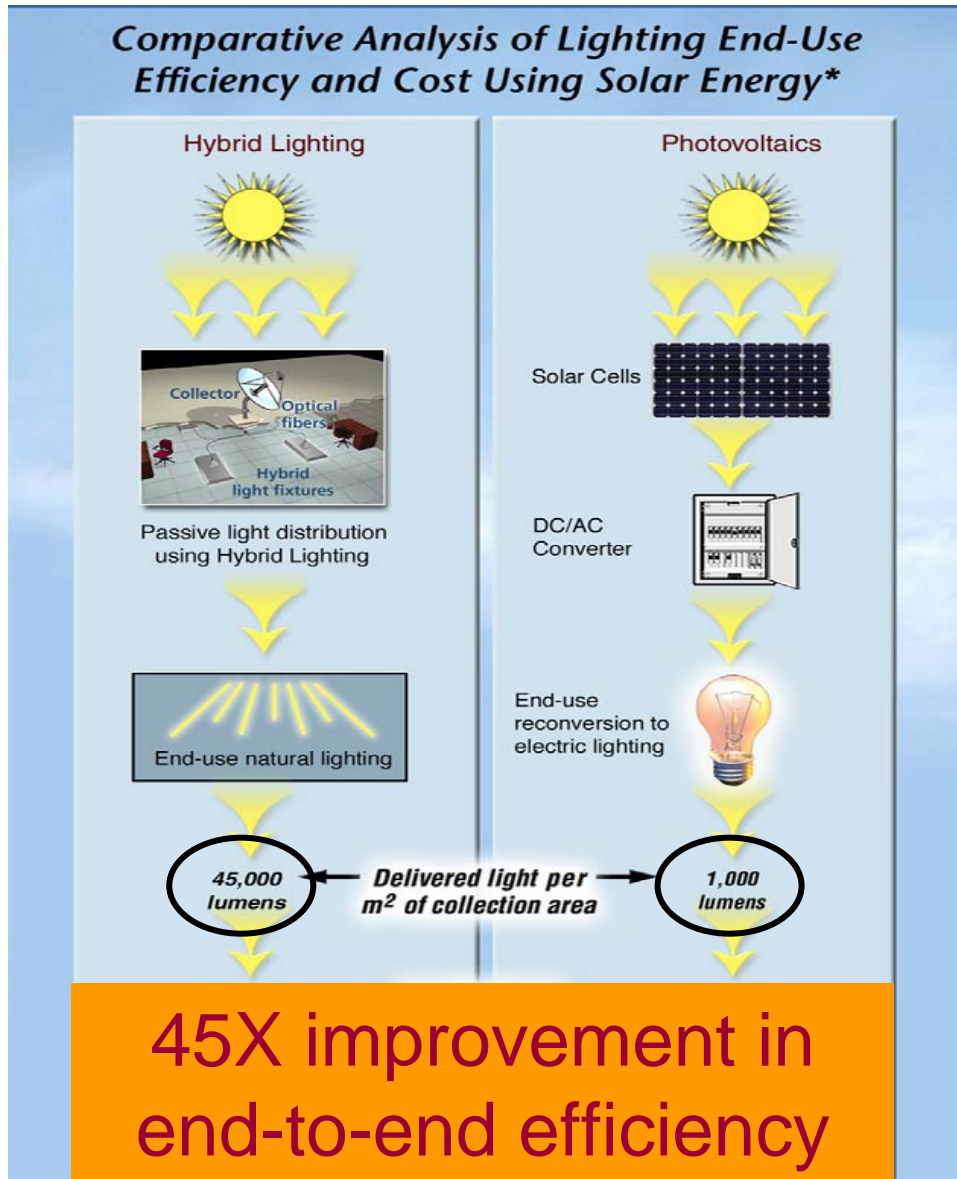
Not all routes for using solar energy require the steps of conversion and storage

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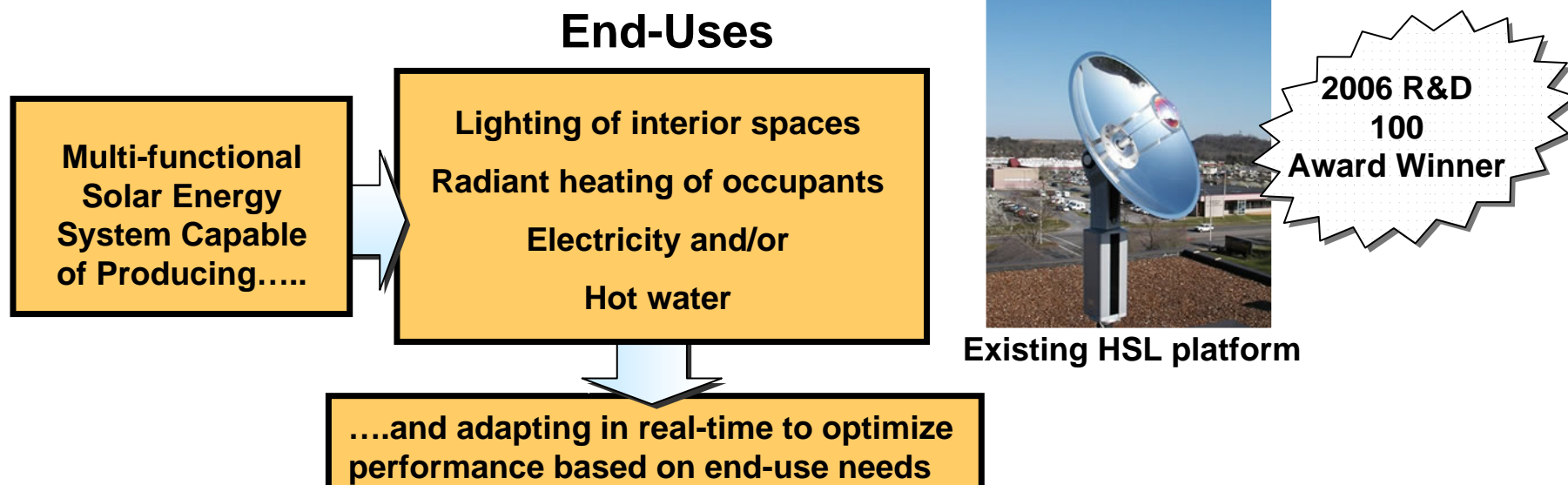
Bypassing conversion leads to radical improvements in solar energy utilization

ORNL 2004-02224/mhr



Example Transformational R&D Activity

Multi-Functional Solar Energy Systems



Challenges

- Double the coverage area of HSL technology through transformational waveguide development
- Double the end-to-end solar energy utilization efficiency per unit area of sunlight collected

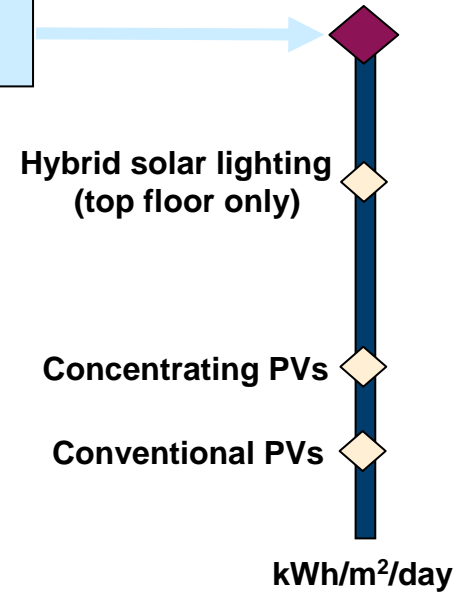
Sample Research Focus Areas:

- Smart, adaptive optical- & spectral- switching techniques and control methodologies – “optical switch yard”
- Low cost, flexible IR-transmitting waveguides
- Air-clad, liquid-core fibers using superhydrophobics

Possible Payoff

Ultra-efficient “on demand” solar energy systems servicing entire (multi-level) structures

Multifunctional solar w/ extended range HSL



“Out-of-the-box” ideas can come from other steps in product delivery

Steps:

- Fabrication
- Manufacturing
- Assembly
- Integration
- Installation
- Operation
- Maintenance
- Marketing / Sales
- Financing
- Others

Functional steps:

1. Capture
- 2a. Distribute & use
- 2b. Convert & store

A few examples where transformation may be possible

Other steps:

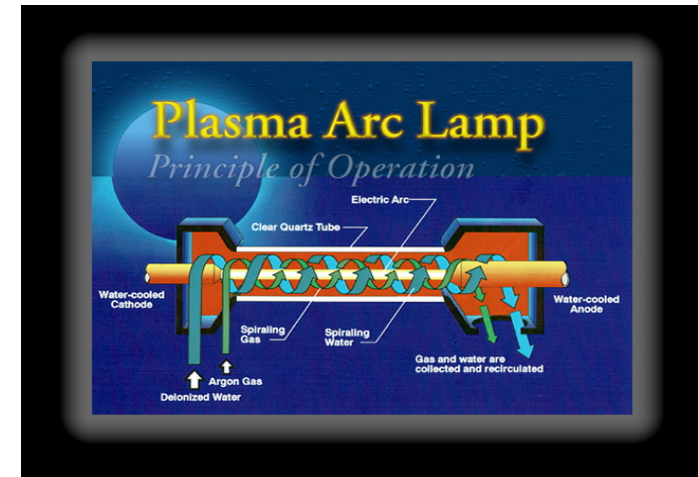
- Fabrication
- **Manufacturing** →
- Assembly
- Integration
- Installation
- Operation
- **Maintenance** →
- Marketing / Sales
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Micro-flash thermal processing of PV materials

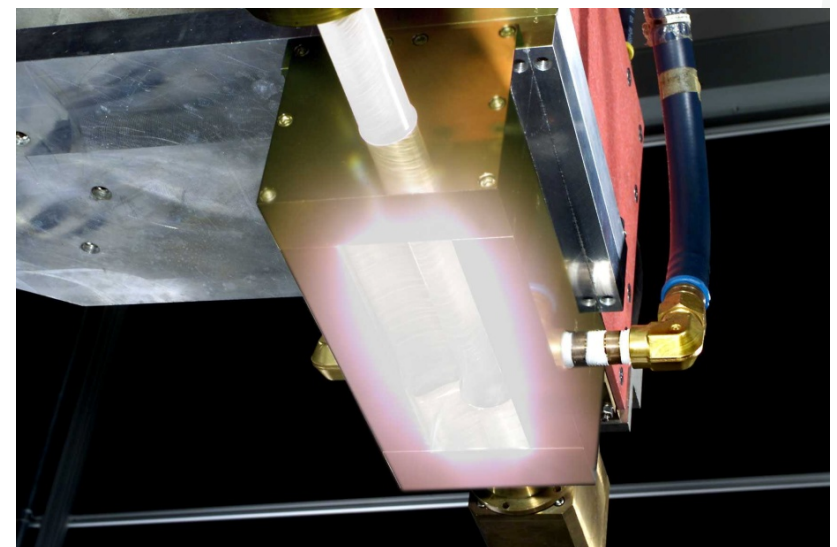
Self-cleaning, optically-transparent polymers

Micro-flash thermal processing of PV materials

- Can process thin films on temperature sensitive substrates
 - Unprecedented heating rates (up to 6000°C/sec)
 - Large power densities (approaching 20KW/cm²)
 - Short processing times (as low as 1 millisecond)
- Can process large areas / improve throughput
- Scalable to production



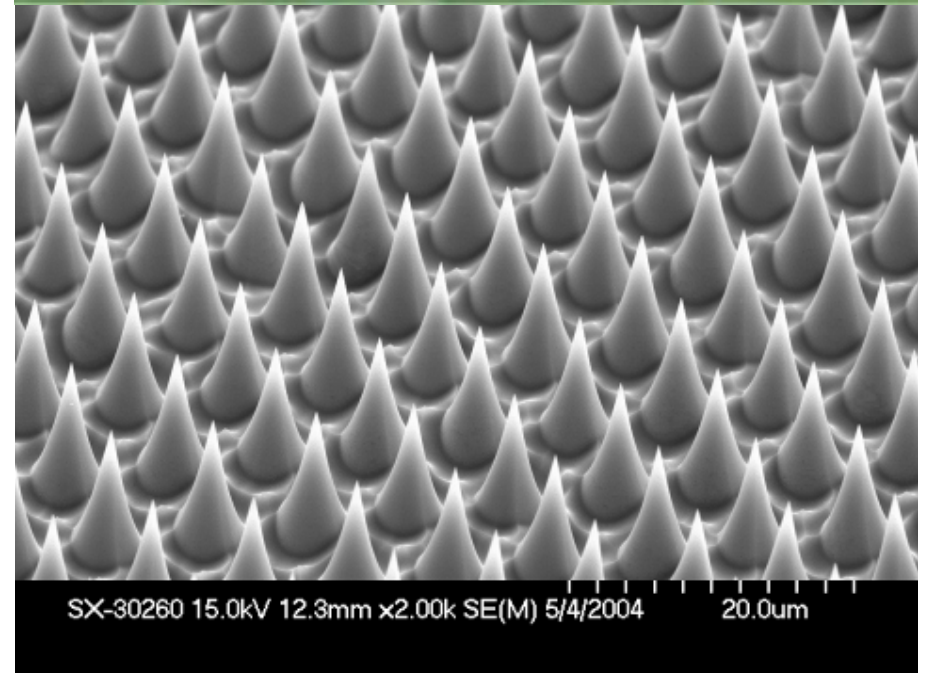
Possible Payoff: Experimental data on thin film PV materials suggest a doubling of cell efficiency is possible.



Self-cleaning, optically-transparent materials

- Use proprietary techniques to make nanocone arrays
- Coat with hydrophobic self-assembled monolayer to make material super-hydrophobic
- Create nanoscale tips.
- Water sits on cone tips.

Possible Payoff:
Significant Improvement in overall performance and reduction/elimination of labor required for cleaning.



Risks to insiders grow as ideas move from materials to systems-level R&D

Levels Where Change Can Occur	Energy-Related Examples			Relative Risk of Change (Disruption) to Insiders
Systems	Land Transportation	Buildings	Solar Energy Utilization	<p style="text-align: center;">High</p> <p style="text-align: center;">↑</p> <p style="text-align: center;">Societal, Socio-Technical, Political, Organizational, Institutional, Personal, Programmatic Risk</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Low</p>
Sub-Systems	Self-Propelled, Human-Driven Vehicles	Electric Lighting Systems	Solar Electric Conversion	
Components	Engine/ Propulsion System	Electric Lamps	Photovoltaics	
Processes & Materials	Hydrogen Fuel Cells	Light - Emitting - Diodes	Photo-Electric Energy Conversion	
Initiatives	FreedomCar Initiative	Solid-State Lighting Initiative	Solar America Initiative	

Existing initiatives: Very high technical risk but very low institutional risk

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Looking outside the box is not easy, but climbing out is even harder

Typical indicators of transformational ideas:

- **Originate with outsiders** having little or no vested interest in existing system or R&D pathway
- **Resisted by insiders** having established personal and or institutional interest in existing system or R&D pathway
- **Cross organizational boundaries;** usually don't fit neatly in existing R&D programs
- **Often very old (and dismissed) or completely new ideas** made possible by recent S&T advancements in other fields

Originated with outsiders

Resisted by insiders

Crossed organizational boundaries

Old (and earlier dismissed) idea



Thank you.

Questions?