

# On Innovation Decision Science

EEPRN Symposium – Ottawa, Canada

PLENARY III: Carbon Pricing, Climate Policy Mixes & Clean Innovation Outcomes

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# Today's Talk



- Some background
- Thoughts on low-hanging fruit
- Thoughts on high-hanging fruit
- Underleveraged theories

# Some Background

“Clean Energy Innovation Decision  
Science” Research

# What do we mean by Clean Energy Innovation Decision Science Research?

*“To accelerate ... clean energy technologies, RDD&D should address ... design, adoption, and use... [at] the intersection of technology, behavior, and **decision science**”*

*2015 DOE Quadrennial Technology Review*

The study of decision-making as it relates to the connection between innovative activities and governance at different levels. It involves creating new knowledge about:

1. How technologies are **invented**, incorporated into **commercial designs**, and **adopted** and **used** by consumers and organizations
2. How new innovations interact with existing **governance** structures

# Some Technologies and Policies Studied

Type of Regulation	SO2	NOx	Wind	PV	STE	SWH	Res Apps	Com Prods	Cars
Performance-based standard	✓	✓							✓
Cap-and-trade program	✓	✓							
Rate guarantees			✓	✓	✓	✓			
Renewable portfolio standards			✓	✓	✓				
Minimum efficiency performance standards							✓		
Procurement regulation								✓	
Building regulation				✓					
CA ZEV mandate									✓

# Thoughts on low-hanging fruit: Good news: It adds up



# Success stories of achieving CTP goals at low cost:

Evidence of technological change in the marketplace



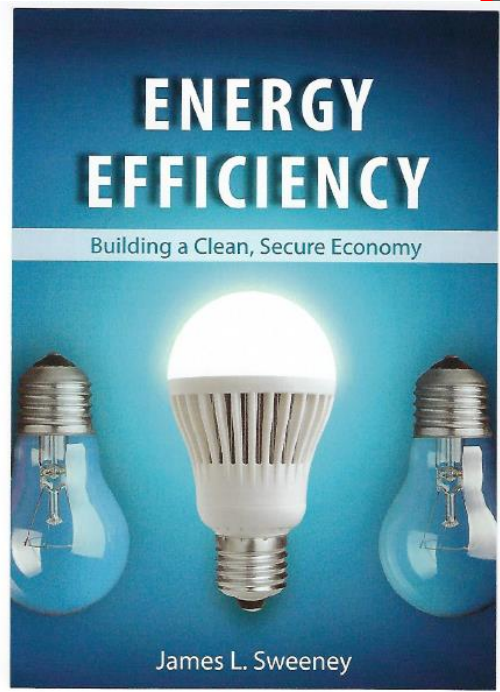
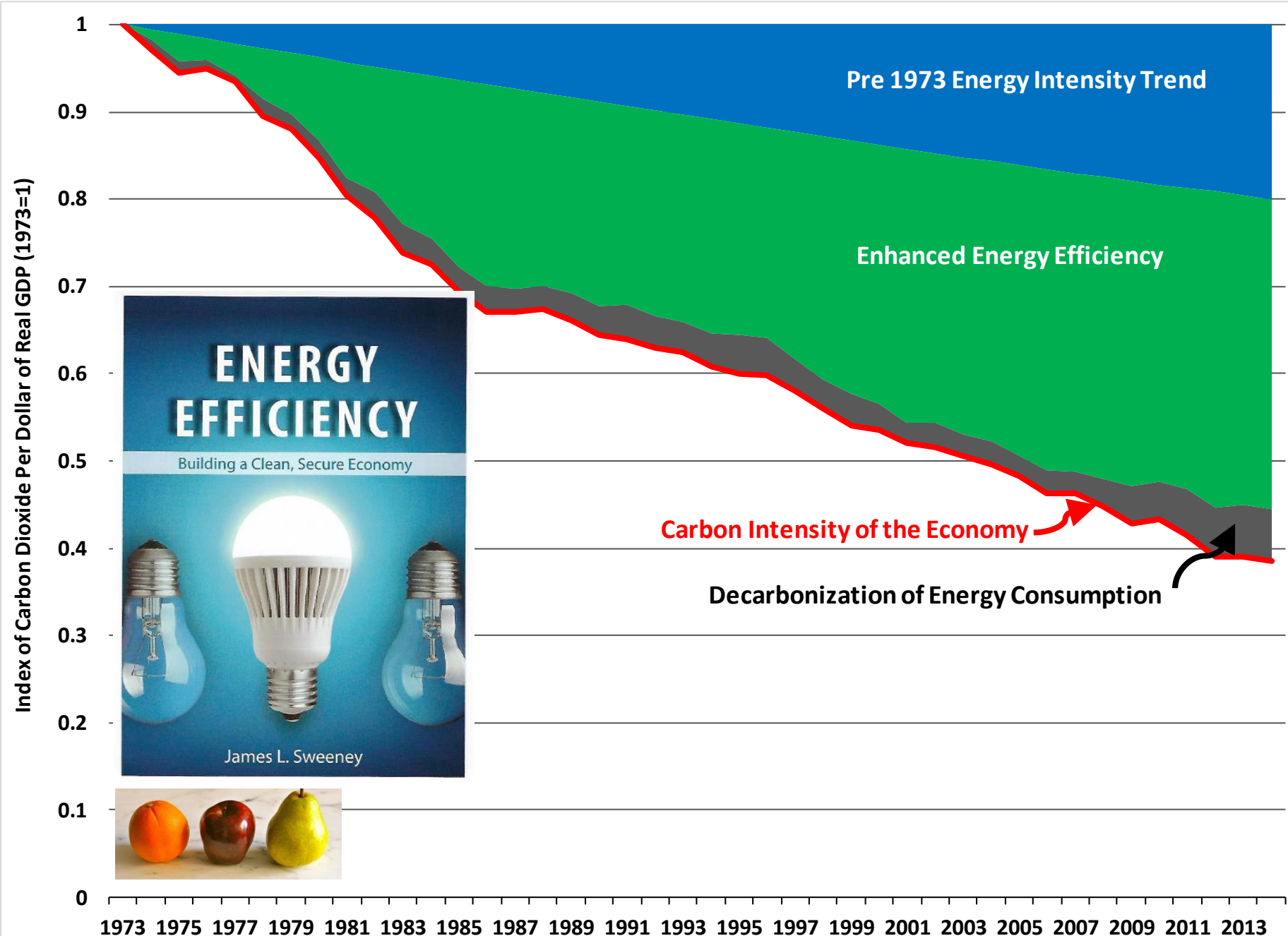
## SO<sub>2</sub>

1. Switched to lower sulfur coals
2. Balanced with post-combustion control
  - Either increased utilization of **existing** systems or
  - A smaller-than-expected number of new installations

## NO<sub>x</sub>

1. Utilized **existing** zero-emitting nuclear power plants and lower NO<sub>x</sub> natural gas-fired power plants more extensively
2. Purchased off-peak power from **outside the region**
3. Benefited from better-than-expected performance from **existing** control technologies

# Success stories regarding Energy Efficiency





# Thoughts on high-hanging fruit

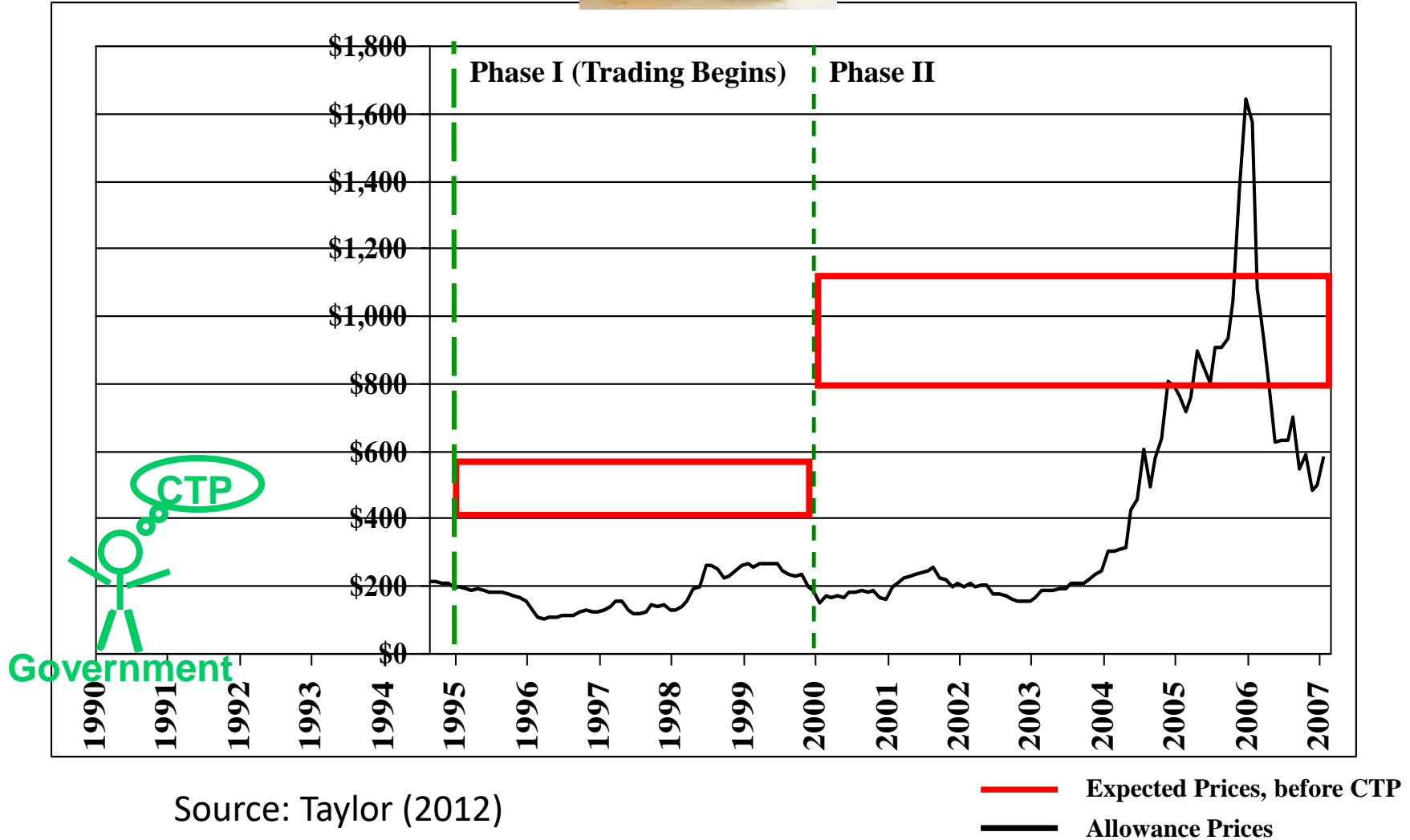


# High-Hanging Fruit

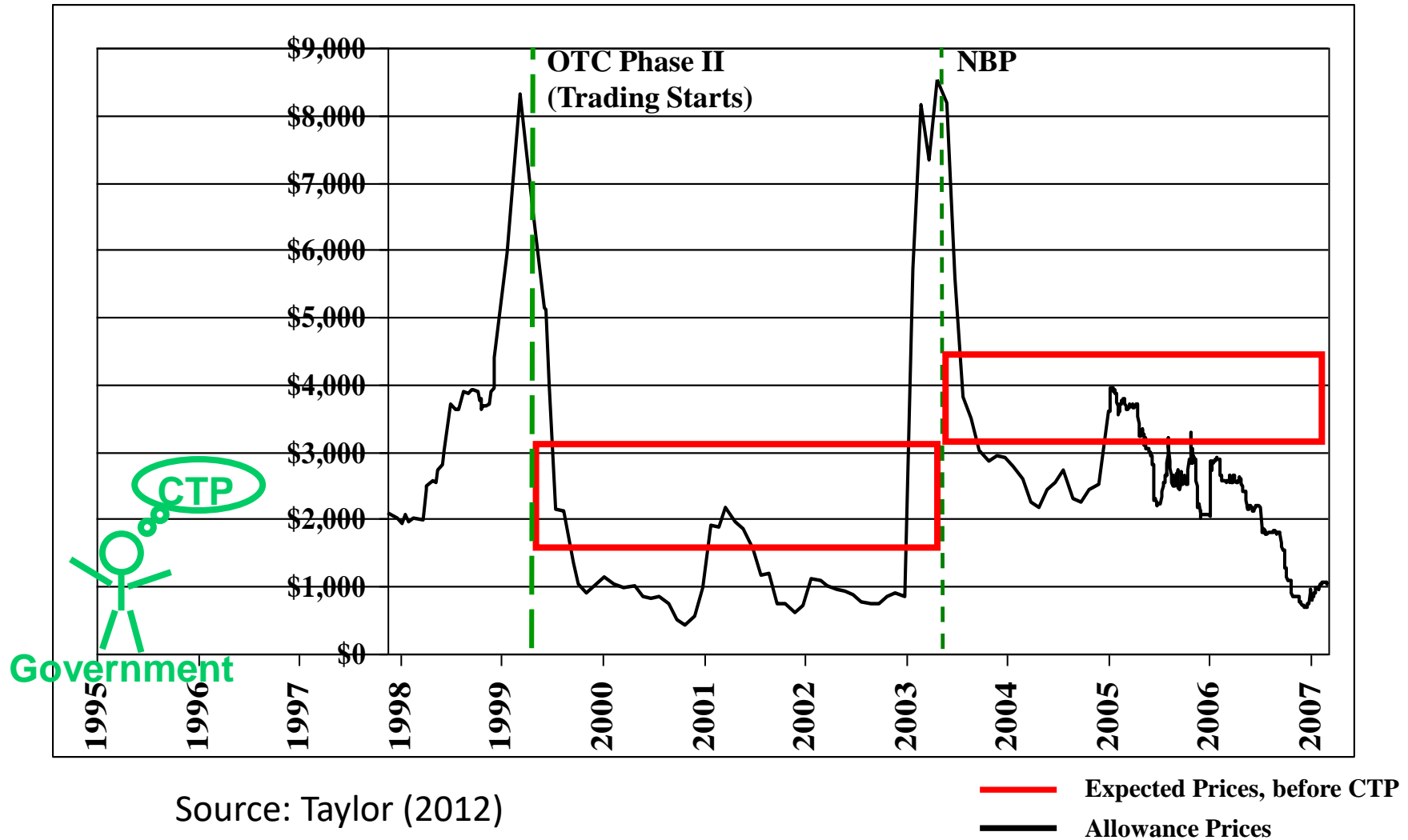


- Currently expensive or not commercially available options
  - Think SO<sub>2</sub> scrubbers for power plants in 1970
  - Think electric cars in 1990
  - Think **INSERT YOUR IDEA HERE** today??
- Typically, policy problems are about **expectations**
- Some policy options:
  - “Push” the technology (e.g., R&D)
  - “Pull” the technology into the marketplace (e.g., regulation)
  - Other (e.g., improving the interface between technology suppliers and users – see Taylor 2008)

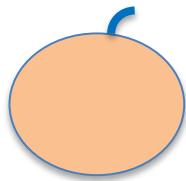
# Expected vs. Actual: Title IV Prices (\$/Ton SO<sub>2</sub>)



# Expected vs. Actual: OTC-NBP Prices (\$/Ton NO<sub>x</sub>)



# Commercial-oriented inventive activity = knowledge for potential high-hanging fruit



(a) Post-combustion SO<sub>2</sub> control

(b) Pre-combustion SO<sub>2</sub> control

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(c) Post-combustion NO<sub>x</sub> control

(d) NO<sub>x</sub> combustion modification

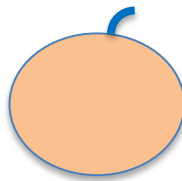


Traditional environmental regulation

Trading preparation (after passage, before actual prices)

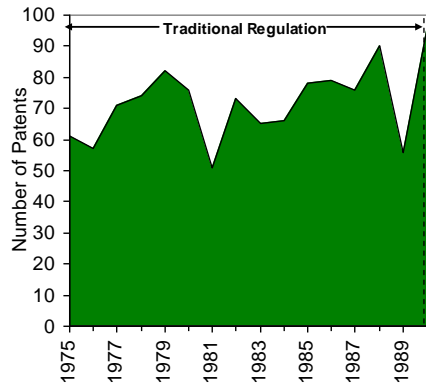
Trading

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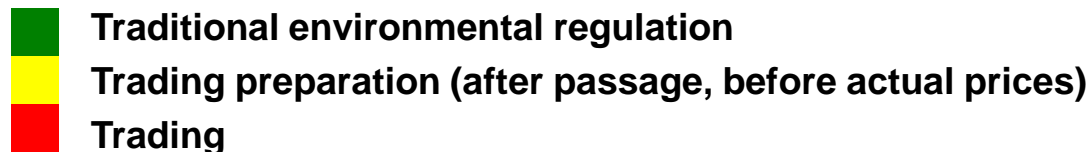
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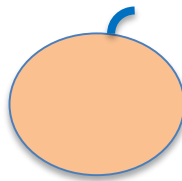


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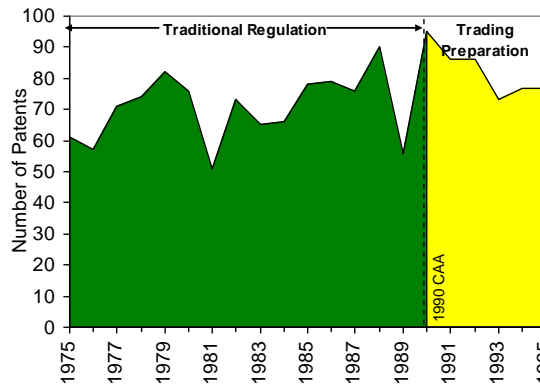


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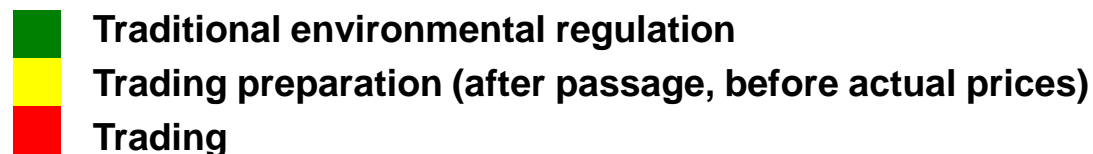
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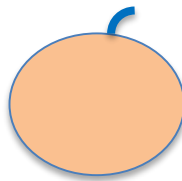


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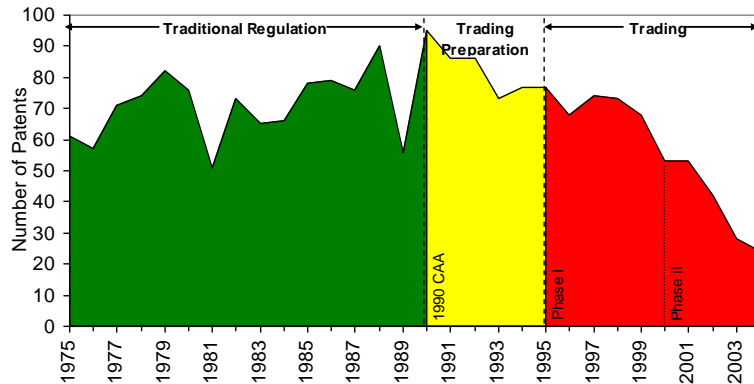


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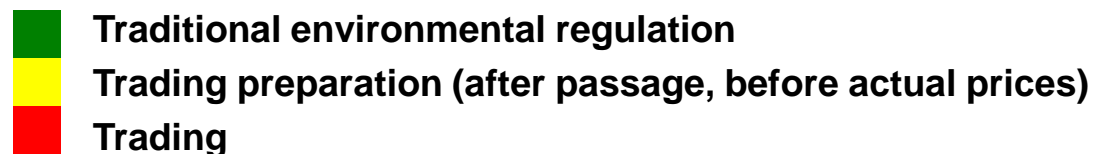
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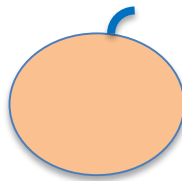
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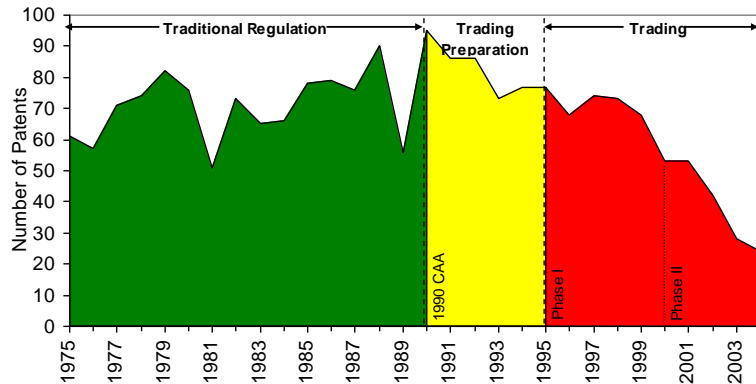




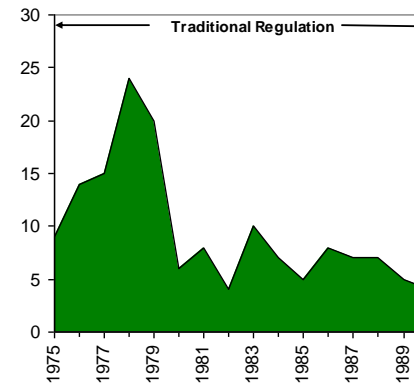
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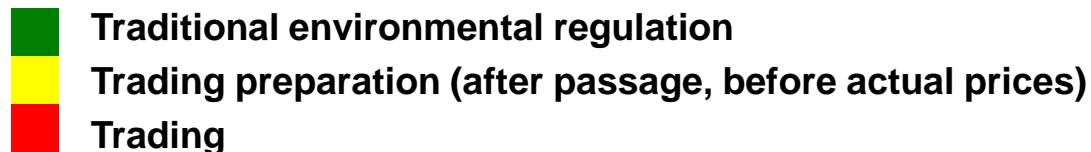


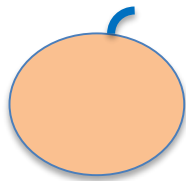
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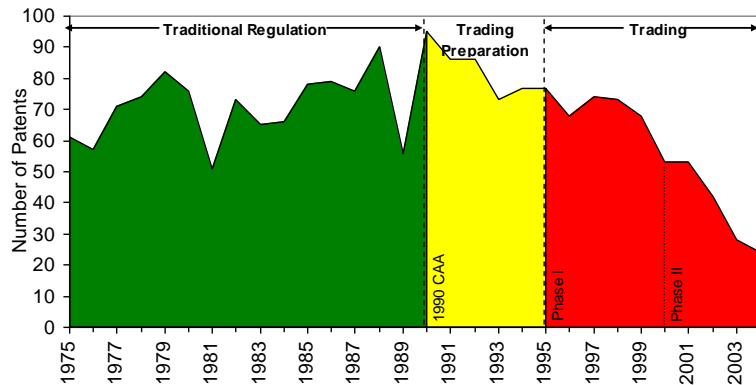
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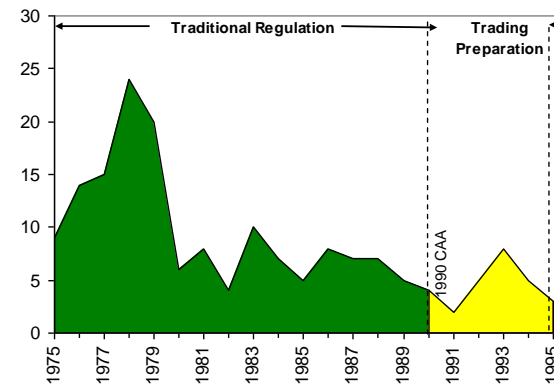


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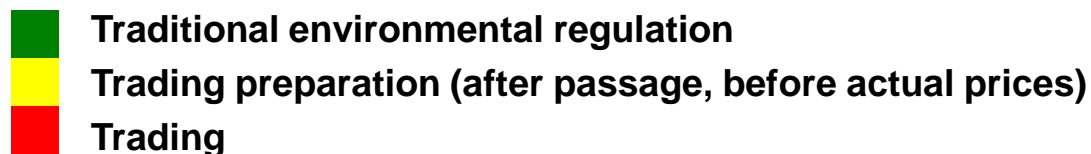
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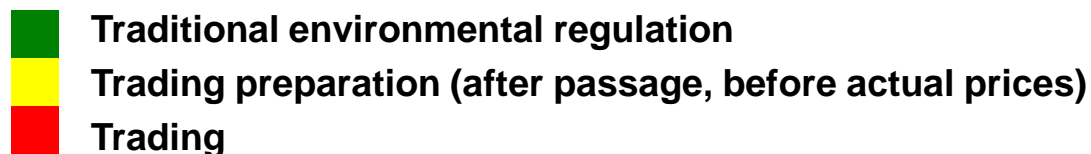
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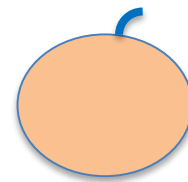
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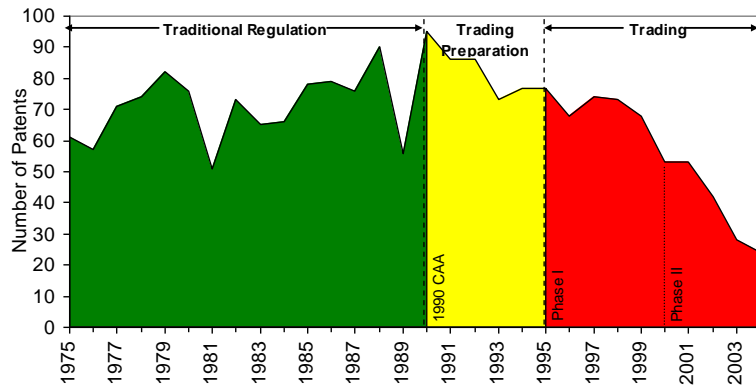
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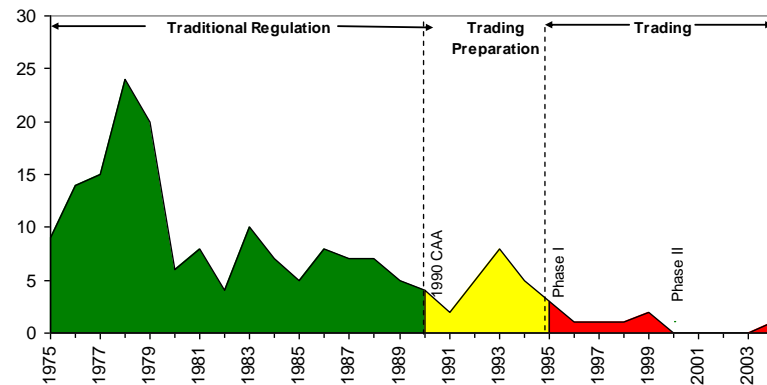
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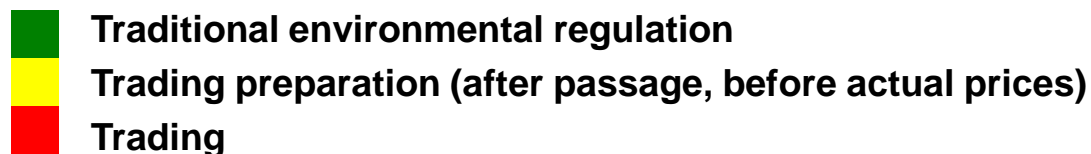
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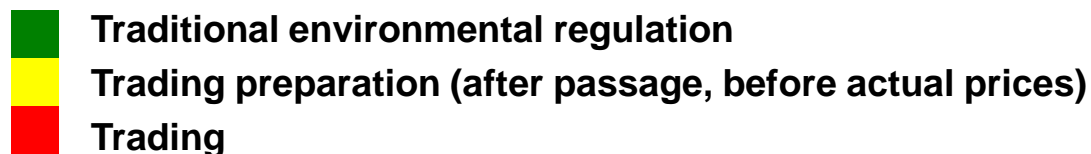
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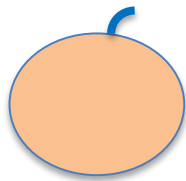
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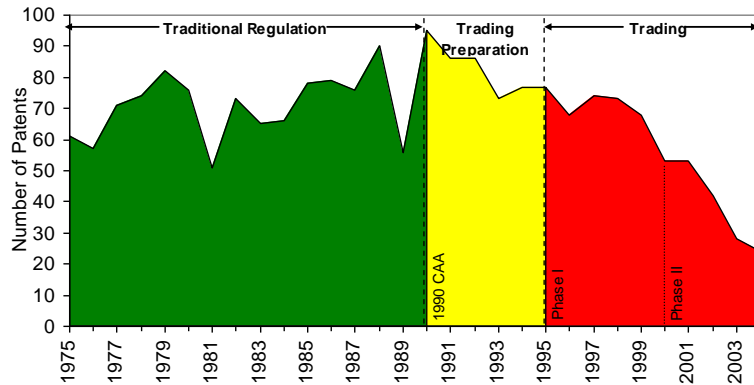
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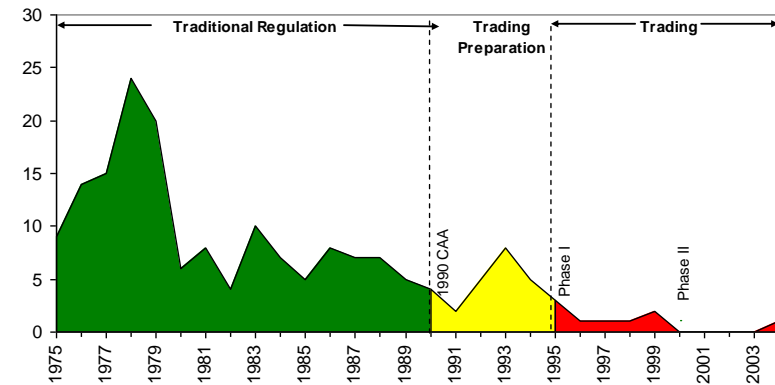
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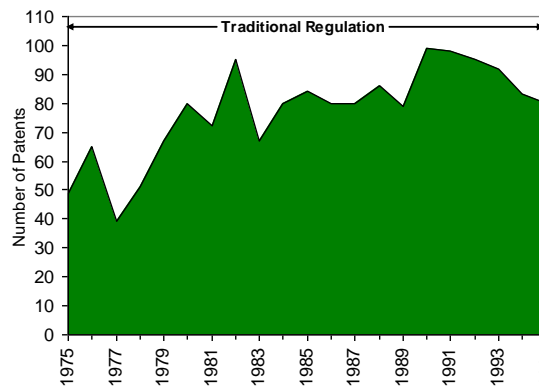
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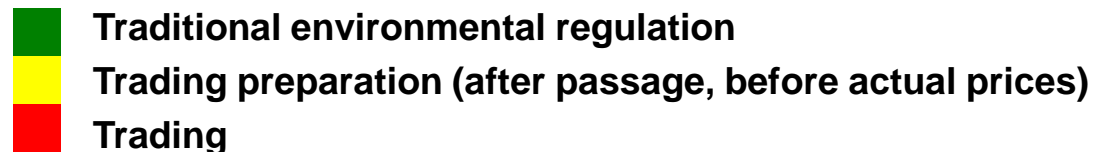
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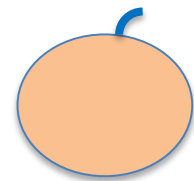
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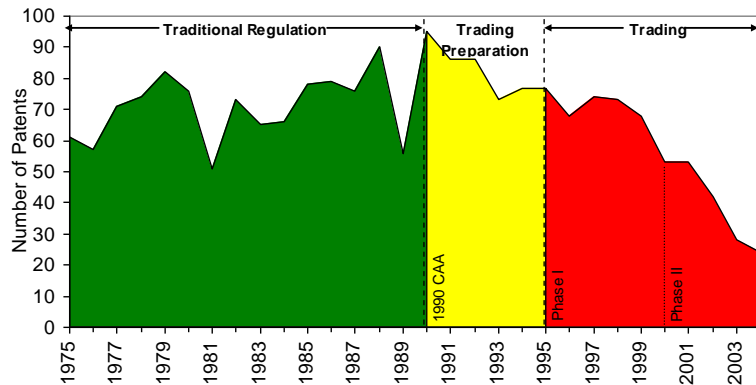
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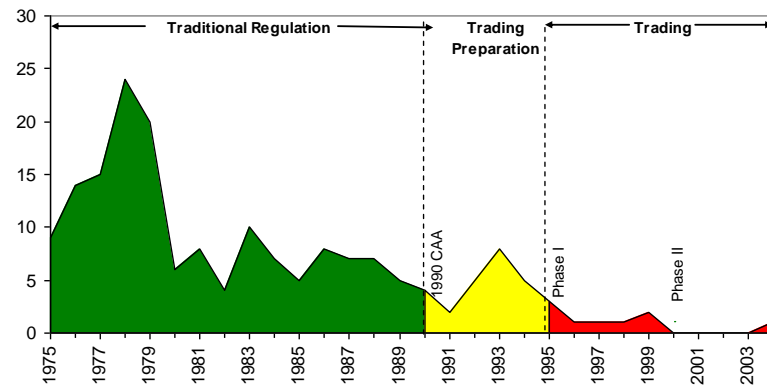
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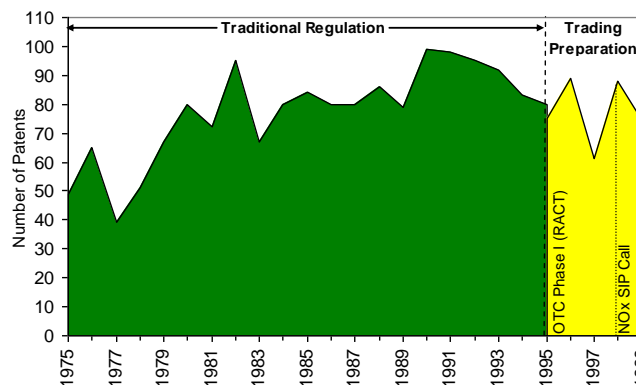
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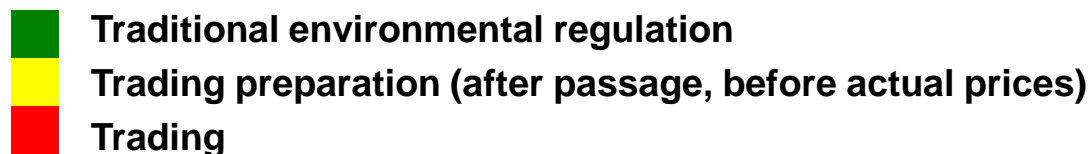
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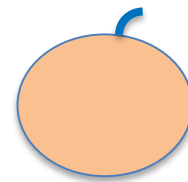
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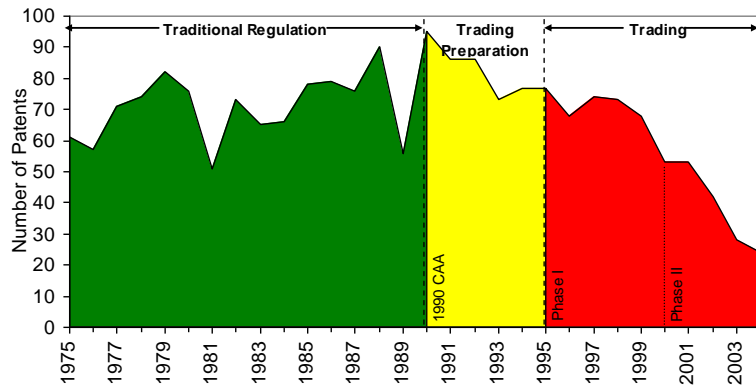
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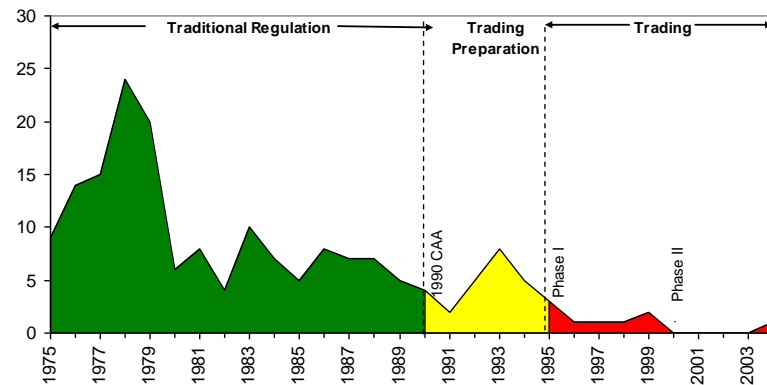
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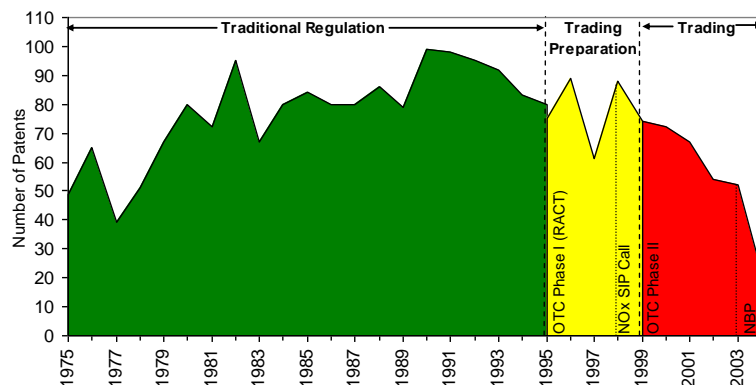
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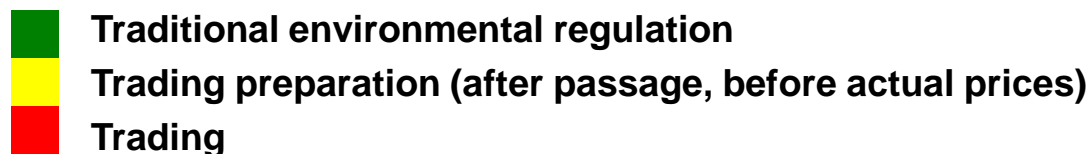
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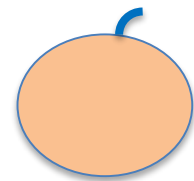
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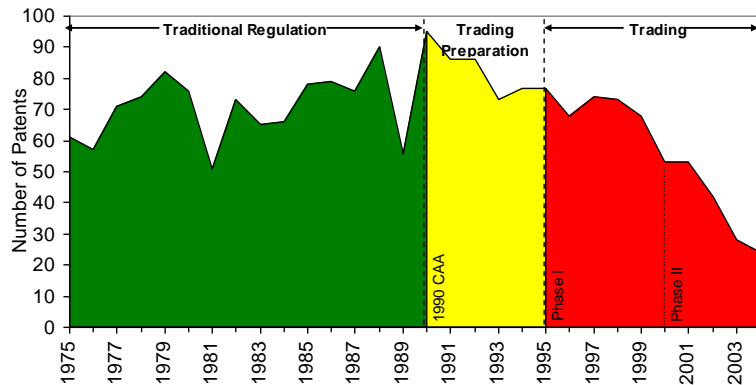
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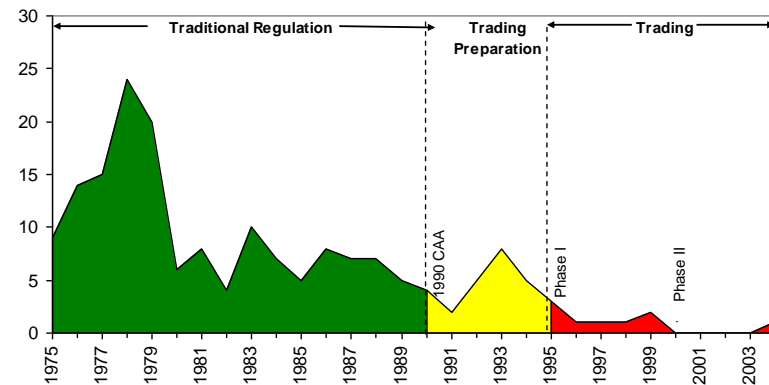
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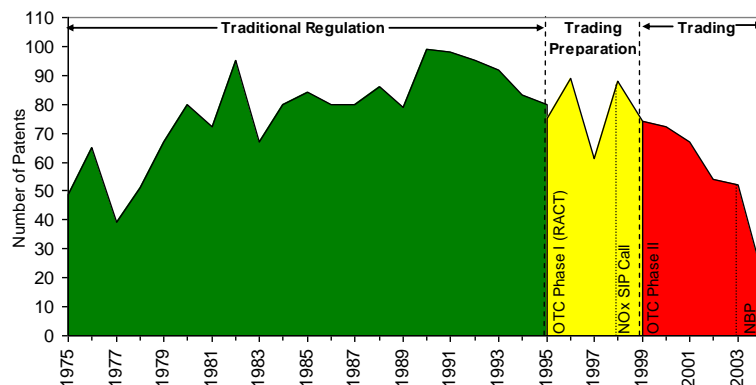
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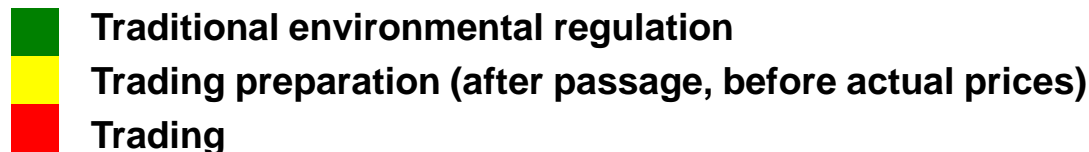
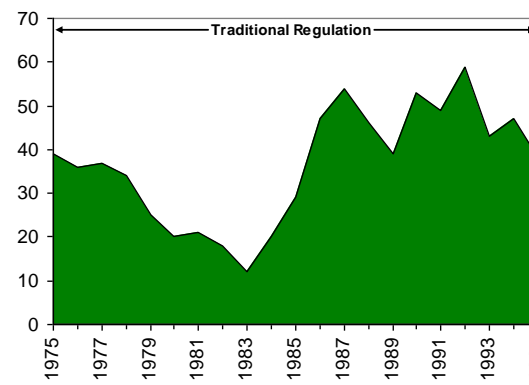
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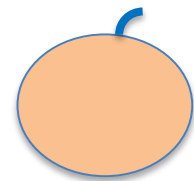
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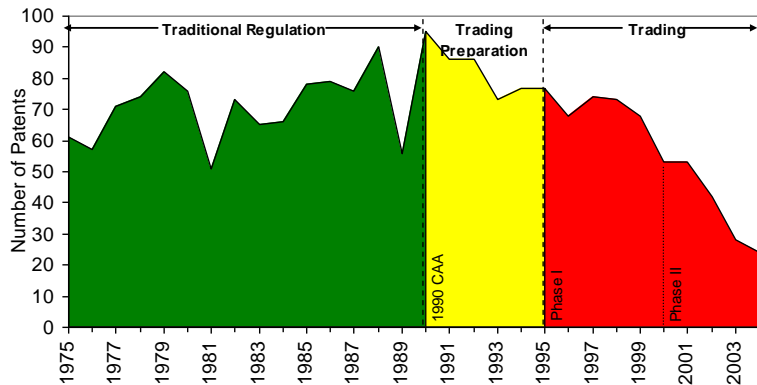
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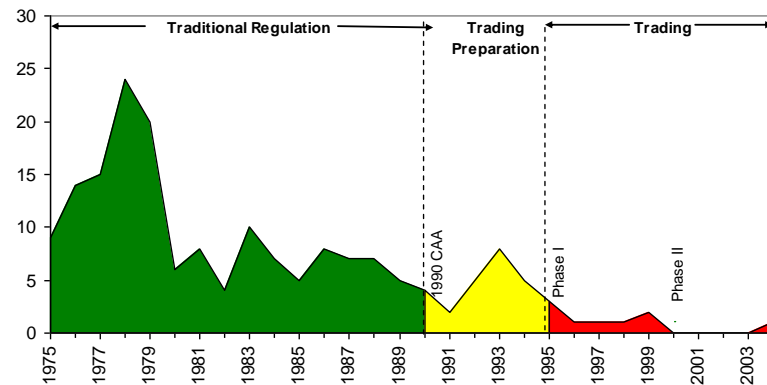
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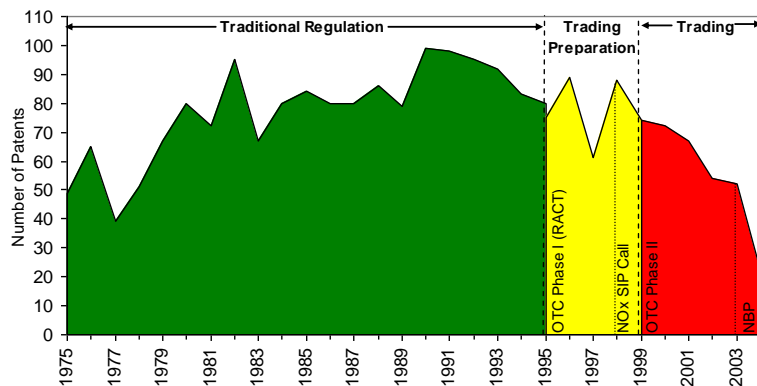
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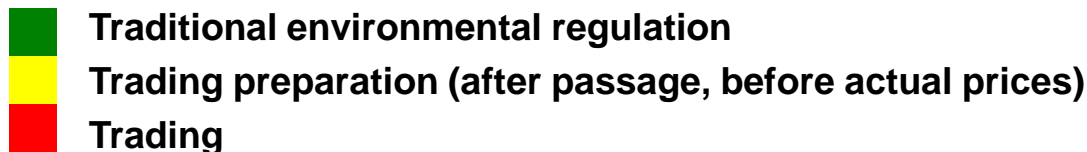
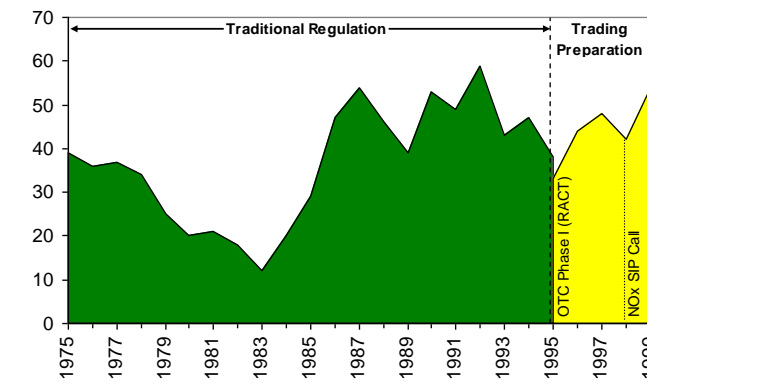
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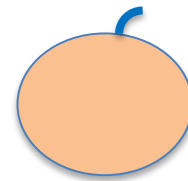


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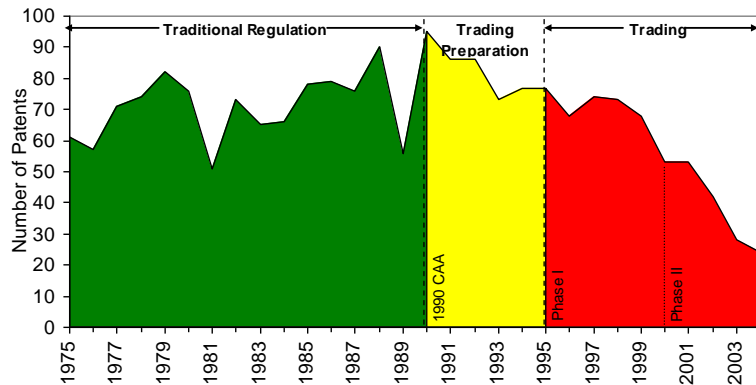




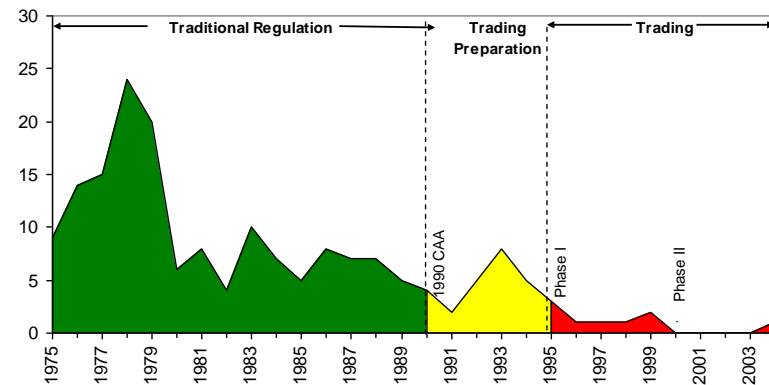
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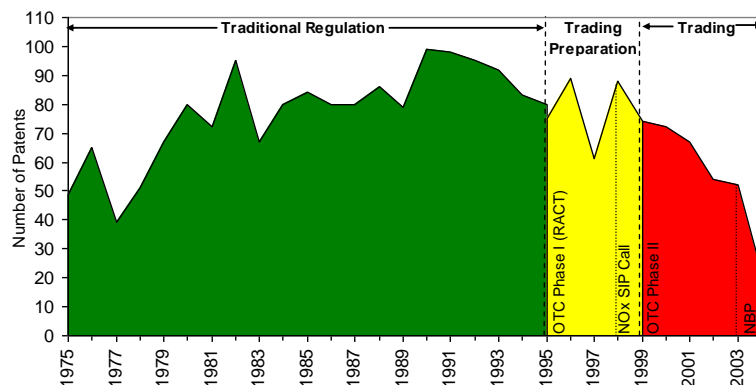
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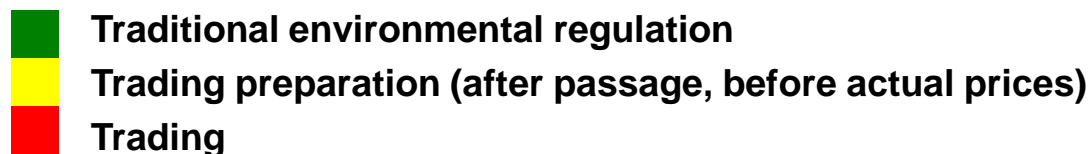
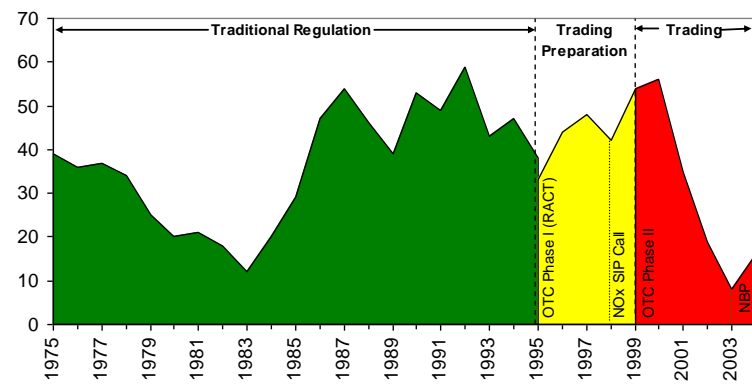
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# Underleveraged Theories

Economic Theory

Design Theory

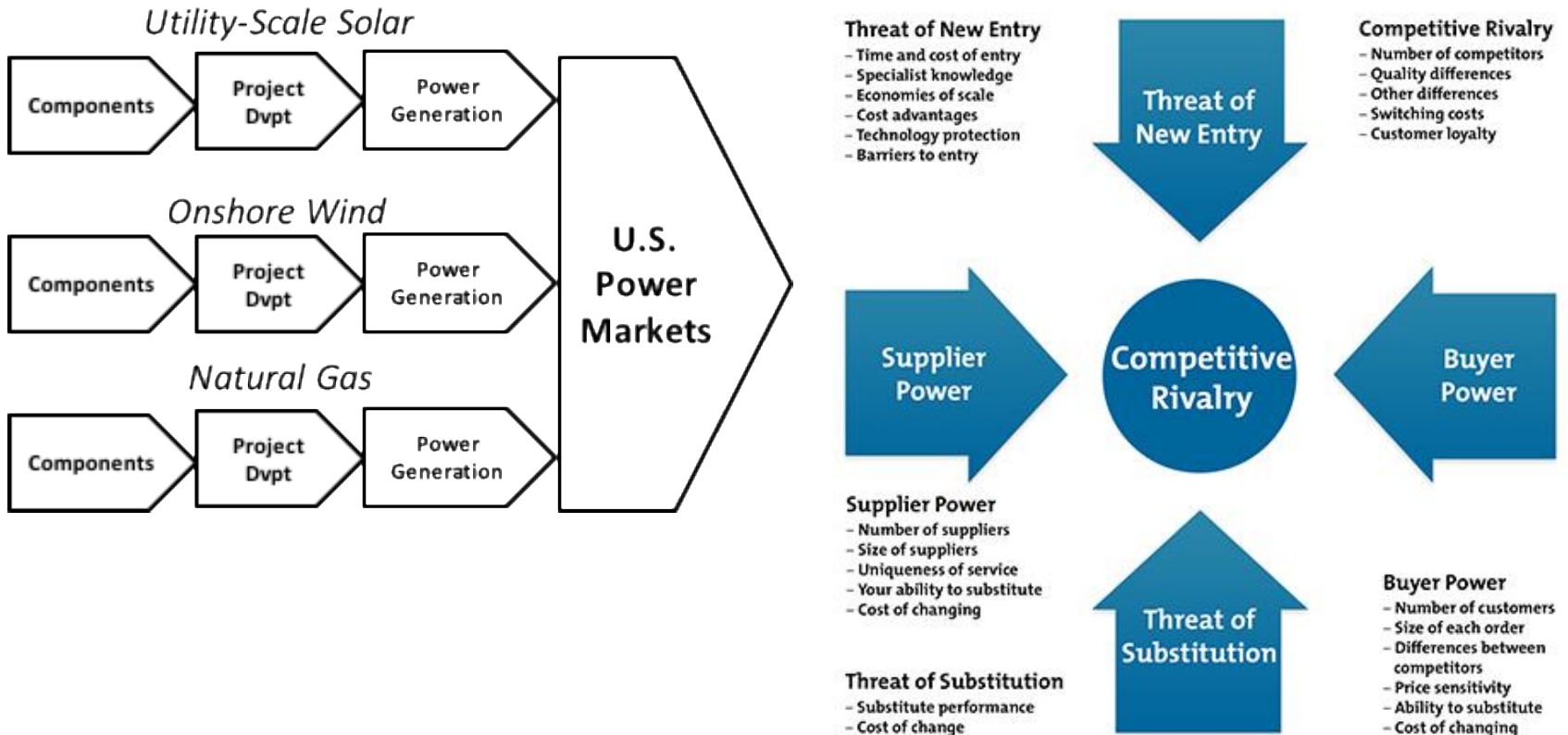
Consumer Theory

# Economic Theory:

## Three Market Failures interact across Clean Energy Value Chains

- Negative externality
  - Pollution
- Positive externality
  - Knowledge creation by firms, the returns of which are not fully captured, leading to sub-optimal investment
- Imperfect competition
  - Imperfect competition changes the way to model technology economics and innovation effects
  - Economic effects include artificially set prices and goods and services that do not fully reflect consumer preferences
  - Innovation effects can be either positive or negative
    - Negative: Dominant firms can be “fat and lazy”
    - Positive: Dominant firms have “slack” resources to invest in RD&D

# Constructing A Knowledge Platform for Researchers to Explore This



# Design Theory: Example of an Automobile

Illustrative Performance  
Attributes (PAs)

Illustrative Technical Characteristics (TCs)

	Engine	Tires	Steering Device	Cup-Holders
Cost				
Acceleration				
Handling				
Fuel Economy				

# Design Theory:

## Example of an **Automobile Emissions Standard**

Illustrative Performance Attributes (PAs)

Illustrative Technical Characteristics (TCs)

	Engine	Tires	Steering Device	Cup-Holders
Cost				
Acceleration				
Handling				
Fuel Economy				
Tailpipe Emissions				

Regulation introduces new PA

# Design Theory:

## Example of a Fuel Economy Standard

Illustrative Performance Attributes (PAs)

Illustrative Technical Characteristics (TCs)

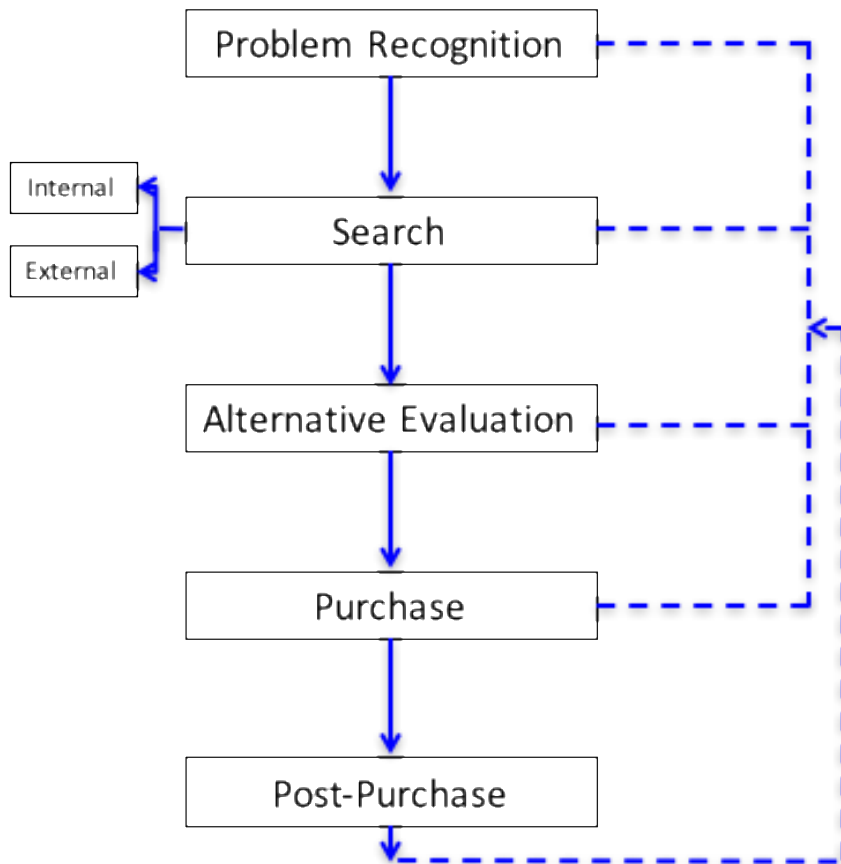
	Engine	Tires	Steering Device	Cup-Holders
Cost				
Acceleration				
Handling				
Fuel Economy				

Regulation influences existing PA

# Consumer Theory:

## New Report on Electric Vehicle Adoption

### Decision Process Steps



### Influences

- **Internal factors**

- Long-term
  - Demographic, psychological, and behavioral attributes
  - Consumer experience with product/brand
  - Switching costs
  - Brand attitude, loyalty
- Short-term
  - Affect throughout the process
  - Impulse triggers

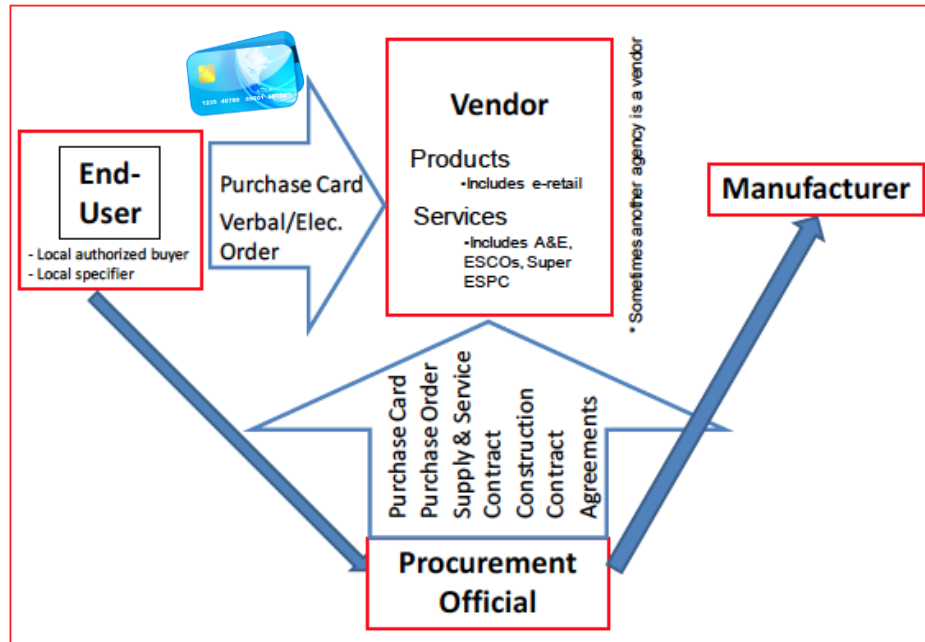
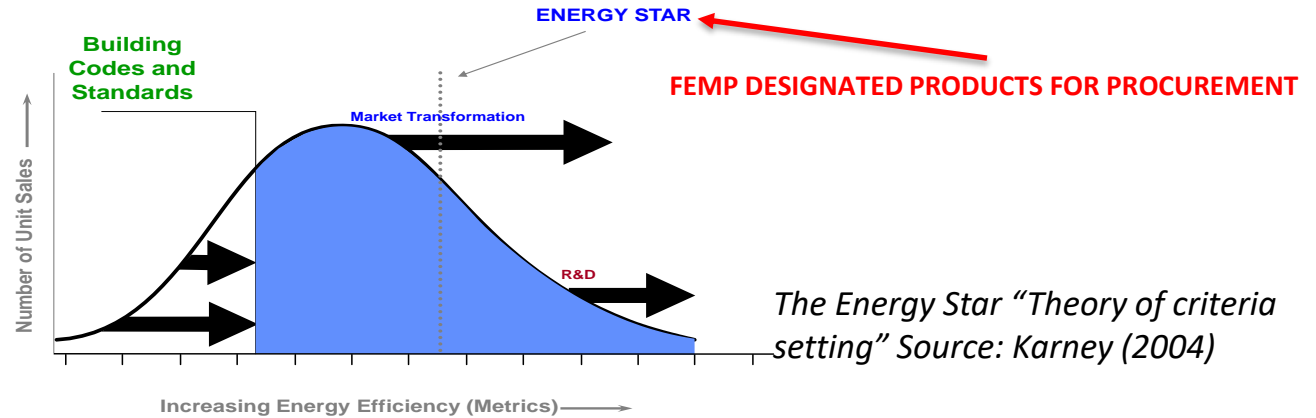
- **External factors**

- Perception of risk
  - Negative consequences of a poor purchase decision
  - Probability of negative consequences
    - Prospect theory
    - Search, experience, credence goods
- Risk management/consumer involvement in purchase
  - Constraints regarding purchase context
    - Too little time
    - Rapidly changing products
- Role of third parties



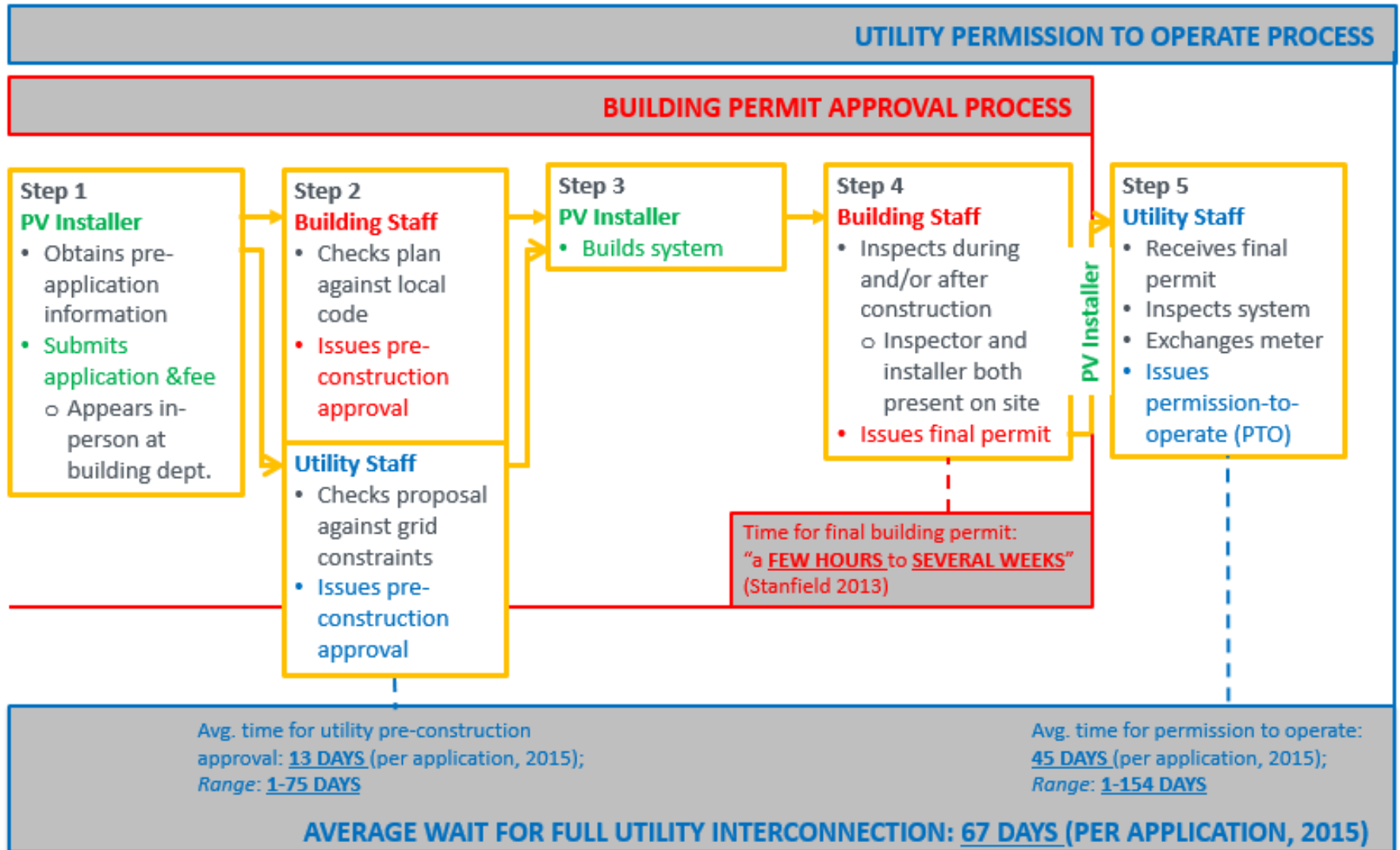
# Consumer Theory: Compliance and EE Product Procurement Regulation

Concept underlying  
U.S. Product Energy  
Efficiency Policy



# Consumer Theory:

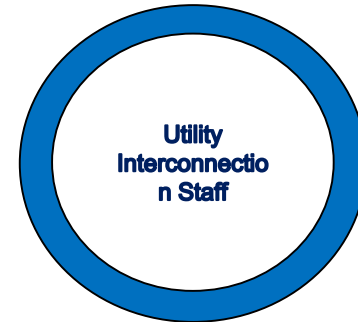
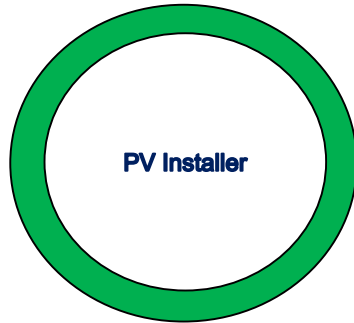
## Designing Solar Permitting Reform to Match Actor Preferences



Permission to Operate process for Residential Solar

# Consumer Theory:

## Designing Solar Permitting Reform to Match Actor Preferences



- Incentives:**
- Scale
  - Customer acquisition, retention, satisfaction

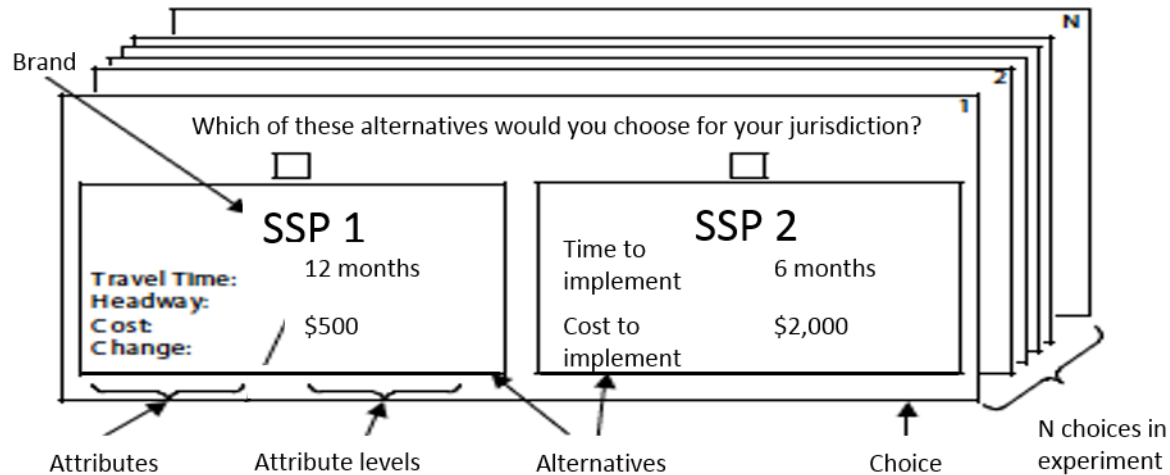
- Constraints:**
- Financial
  - Not incumbents

- Incentives:**
- Protect public safety
  - Maintain relationships with stakeholders

- Constraints:**
- Dillon Rule
  - Model codes
  - Workload
  - Resources

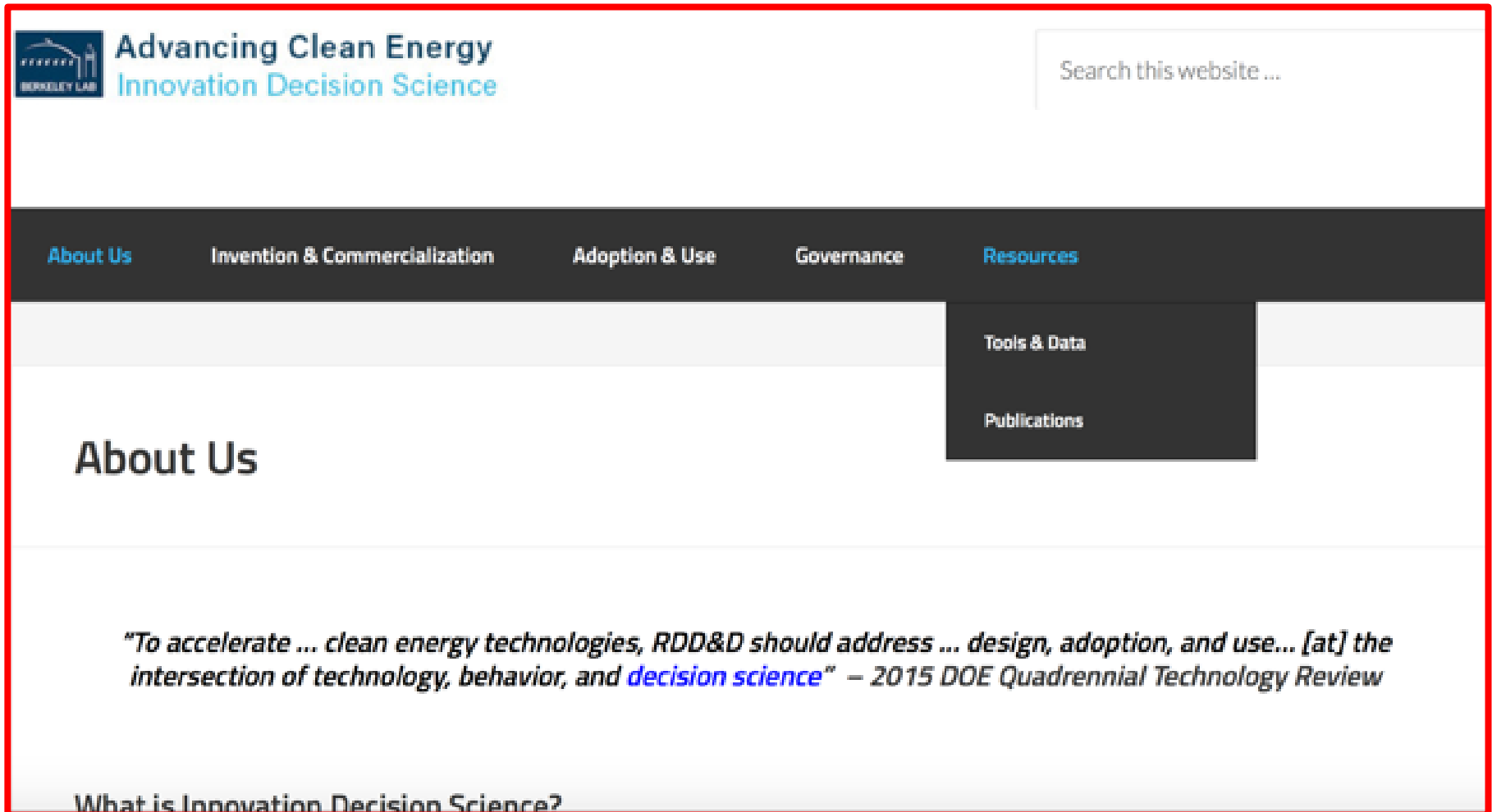
- Incentives:**
- Maintain grid

- Constraints:**
- Regulation(?)
  - Workload
  - Resources



# Thank You!

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The screenshot shows the top portion of a website. In the top left corner is the Berkeley Lab logo, which includes a stylized sun and the text "BERKELEY LAB". To the right of the logo is the text "Advancing Clean Energy" in a dark blue font and "Innovation Decision Science" in a lighter blue font. In the top right corner, there is a search bar with the placeholder text "Search this website ...". Below the logo and search bar is a dark grey navigation bar with five items: "About Us", "Invention & Commercialization", "Adoption & Use", "Governance", and "Resources". The "Resources" item is highlighted in blue. Below the navigation bar, a dark grey dropdown menu is open under "Resources", containing two items: "Tools & Data" and "Publications". Below the navigation bar, the text "About Us" is displayed in a large, bold, black font. At the bottom of the page, there is a quote in italics: "To accelerate ... clean energy technologies, RDD&D should address ... design, adoption, and use... [at] the intersection of technology, behavior, and **decision science**" – 2015 DOE Quadrennial Technology Review. Below the quote, the text "What is Innovation Decision Science?" is visible.