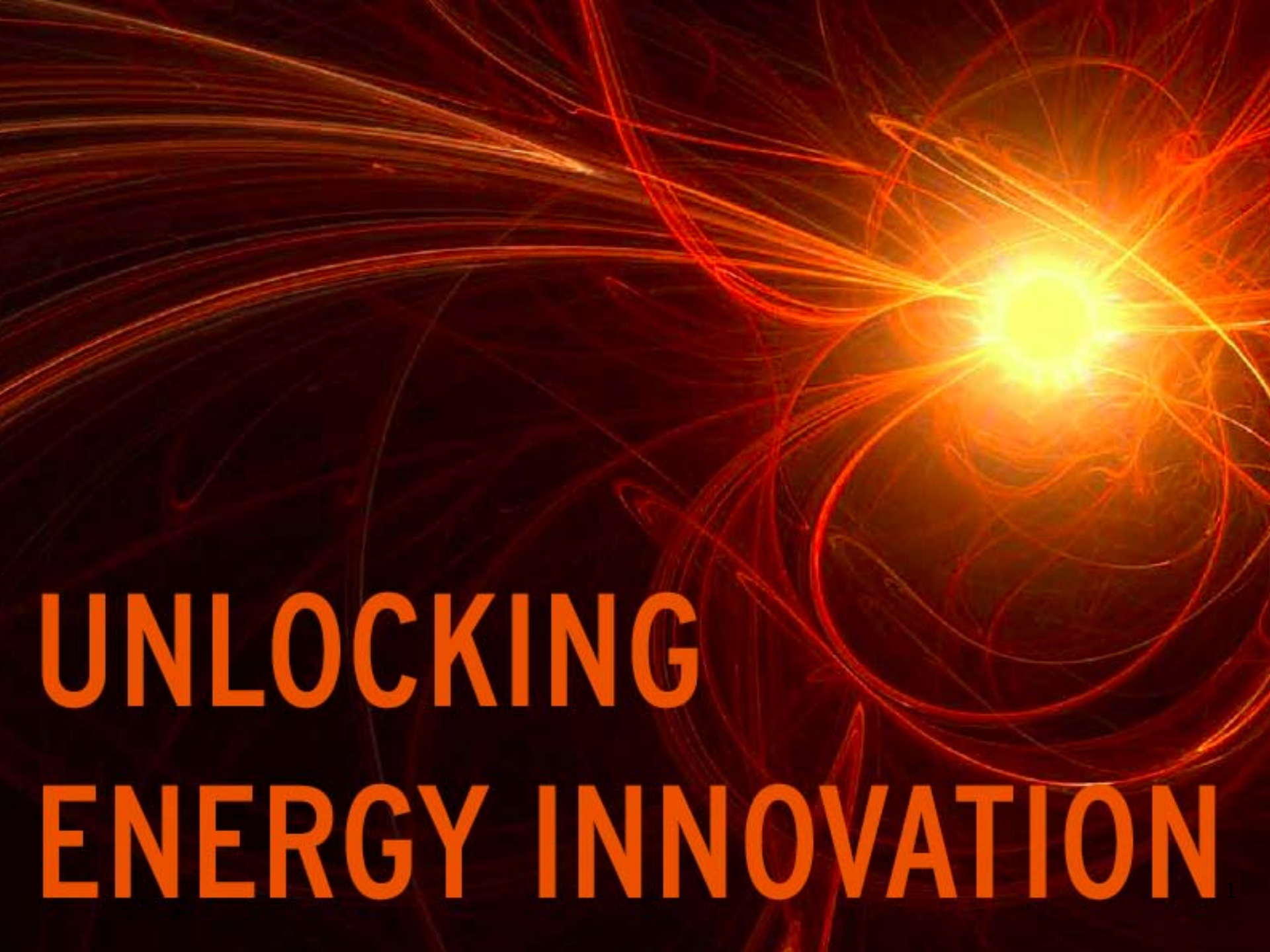

UNLOCKING
ENERGY INNOVATION

Our Goal: "Expanding the Menu"

- Techies: More money for R&D
- Visionaries: A new Manhattan/Apollo Project
- Economists: Get prices right
- Policy wonks: Reform government
- Culture warriors: Change behavior

We're *Not* Joking

"To a first approximation, raising the price of carbon is a necessary and sufficient step for tackling global warming. The rest is largely fluff."

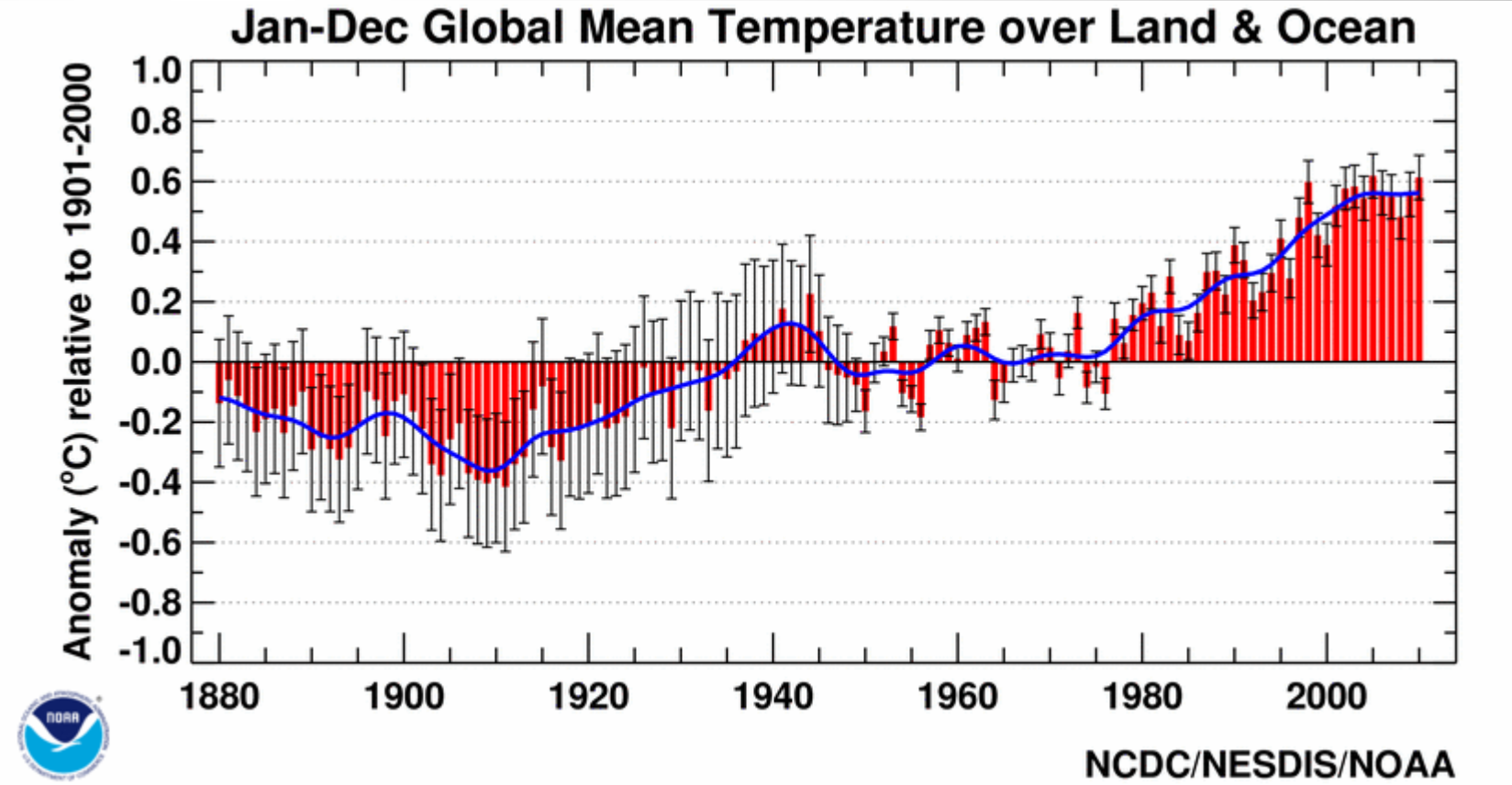
William Nordhaus, 2007

Our Big Question

What kind of *innovation system* does the U.S. need to build in order to accelerate the transition to an affordable, reliable, low-carbon energy economy?

Contents

Fact



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Where Innovation Is Tradition

Getting To “80 in 40”

Percentage reduction rate in carbon intensity	=	Percentage reduction rate in energy intensity	+	Percentage rate of decarbonization of energy supplies
(- 7%/year)	=	(- 3%/year)	+	(- 4%/year)

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Where Innovation Is Tradition

The Last 25 Years vs. the Next 40

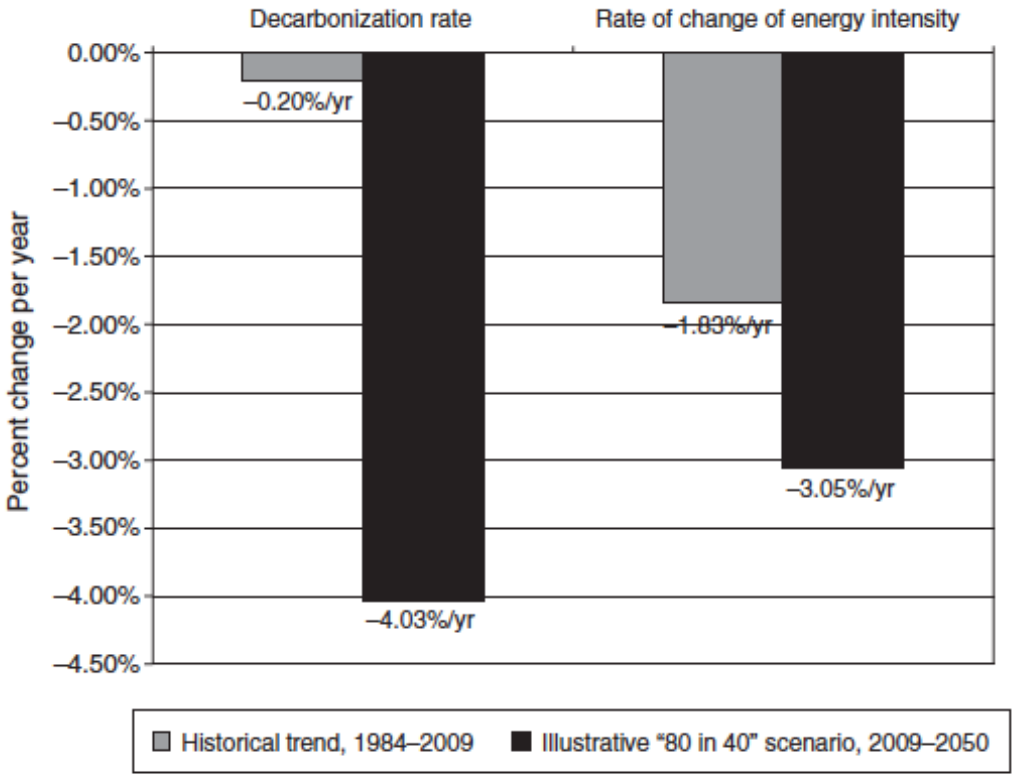

Figure 1.2

Rates of decarbonization and energy intensity reduction in the United States: (a) from 1984 to 2009; (b) for an illustrative scenario, 2009–2050.

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Where Innovation Is Tradition

Some Other Notable Assertions

Electricity is the “central front”

Shale gas and “second generation” biofuels:

- Could reduce CO_2 emissions in the short run
- But in the long run, their emissions are still too great
- And there is a danger that they could become a “bridge to nowhere”

Focusing on the climate goal will (at a minimum) not worsen capacity to achieve other goals (security, jobs, local pollution, etc.)

Four Stages of Energy Innovation

‘Design Criteria’ for the Energy Innovation System

Accelerate all stages: option creation, demonstration, early adoption, and improvement-in-use.

Create space for new entrants.

Competition at each stage.

Rigorous and timely down-selection at each stage

Scale of the system should match the scale of the task

Accommodate and exploit diversity (regional, organizational, technological, etc.)

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The current energy innovation system satisfies none of these criteria.

Three Waves of Innovation

First wave: 2010-2020+

- Mostly energy efficiency
- Innovation in financing and business models

Second wave: 2020–2050+

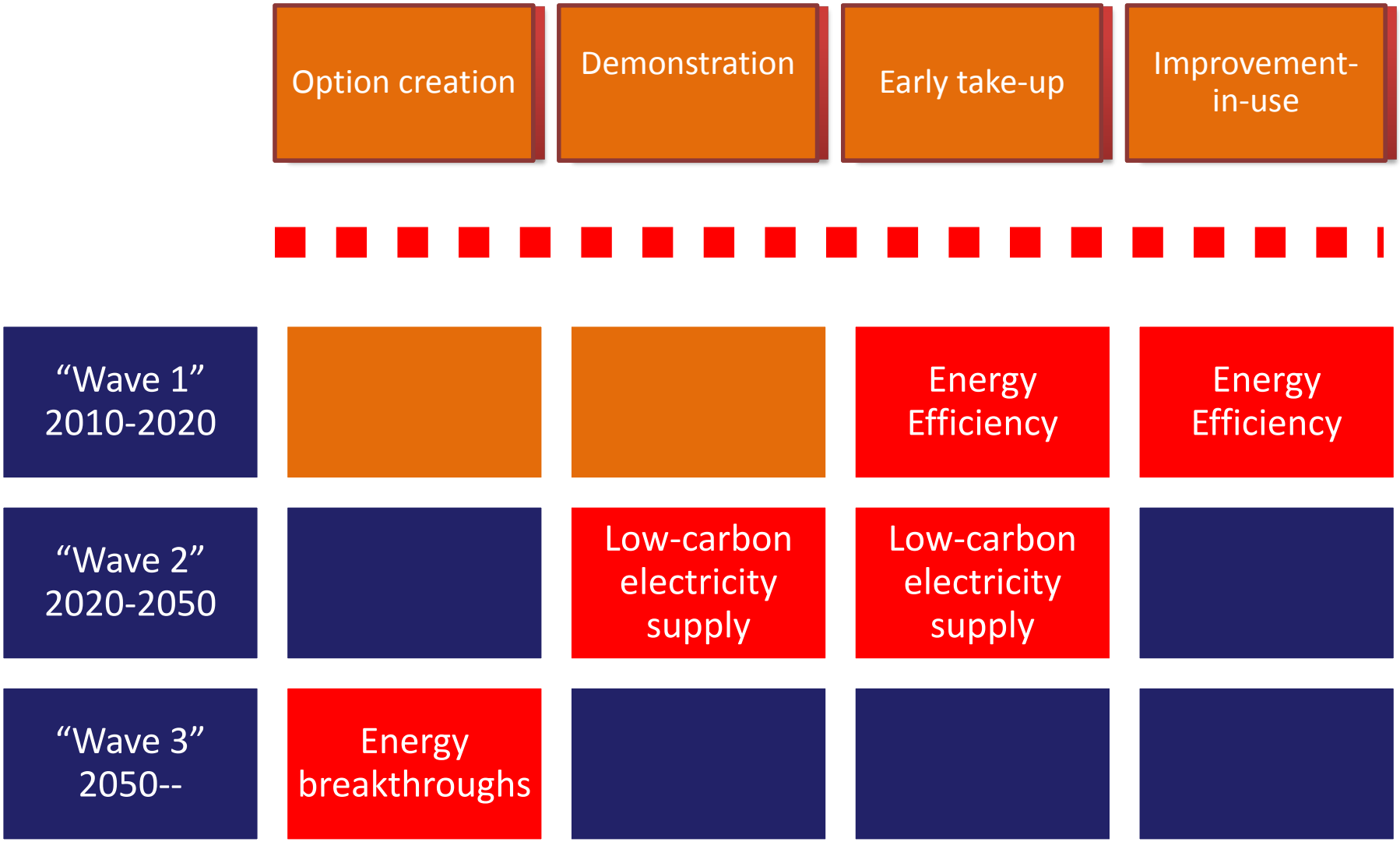
- Reduce the costs and risks of existing low-carbon electricity supply technologies (nuclear, wind, solar, CCS, etc.) and infuse ICTs into the grid ("smart grid")
- Large-scale deployment of these systems

Third wave: >2050 (?)

- Fruits of basic research
- Entirely new concepts, materials, etc. (e.g., artificial photosynthesis, fusion, etc.)

All three waves must be pursued simultaneously and immediately.

4 Stages x 3 Waves



All Three Waves:
Structural Reform of the Power Sector

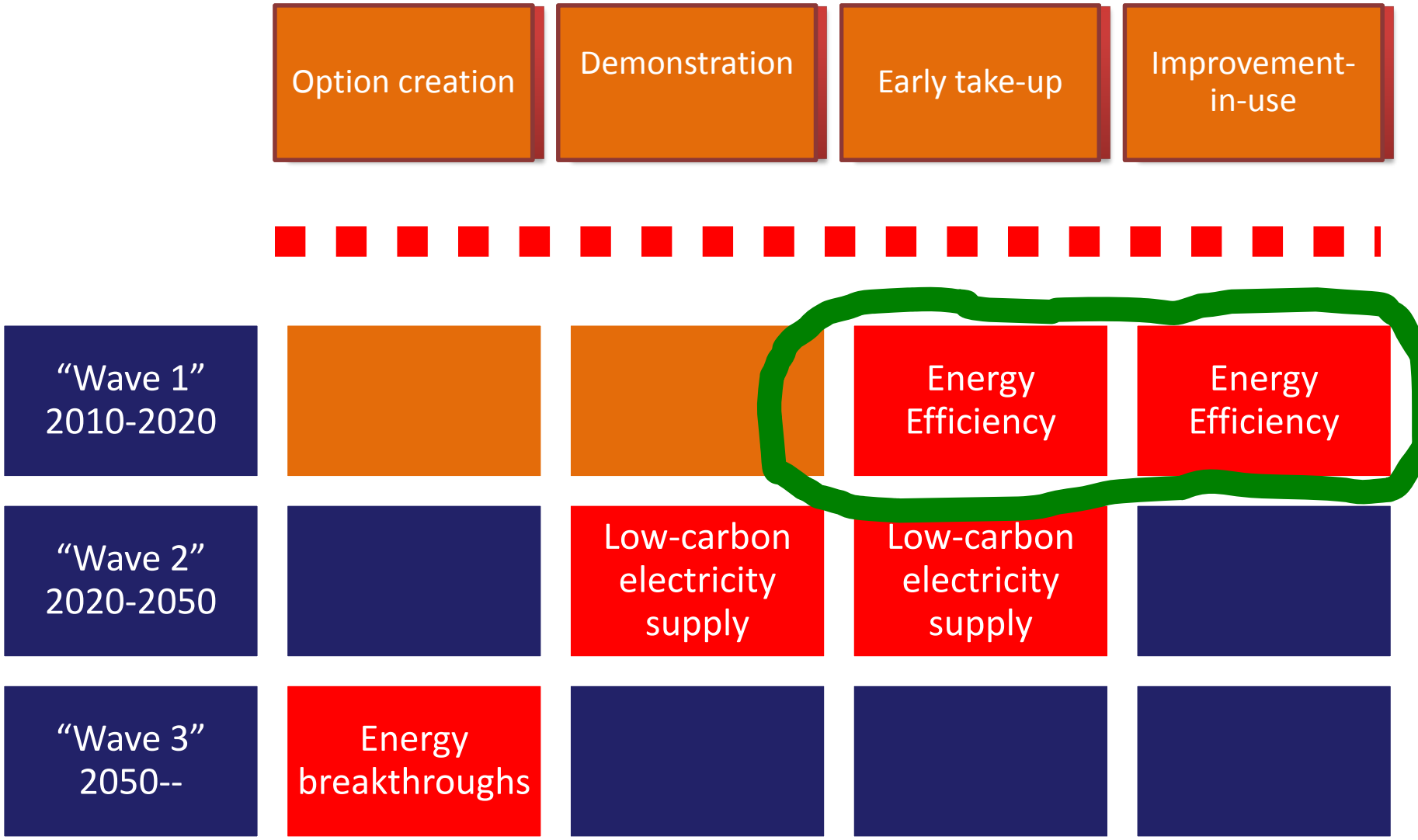
The electric power industry today is less an innovator than an obstacle.

Structural reform in the electric power industry is a prerequisite for building a new energy innovation system

"Smart integrator" utility:

- Would own and operate transmission and distribution networks
- Would maintain a grid architecture that is open to all sources and types of generation and energy management services
- Would not be responsible for devising/refining innovative generation/energy management technologies, nor scaling them up
- New entrants and economic competition, not regulation, would drive innovation in power generation and energy management services

4 Stages x 3 Waves: Wave 1



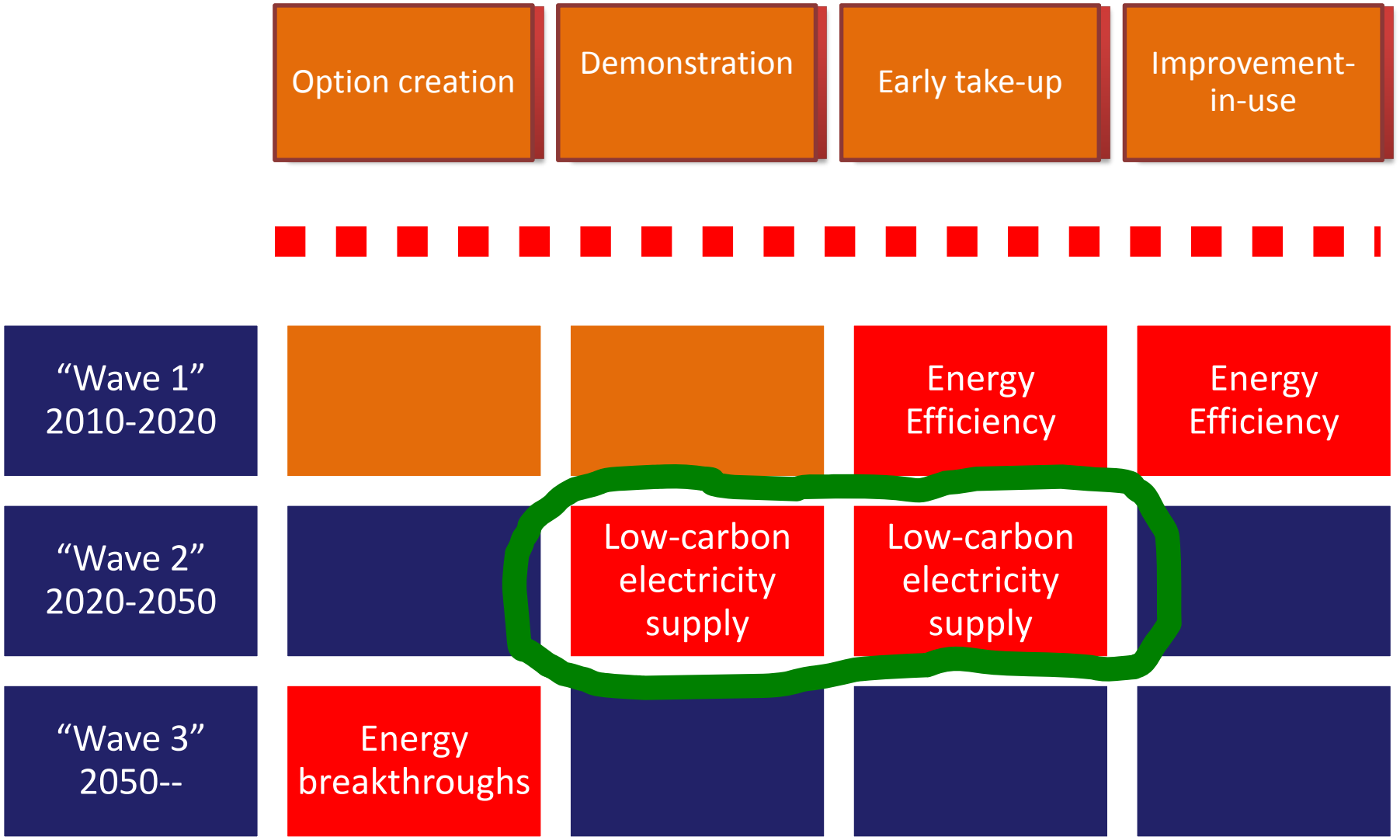
The First Wave:
Energy Efficiency in Buildings

An enormous and immediate opportunity

"Green shoots" are evident and must be nurtured:

- Energy codes for new buildings enacted and enforced
- Sustain the drive to tighten appliance EE standards
- Expand and simplify incentives for building retrofits
  - Financial innovation: Green Bank, PACE, on-bill finance, etc.
  - Building labeling
  - Continued investments in building design and technology

4 Stages x 3 Waves: Wave 2



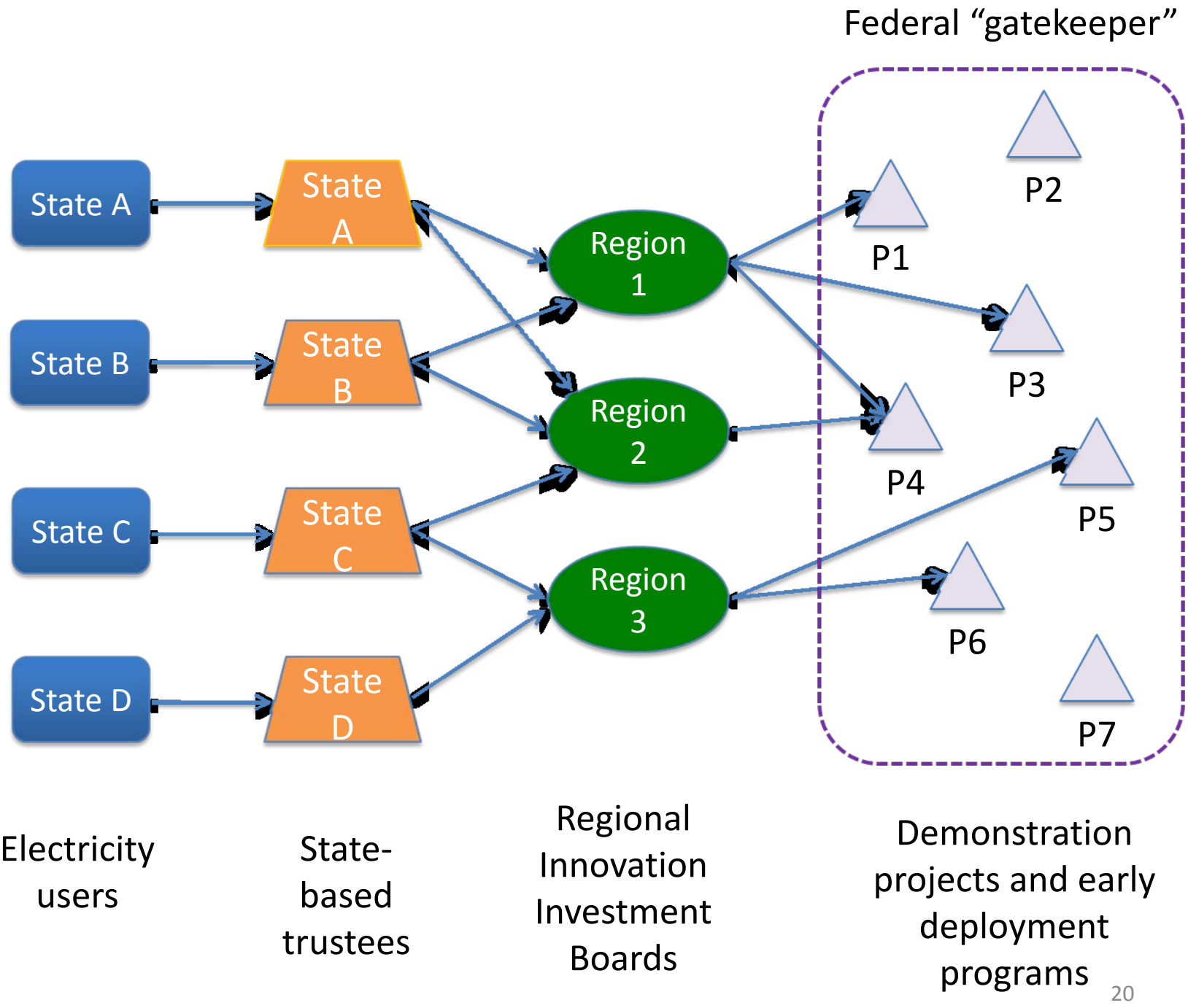
The Second Wave – Part 1: Low-Carbon Electricity Supply

A federally-mandated innovation surcharge on retail electricity sales

State-appointed trustee organizations would allocate revenues to . . . .

. . . . . regionally-based innovation investment boards (RIIBs) which would fund, through a competitive process, demonstration or early take-up projects certified by . . .

. . . a federal ‘gatekeeper’ organization, representing the public interest, which would ensure that candidate projects would advance the goals of the energy transition by offering the potential of significant reductions in carbon emissions


Federal "gatekeeper"
State A
State B
State C
State D
State A
State B
State C
State D
Region 1
Region 2
Region 3
P1
P2
P3
P4
P5
P6
P7
Electricity users
State-based trustees
Regional Innovation Investment Boards
Demonstration projects and early deployment programs

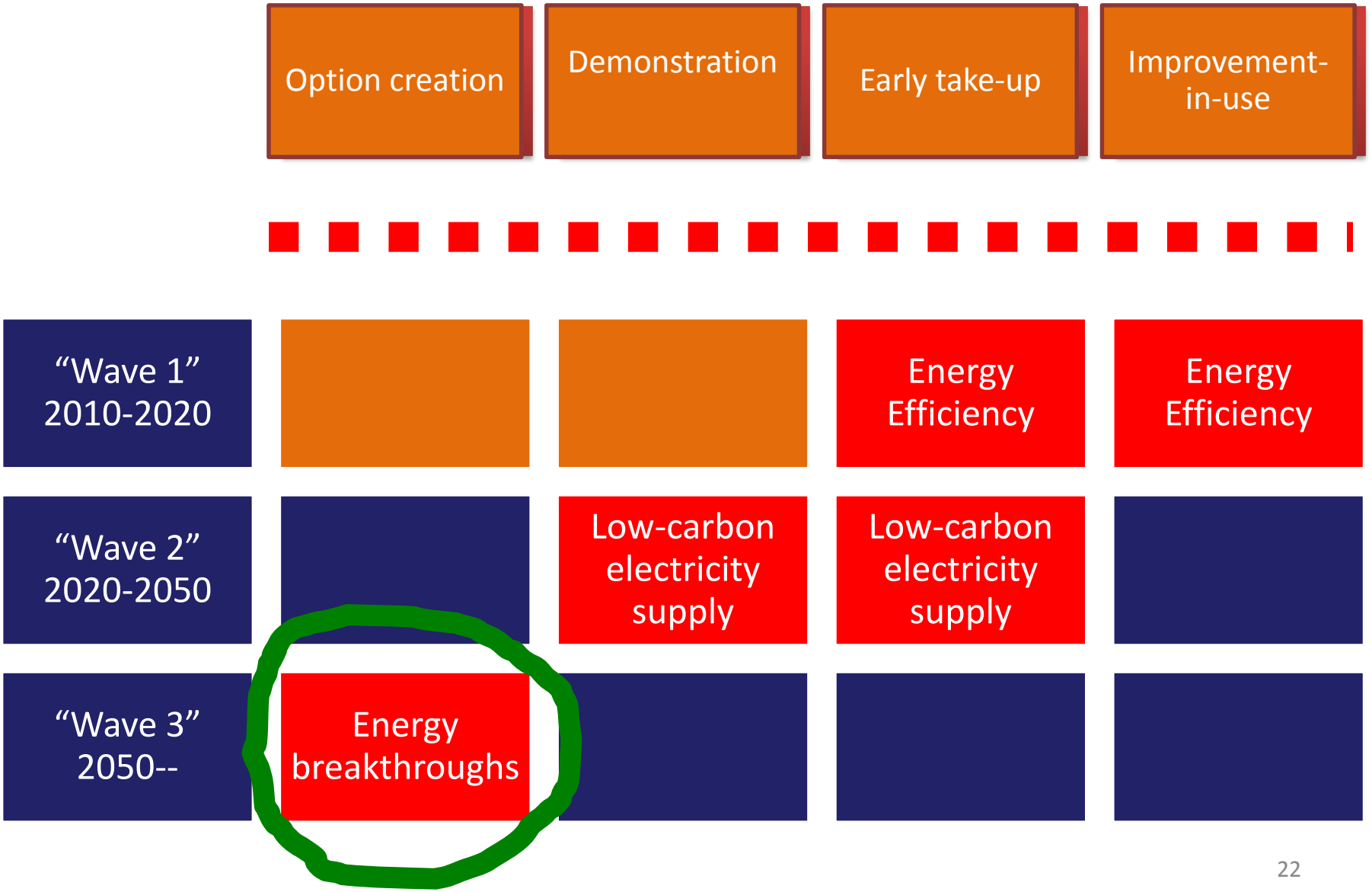
The Second Wave – Part 2: The Rest of the Electricity System

There are major technological opportunities beyond central station power

But they will not be realized without organizational and institutional innovation, such as:

- Open architecture
- Dynamic pricing
- Cost recovery for hard-to-price services
- Public support for demonstration and early adoption

4 Stages x 3 Waves: Wave 3

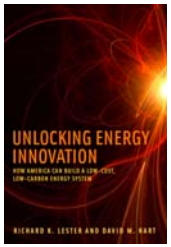


The Third Wave:
Creating Breakthrough Options

"History will not end in 2050"

To address new challenges and seize opportunities that will emerge between now and then:

- More and more sustained investments in option creation, including through ARPA-E
- Pluralistic funding and open information exchange, globally as well as domestically



A 10-point framework for building a new U.S. energy innovation system

- New innovators, start-ups and entrants from elsewhere
- Expanded competition in electric power markets
- 'Smart integrator' transmission and distribution utilities
- An invigorated energy efficiency marketplace
- Regional Innovation Investment Boards (RIIBs)
- State Energy Innovation Trustees
- A federal 'gatekeeper' agency
- Dynamic pricing
- Open grid architecture and customer control
- A much larger and more diverse federal energy research structure