Residential Renewable Energy: By Whom?

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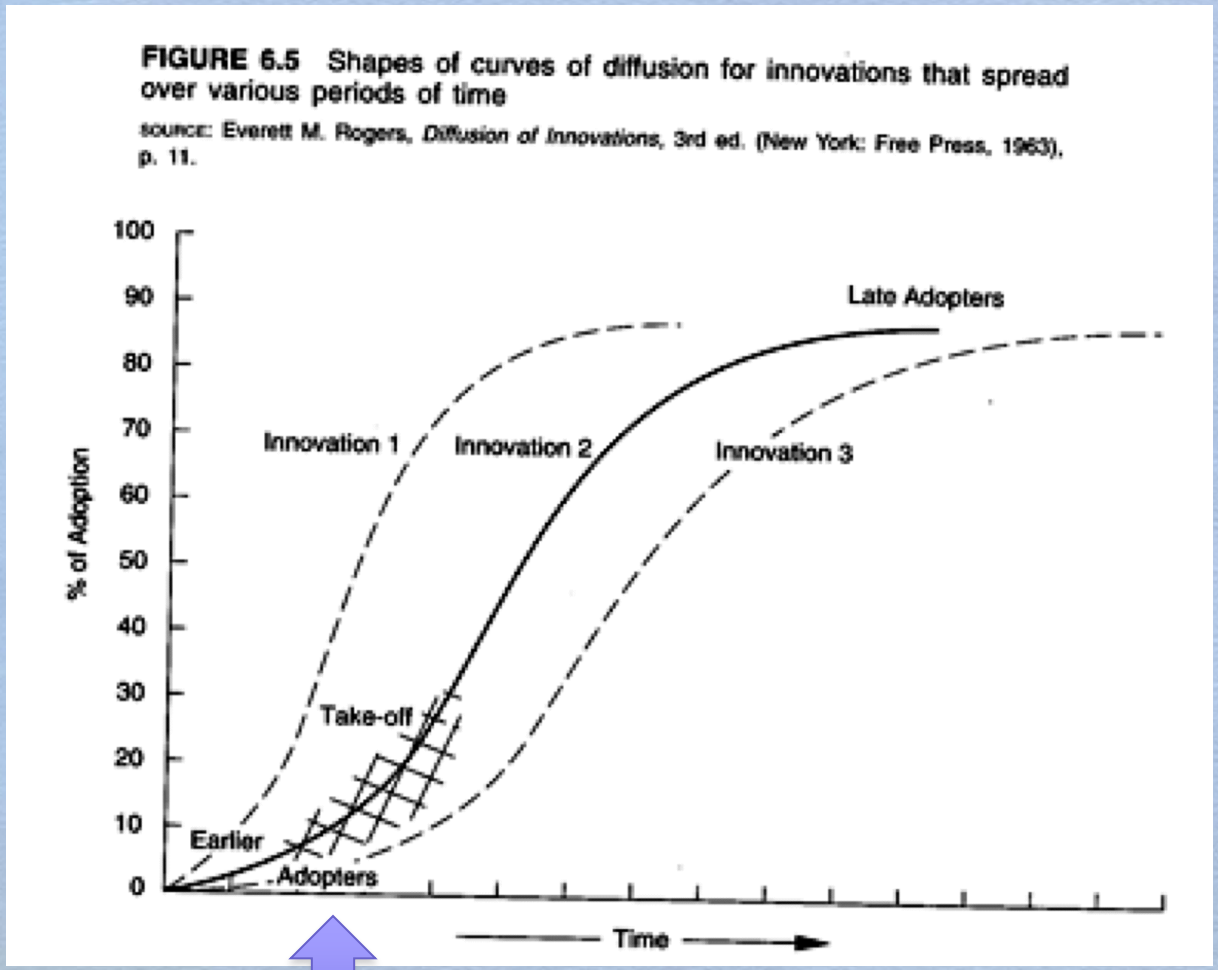
"Someone has got to do for solar installation what Apple did for the cellphone: make it so simple that even an astrophysicist could do it."

"Disruptiveness" and Residential Solar PV

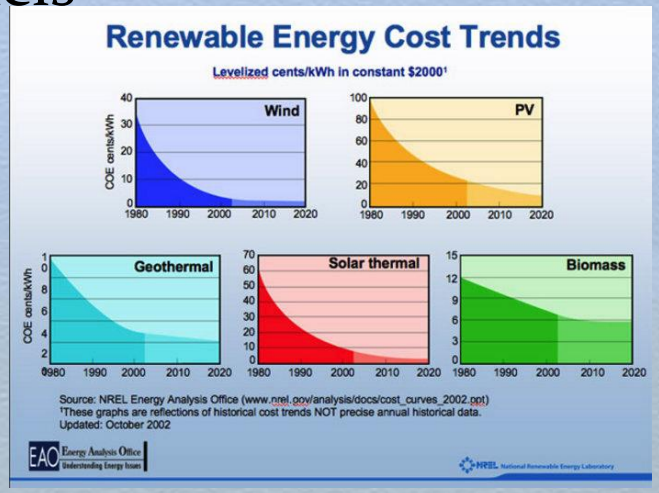
- "S-curve" of technology adoption: at "takeoff" point more than early adopters buy in, but resistance until then



How do we get past here??

"Disruptiveness" and Residential Solar PV

- Can residential solar be "disruptive": substantially displace existing technology?
  - Example of fax machine = "can't live without it" (now itself being displaced by e-mail/PDF)
  - Solar has advantages that fossil fuel-fired generation does not: less expensive power over long term, reliability (although intermittency still a concern)
- Not a technology development problem = "tipping point"/more efficient PV panels



Obstacles to More Widespread Adoption

Suppose that instead of having cars, millions of households had "Personal Mobility Vehicles" (PMVs) and car builders were small firms trying to market their products. . .

Obstacles to More Widespread Adoption

- Who would buy a "car" instead of a "PMV" ?

Cars:
Built by hand (custom builders)
No network of dealers
No nationwide promotion
Small track record of industry

PMVs:
Every suburban household has one (including your neighbors)
Widely available (dealers, alternative channels, advertising)
Easy financing/low transaction costs
Industry subsidization lowers perceived cost to consumers

Only early adopters would buy cars if both furnish "transportation"; to succeed more broadly, a car would have to be a "disruptive" technology with different attributes

Obstacles to More Widespread Adoption

- **Solar panels are "cars"**:

- Utilities have considerable direct and indirect subsidies that dwarf anything offered currently to solar power firms

- Financial subsidies

- Regulatory subsidies (system designed for them, familiarity over decades, etc.)

- Political subsidies (protection from failure by legislatures, etc.)

- Use of existing infrastructure (no 2d line to houses)

- >>> Laissez faire attitude toward growth of the solar industry is unlikely to surmount these obstacles and lead to a critical mass of solar deployment

Obstacles to More Widespread Adoption

Survey in 6 metro areas done for this project

Areas selected for different criteria: receptiveness of state to solar, regulated/deregulated, amount of installed solar capacity, etc.

Table 1: Price Quotes Received For Average Solar PV Systems, Nationwide

Metropolitan Area	Average Home Size (sq. ft.)	Price Quote (system size)	Net Price After Incentives	Notes
Los Angeles, CA	2,487	$22,000 (3 kW)	$9,900	
Jacksonville, FL	1,561	$30,000 (5 kW)	Not quoted	Calls to 2d installer were not returned
Newark, NJ	1,901	$60,000 (6 kW)	Not quoted	6 kW system claimed to reduce monthly electric bill by $100; 2d installer would not provide price quote
Albuquerque, NM	2,142	$23,633-$46,747	$14,180-$28,078	2d installer provided similar quotes
Memphis, TN	2,136	$8/kW (~$48,000 at 6 kW size)	Not quoted	2d installer quoted $60,000 for a 6 kW system
Norfolk/Virginia Beach, VA	1,553	No price quote	Not quoted	

Obstacles to More Widespread Adoption

- High initial cost ($15,000 or more) outweighs any perceived future benefits: studies show consumers discount future benefits (rational because homeowners move every 3-5 years)

- Hassle factor: have to be a "general contractor"
  - "[**COMPANY REPRESENTATIVE**] also identified that they must perform a site visit to confirm the estimated price on retro-fit installations – a site analysis is necessary to determine a hard bid to see if there are any unforeseen circumstances such as 'having to trench for the conduit runs.'"

- Operating and maintenance responsibilities

Compare: cable/satellite TV – low initial cost; can be done in 1 day/homeowner not responsible for selecting installer

1st Challenge: High Upfront Cost

System cost after credits/rebates can be as much as $10,000 or more

"Generally speaking [**COMPANY**] is around $5.80 per watt for most residential systems, and a general system size is 3000watts or 3kWs.* That puts the general system estimate at around $17,400 before any tax credits and that size of system will supply approximately 460kWh's per month."

**Larger and more expensive systems were quoted as well.*

1st Challenge: High Upfront Cost

- Solution = PPA-like agreement or lease
- Little or no upfront cost; compare cell phone hardware subsidized by carrier
- Provider bears cost, recoups over time

2d Challenge: Significant Transaction Costs

What System Should I Use?

Research	Requires technical sophistication

Who Will Install It?

More Research	Technical and legal know-how: permitting requirements of HOA, etc.

How Will I Pay For It?

More Research	Financial acumen: find and compare tax credits, rebates, other financing; estimate benefits

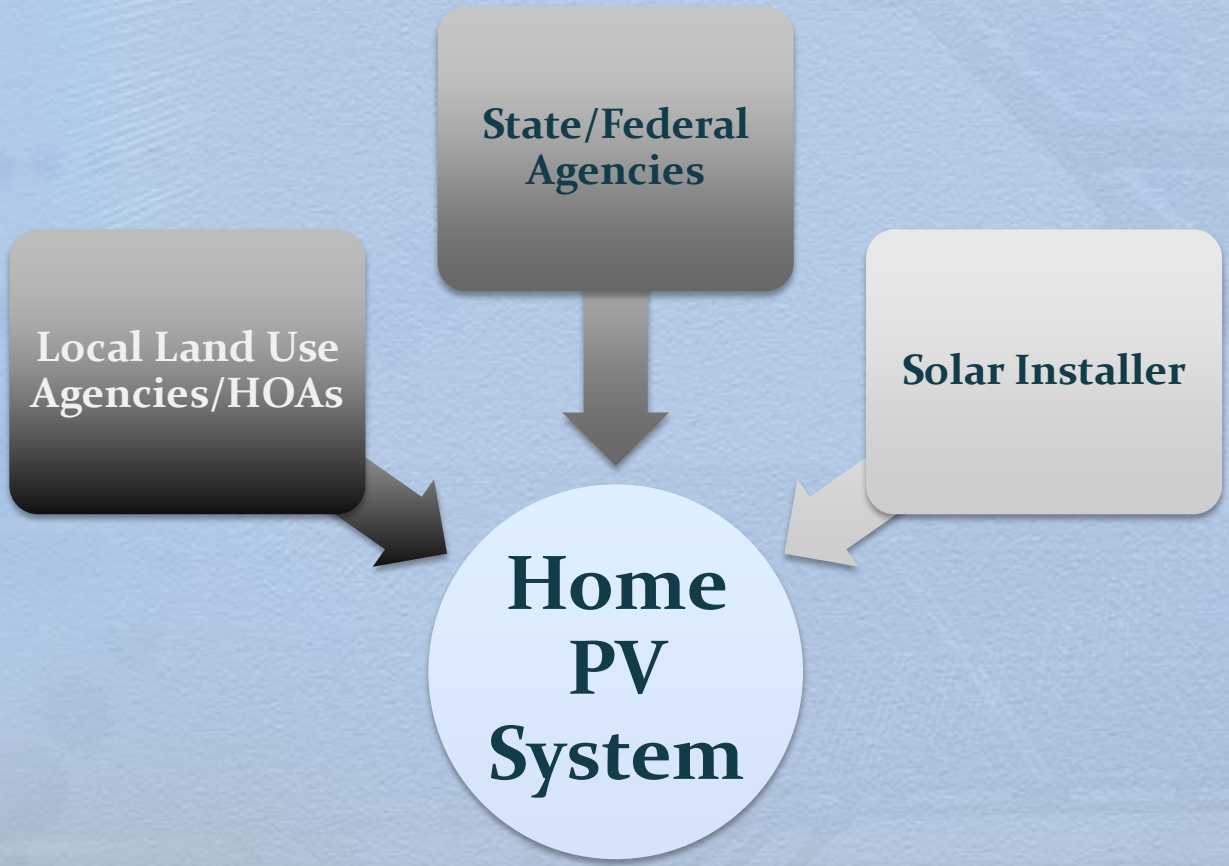
2d Challenge: Significant Transaction Costs

- Solution: one entity handles installation, financing, engineering

- Streamlined process, technical aspects transparent to consumer

- Compare: do not have to know trenching requirements before signing up for cable TV

3rd Challenge: Dealing with Multiple Decision-Makers



3rd Challenge: Dealing with Multiple Decision-Makers

- Solution: provider handles these tasks
- More likely to have/develop financial/legal expertise
- Compare: cell phone companies, cable companies

4th Challenge: No Economies of Scale

- Complex regulatory, engineering, financial tasks
- Historically decentralized industry
- Solution: experience with multiple installations = lower transaction costs

Do Existing Incentives Foster Movement on the "S-Curve"?

- State/Federal Tax Credits/Incentives
- Feed-In Tariffs (FITs)
- Property Tax Financing (PACE)
- Power Purchase Agreements (PPAs)

Do Existing Incentives Foster Movement on the "S-Curve"?

- 5 criteria for widespread diffusion:
  - Availability of regular organizational channels
  - Understanding of the technology
  - Salience to individual making decision
  - Support system (for maintenance etc.)
  - **Financial ability to make decision**

Only the 5th of these is addressed in a meaningful way by existing incentives

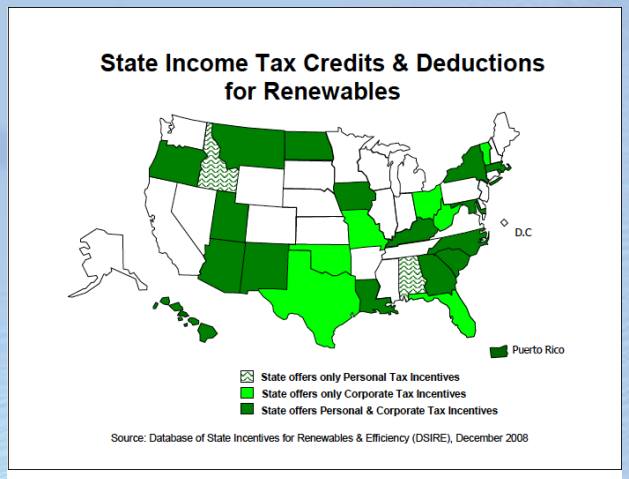


Figure 4. State income tax credits and deductions for renewable energy

Tax Credits/Financial Incentives (Rebates)

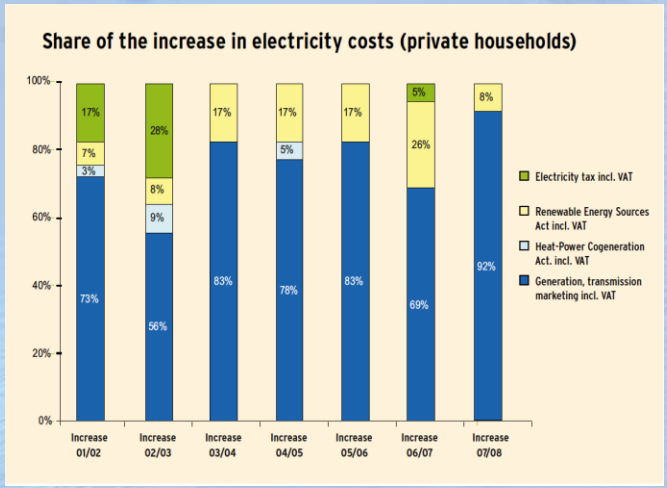
- Pay only part of cost = do not solve upfront cost problem
- Typically recouped *after* initial investment

Tax Credit: 30% of cost with no upper limit
Expires: December 31, 2016
Details: Existing homes & new construction qualify. Both principal residences and second homes qualify. Rentals **do not** qualify.

- Geothermal Heat Pumps
- Small Wind Turbines (Residential)
- Solar Energy Systems

Federal tax credit: 30%, no cap on system cost (ARRA removed cap)

Feed-In Tariffs (FITs)

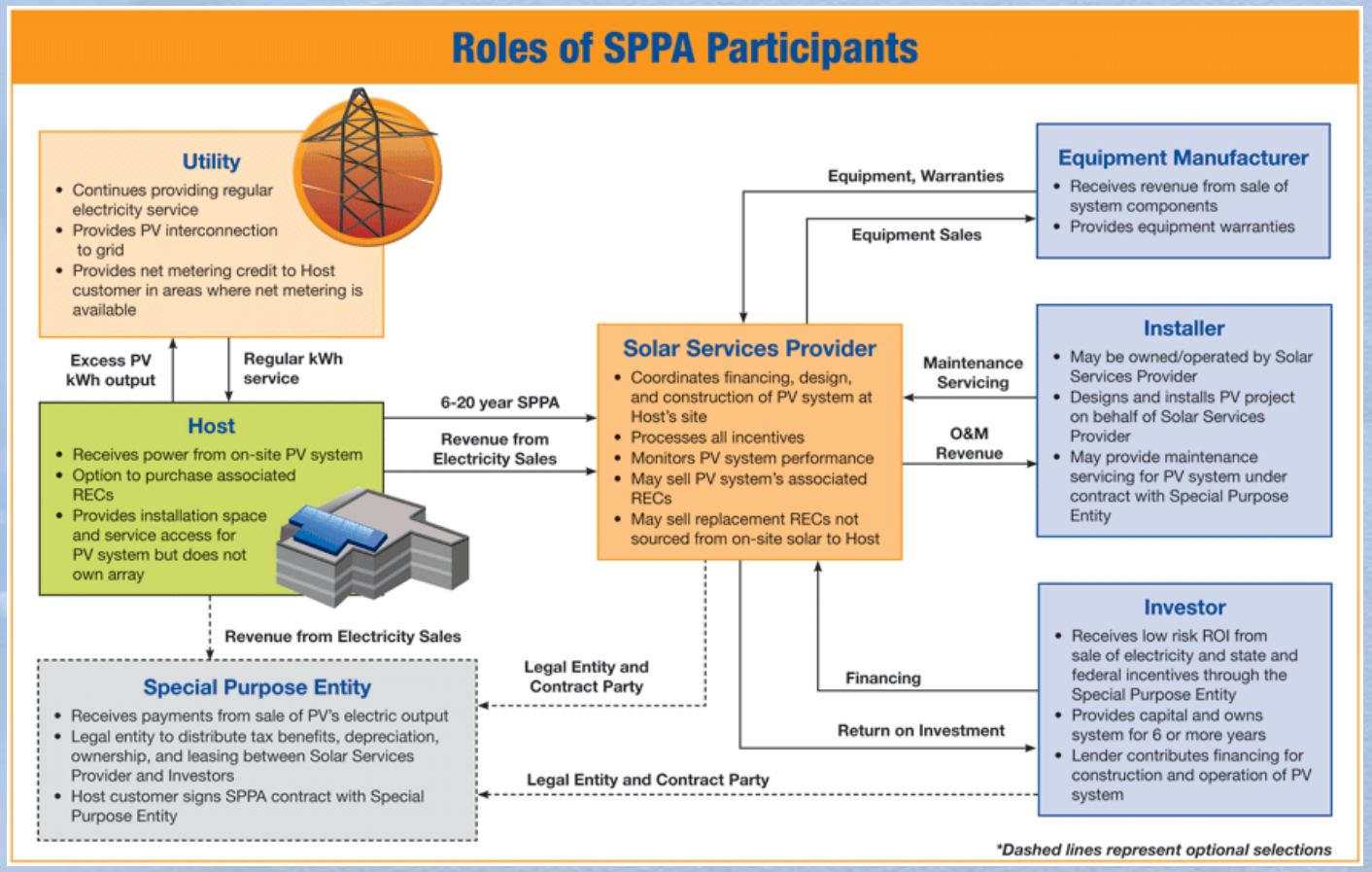


- Payment per kWh for electricity generated from renewable sources (e.g., VermontSPEED)
- Pays for power, doesn't pay system cost (although makes financing easier)
- Increases electricity prices for all consumers: can be politically difficult
- Preemption by federal law/permissible under PURPA only if related to "avoided costs"/level of subsidy limited

Property Tax Financing (PACE)

- Special assessment district = need new one in every city
- Bonds issued to cover cost
- Homeowners apply for 100% financing = no upfront cost
- BUT: repayment in full through increased property taxes; obligation may not run to new owner (state property law)
- Cities may not have expertise, political will, & resources to create districts/administer programs
- Ongoing Fannie Mae/Freddie Mac dispute limits viability

Power Purchase Agreements (PPAs)



Power Purchase Agreements (PPAs)

- Company installs equipment
- Host pays for electricity
- Not generally considered viable in residential setting = most PPAs to date have been governments, universities (Smith College), large companies (Walmart, Whole Foods, Kohl's)

Borrego Solar/Community Energy 130-panel system on Smith College's Campus Center (2009)

One Proposal: "Solar Utility"

- One company
- Handles all tasks from installation through service and billing
- PPA-like model/government charter

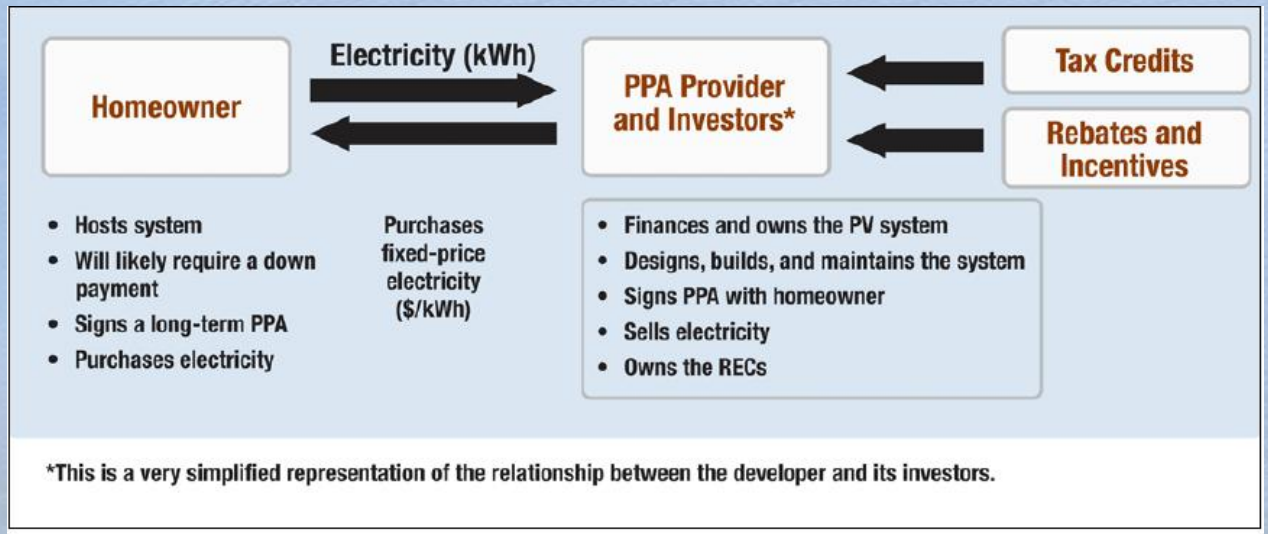
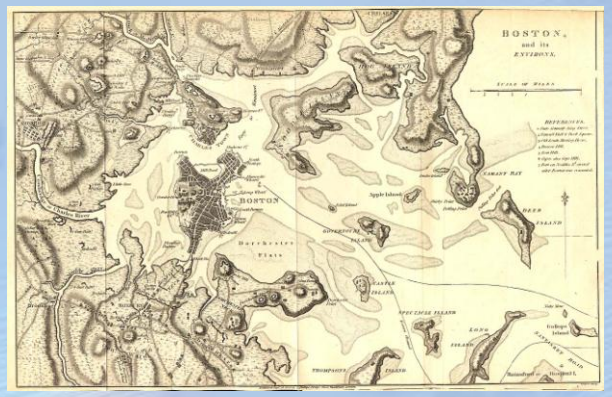


Figure 10. The residential power purchase agreement

Joel B. Eisen, *Can Urban Solar Become a "Disruptive" Technology?: The Case For Solar Utilities*, 24 Notre Dame J. of L., Ethics & Public Pol'y 53 (2010) describes the "solar utility" concept.

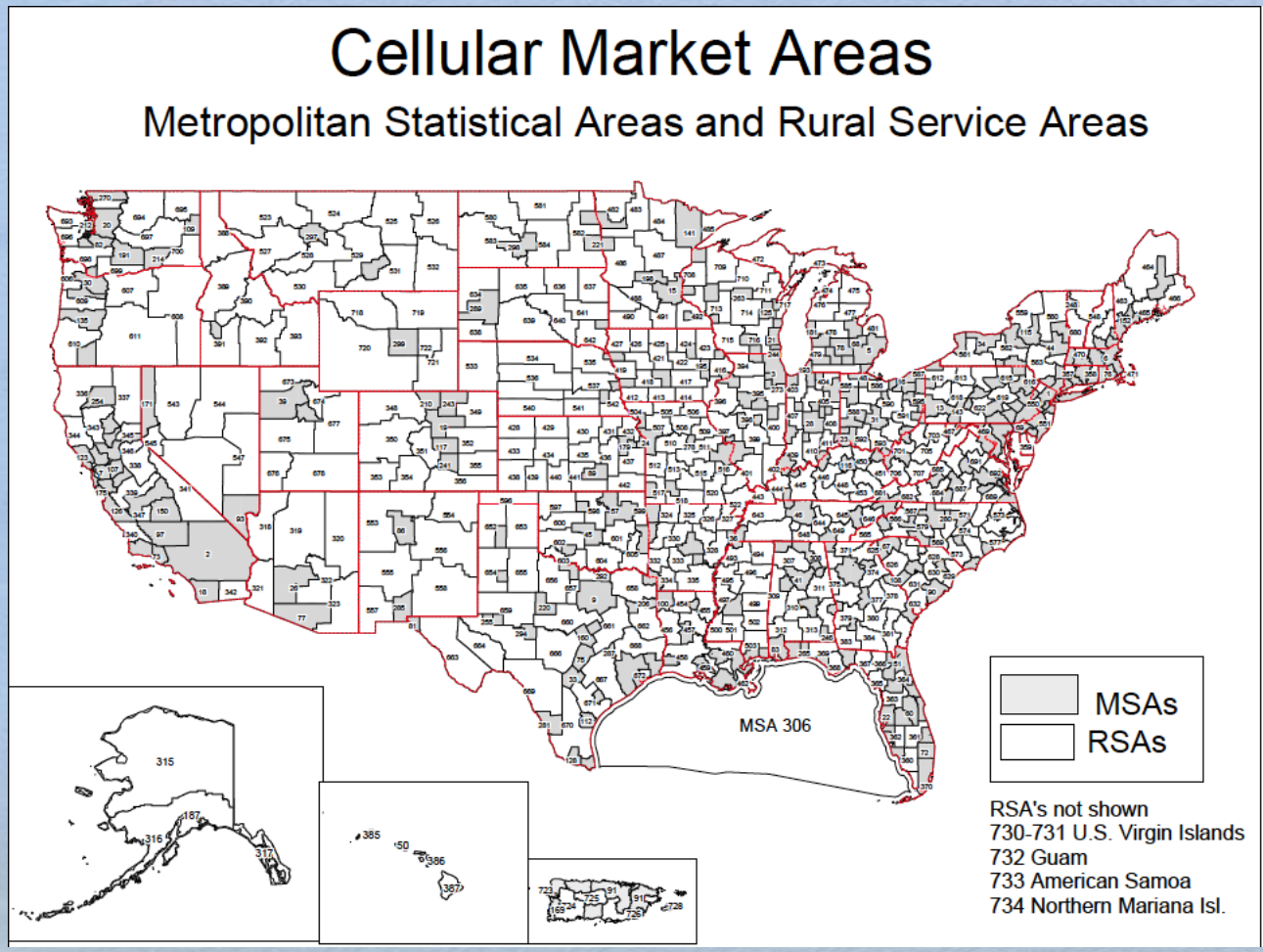


Government Selection of Participants

- Dates to 1800s and *Charles River Bridge*
- "Regulatory compact": protection from competition with rate regulation stimulates industry development; introduce competition later
- Careful design to avoid monopoly rent

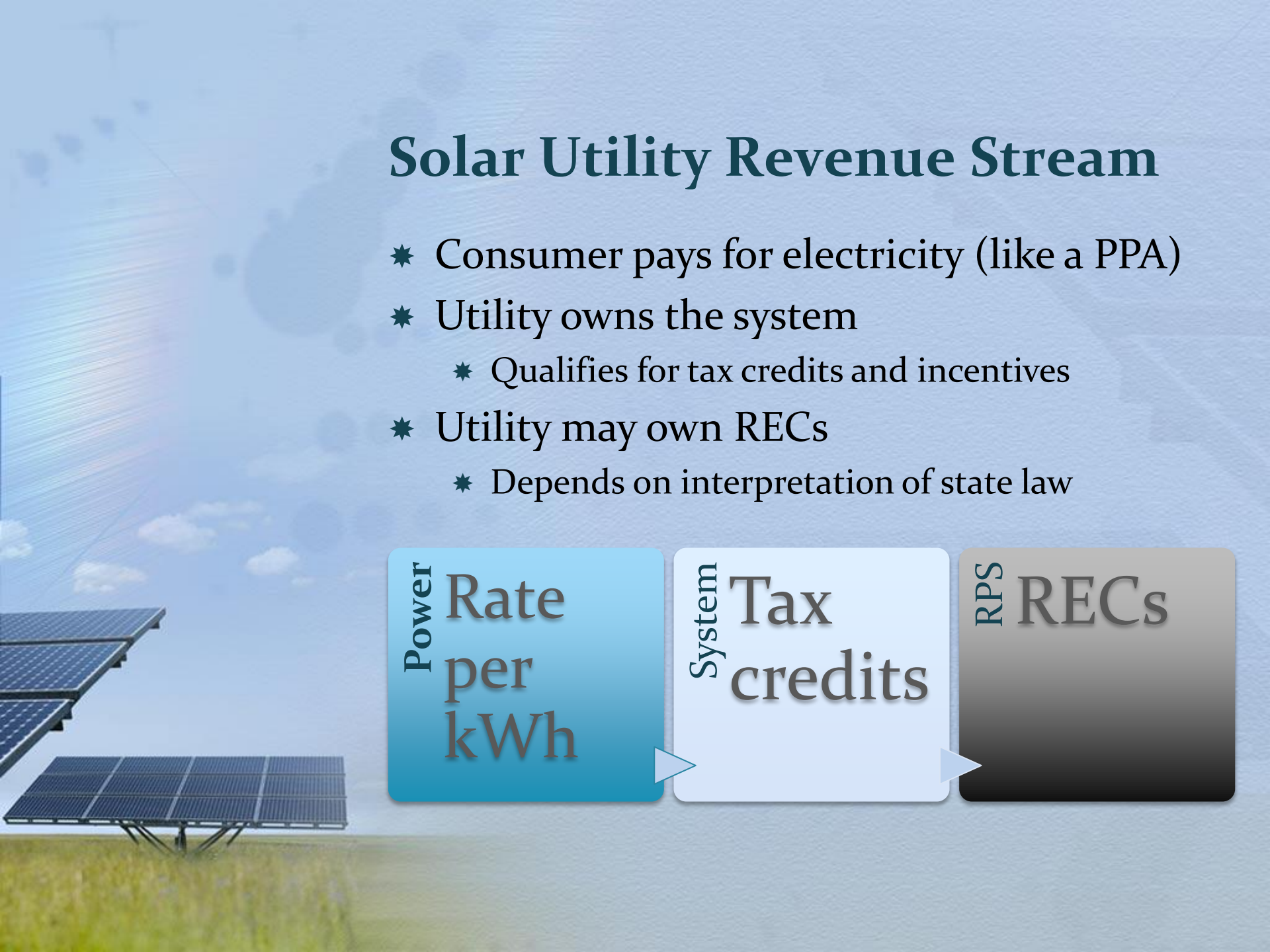
Government Selection of Participants

1981-1991: FCC lottery assigns "A" (new entrant) and "B" (wireline) cellular licenses; required build out within 5 years

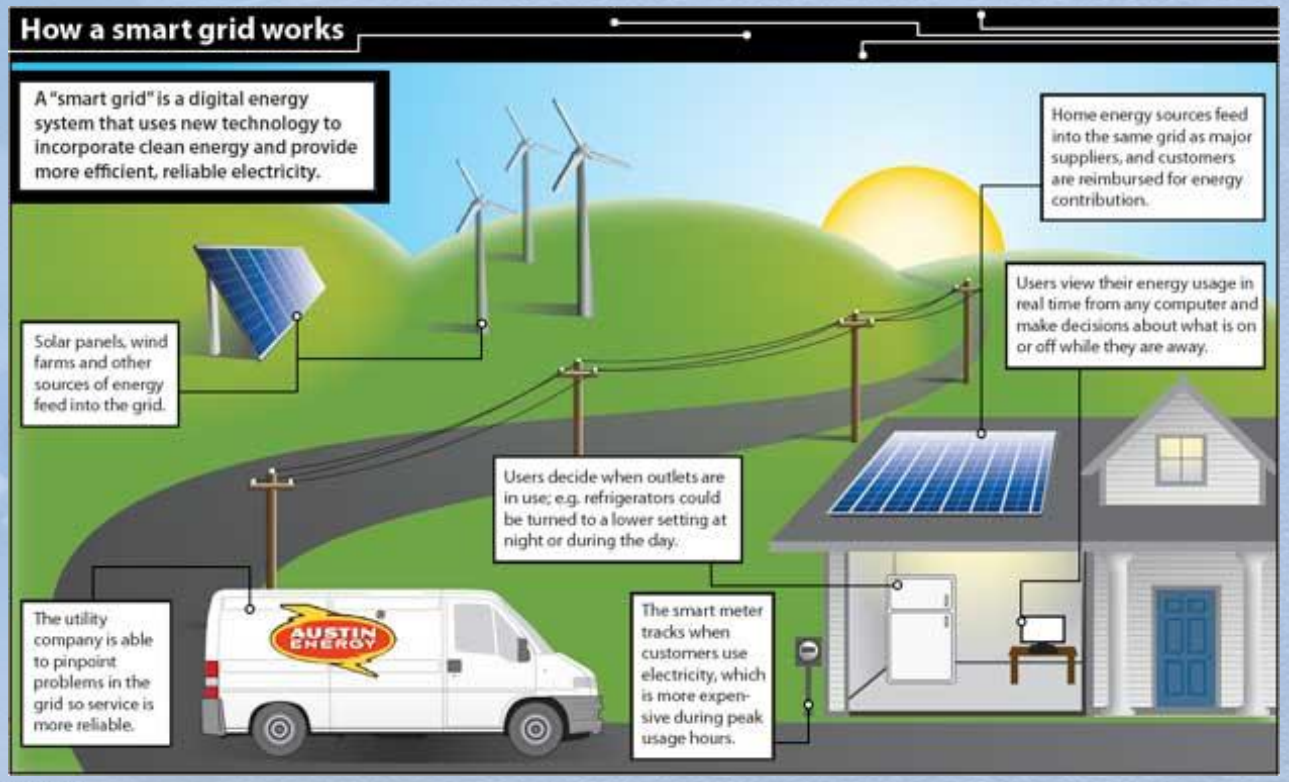


Solar Utility Revenue Stream

- Consumer pays for electricity (like a PPA)
- Utility owns the system
  - Qualifies for tax credits and incentives
- Utility may own RECs
  - Depends on interpretation of state law



What About the Smart Grid??



Smart grid company: views panel as one of many services/products offered

Testing Important Assumptions

"You wouldn't want those houses" (1993)

- Market Structure: Is a monopoly structure necessary?
- Financial viability: Would companies enter market/survive/prosper?
- What about incumbent utilities? = disruptiveness theory suggests they will NOT do this

The 1977 Grumman (yes, THAT Grumman!) Ad-Sunstream Solar Water Heater!

Concluding Thoughts: Going Beyond the Status Quo

- These challenges should not deter us from making solar installations high volume transactions

- "Disruption can take decades if independent disruptive companies rely on other disruptive companies"

Time to get to work on this . . .