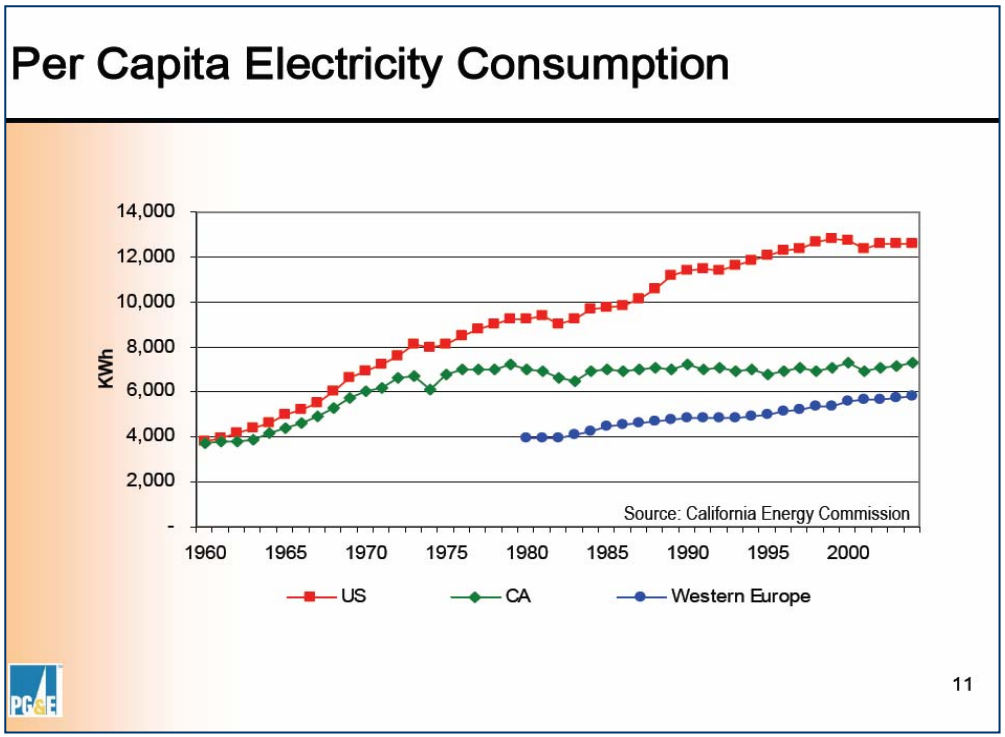
Modeling the Energy System:

Creating Evolutionary Models

Useful to Evaluating a Full Range of Policies



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7 November 2006

Economists Assert and Policy Makers Have Tended to Agree

- Costs of limiting global warming are high
- Raising prices
  - Is the least expensive means to reduce global warming
  - Taxes or ‘Cap and Trade’

Is this assertion

scientifically valid ?

Why do most economists make such claims

- Economy already efficient
  - Buyers
  - Producers
  - Transaction facilitators
- Supply curves
  - No diminishing marginal cost
- Innovation fixed (or static)
  - Exogenously determined

The claims are disproved by a large body of evidence

Energy Models Are Flawed in Assumptions

- Buyers not efficient
- Supply curves
  - Slope down with increasing volume
- Innovation endogenously determined
  - Speed and magnitude of market acceptance important
  - Perceptions of future
  - Institutional supports

Energy Models Are Flawed in Process Representation

Models Now

- Static behavior
  - Producers
  - Buyers
  - Institutions
- Policies primarily influence price
- Response to price tends to be fixed

Reality

- Behavior is changing
- Agenda setting/mindshare is critical
- Responses to prices and stimuli vary
- Prices often peripheral

Reminder

We want Services

Not to use energy

Inefficiency means energy can be reduced at a profit

Innovation means their will be greater opportunities

Relationship Between Service, Work, and Energy

(Lighting Example)

Service Required

(Light for example at a certain color temperature and color rendition in a certain quantity)

↑

Energy conversion devices, Including controls

(Fixtures, lamps, occupancy sensor, dimming capability, maintenance program)

↑

Work required to provide services

↑

Arrangement of building/space/capital equipment

(Windows, skylight, materials in space –reflectivity)

Enormous body of evidence:

Buyers Of Products And Services
Using Energy
Do Not Act Like Economically 'Rational Investors'

1. **Habit** dictates **most** purchases

2. **Some** buy lowest first cost products that meet desired attributes

3. **Fewer buy** products with efficiency as attribute
   - But do not buy 'enough' efficiency
   - Fewer use simple rules of thumb like a two year payback

4. **Very few** use net present value after taxes
   - Cost of capital (or alternative investment return)
   - Long term stream of savings
   - Investment of savings
   - Net present value or future value of options

5. **Results**
   - Large cache of untaken opportunities to improve energy intensity
   - Dynamic efficiency (innovation) lags due to lack of market pull

Efficiency is a peripheral buying issue

Habit

Economic Logic

	Versus	
$85.00	True Cost Over Ten Years	$23.16
3500	Color Temperature	3500 to 6000
100	CRI	85
$8.00	Cost to operate 1000 hours at $0.08 per kWh hour for 100 watt equivalent light	$2.16
n.a.	Internal Rate of Return for Extra ‘Investment’	147%
10	Times Bulb Must Be Changed Over Ten Years	1
$.50	Purchase Price	$2.00

ECONOMIC BENEFITS OF REPLACING INCANDESCENTS WITH CFLS & WITH MORE ADVANCED TECHNOLOGY

	INCANDESCENTS		CFLS		Advanced Technology
Sockets	3,044,140,030		3,044,140,030		3,044,140,030
Lamps sold each year	2,000,000,000		200,000,000		200,000,000
Hours on	657		657		657
Typical Wattage	50		9		4.5
Cost per kWh	0.08		0.08		0.08
Cost of lamps	$0.50		$2.00		$2.50
kWh Used	100,000,000,000		18,000,000,000		9,000,000,000
Cost of energy cost/yr	$8,000,000,000		$1,440,000,000		$720,000,000
Cost of lamps per year	$1,522,070,015		$400,000,000		$500,000,000
Total Annual Cost	$9,522,070,015		$1,840,000,000		$1,220,000,000
Net present value of energy used over next 100 years	$93,228,665,426		$16,781,159,777		$8,390,579,888
Net present value of energy plus lamps	$110,966,234,952		$21,442,593,048		$14,217,371,477
NET BENEFIT CFL OVER INCANDESCENT			**$89,523,641,904**		
ADDITIONAL DYNAMIC BENEFIT					**$7,225,221,571**
GREENHOUSE GAS REDUCTION			**82%**		**91%**
Term	25				
Discount rate	7%				

What can be done???? Prices Have Not Worked

Make it easy !!!!!

Find policy

to reduce

first cost of products

to products with lowest true cost

&

Make buying efficiency a habit

How to Get Solution:
Three Options

- Efficiency standards
- Taxes on product at sale related to energy used
- Transaction bridges

Standards

Minimum lumens

per watt

Evaluation of Option: Standards

DISADVANTAGES

- All benefit goes to the buyers
- Manufacturers finance transition
  - Absorb risk in transition
- Tendency towards political gridlock in setting standards
- Lack of continuing incentive for manufacturers
- Rarely are standards set at best point economically
  - Due to political process

ADVANTAGES

- Setting standards is very simple to understand

Set tax on lamps:
Light Bulbs

- Set tax on lumens/watt
- Advantage Over Efficiency Standard: some dynamic efficiency
  - Continuing incentive to produce better lamp

Option: Create Transaction Bridges

Transactions bridge:

a form of social infrastructure

that creates market intermediaries

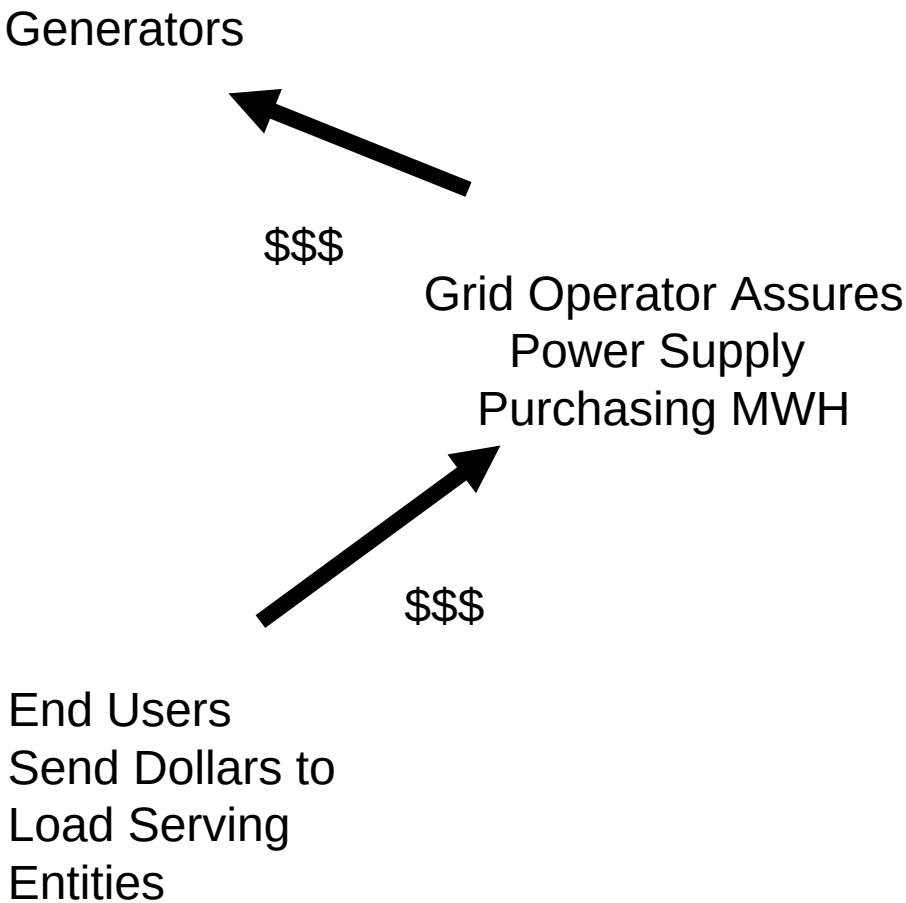
to achieve more effective market

Transaction Bridges Already Exist

- Grid acts as agent for buyers
- Assures future power available
  - Constant voltage
  - Provides whatever supply demanded
  - Finances expansion
  - Allocates cost
  - De-regulation has not changed much
- Buyers power never worry

Energy Supply: Transaction Bridge

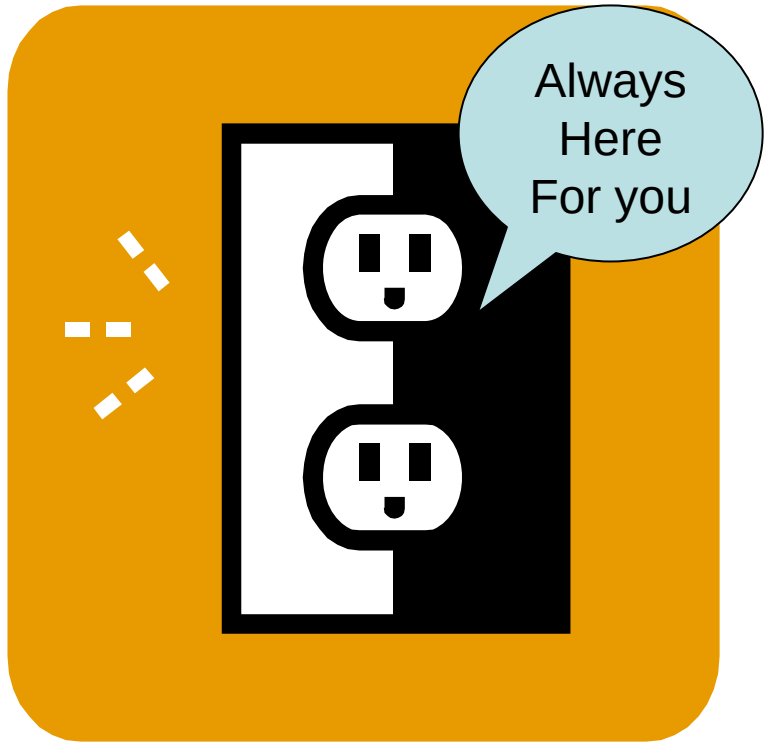
(Currently the grid operates as a transaction bridge for buyers of power)



Buyer Never Worries

No matter how inefficient product

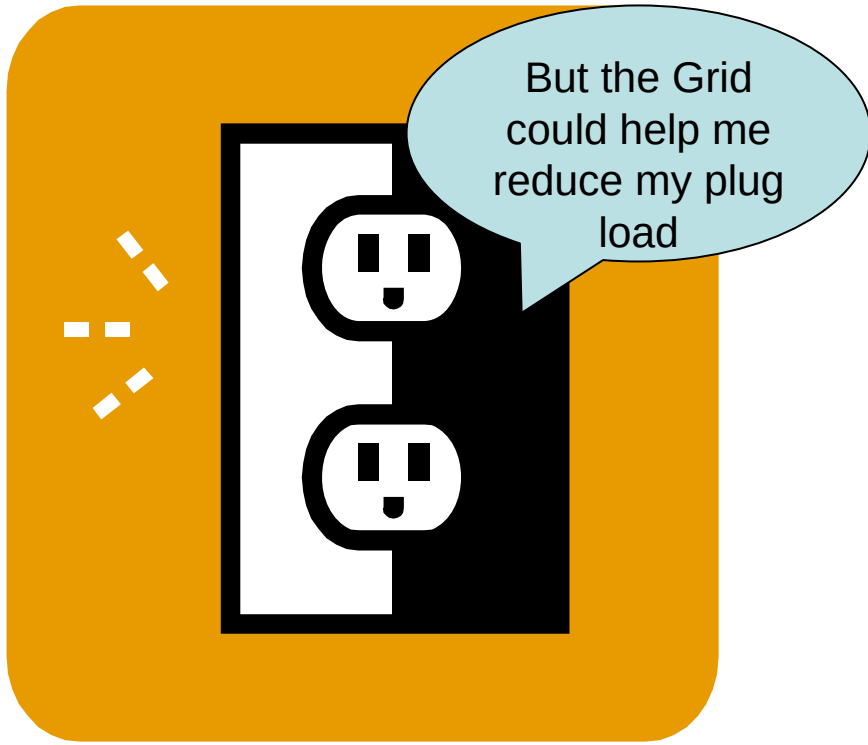
- Grid invests in new generation
- Everyone shares cost
- End user does not finance/buy new capacity



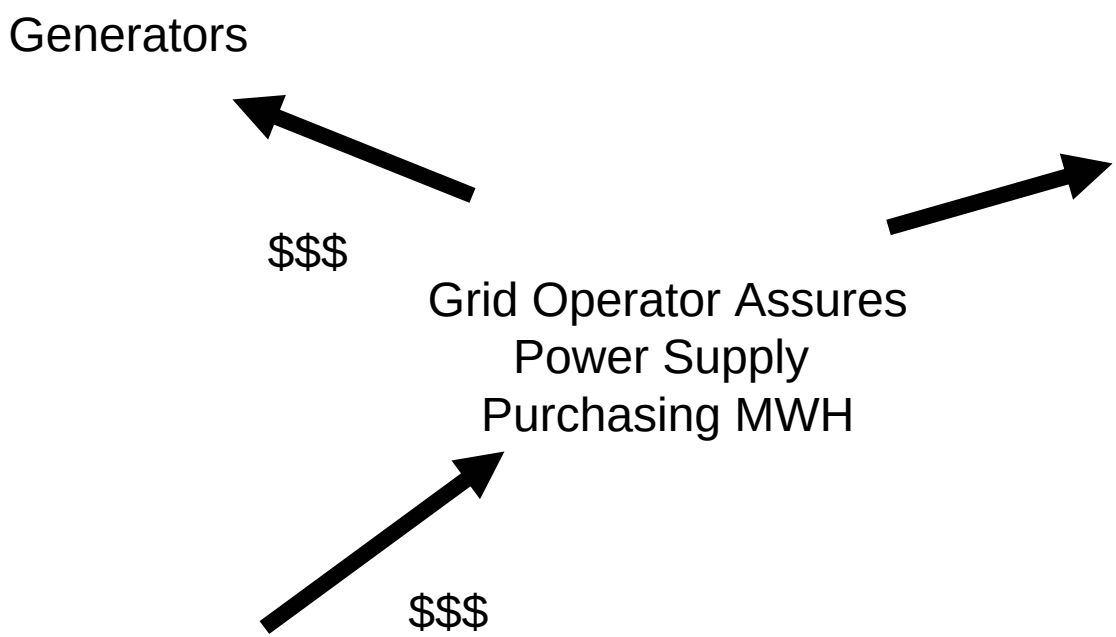
No Equivalent Transaction Bridge For More Efficient Products

Buyers on their own: inefficient products

Result: Grid spends more on costly generation



Option: Transaction Bridges
(Including Fair Treatment of Producers of Efficient Products)



CFL Makers
Get paid

For **negawatt hours**:
Long term sale

Based on agreement

That they always
Accept less than
Generators

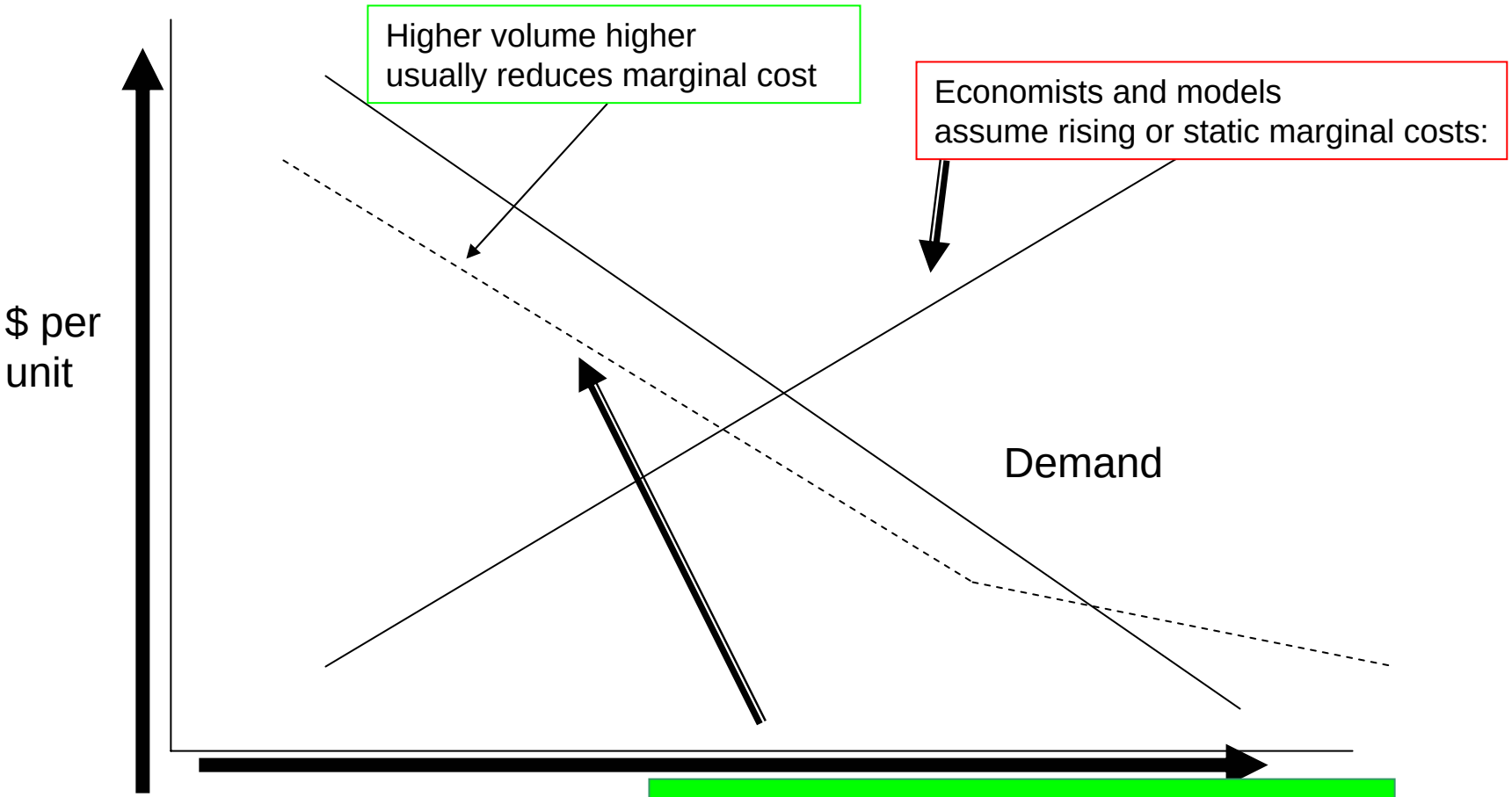
Each nkWh paid
At percent
Of lowest cost
For dispatch
Of power

Result of Transactions bridge

- Manufacturers
  - Lower Price to gain market share
  - Revenue stream from energy savings very profitable
- Markups Avoided
- Scale Economies
- CFL *become lowest priced product*
- Incentive for *dynamic efficiency: Innovation*

Differences between Transaction bridges and IRP/DSM	DSM & IRP	TRANSACTIONS BRIDGES
GOAL	Meet energy service needs at lowest resource cost to society	Same
GRID IMPLEMENTATION	Planning model Programs	Integral to grid operation
PROGRAM IMPLEMENTATION	Usually rebates with fixed budgets Starting and stopping Target usually buyers	Part of daily auction No budget limits No starting and stopping Target producers of products
BUYER MOTIVATION	Buy down Investment basis remains	Producers lower prices to sell Producers support to sell Lower prices New habit
PRODUCER ATTITUDE	Dislikes starts and stops Dislikes regulator control of rebates No direct profit	New revenue stream becomes major motivating factor in: Marketing Pricing Distribution R&D

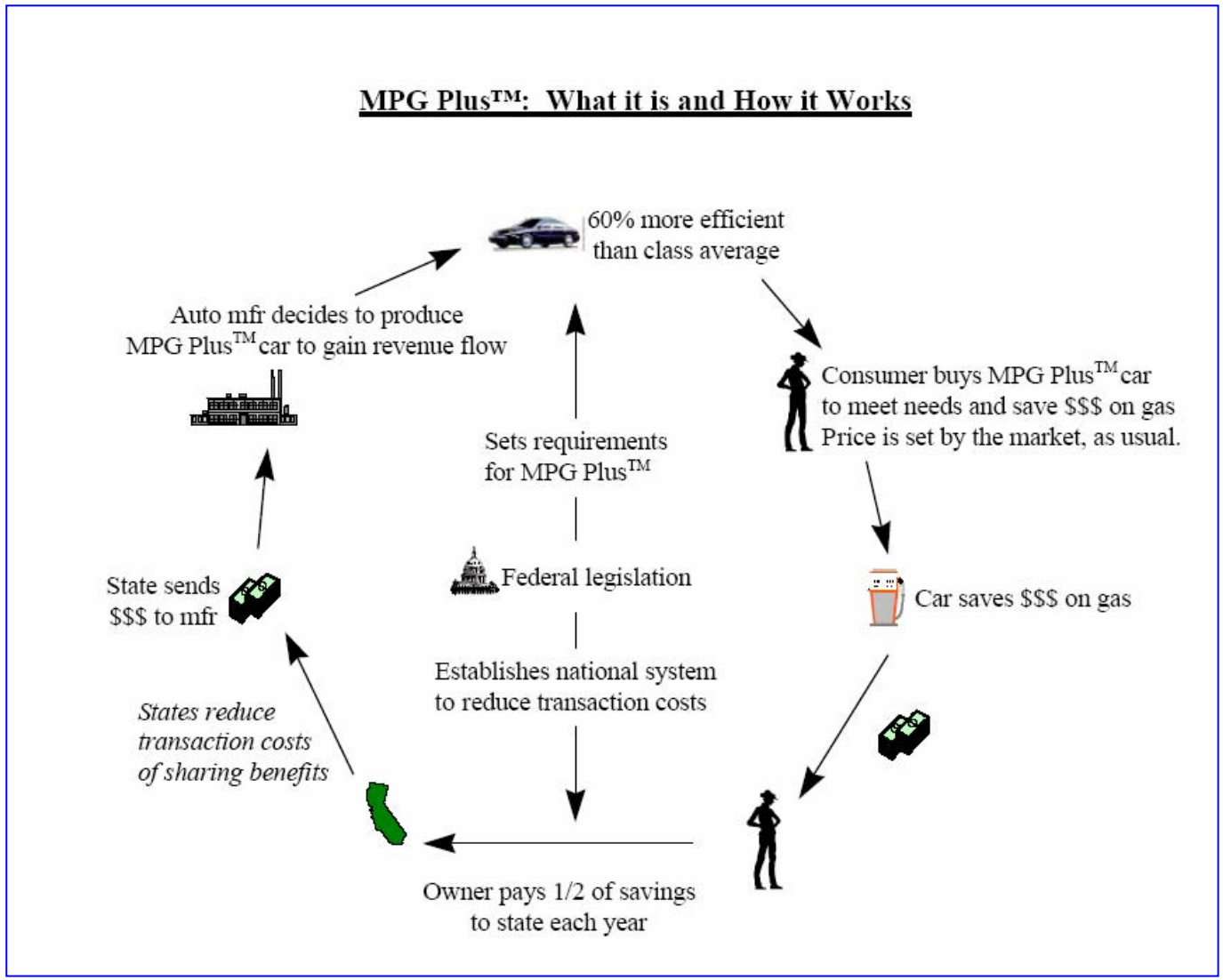
Scale Economies Ubiquitous: Marginal Costs decrease with increasing sales



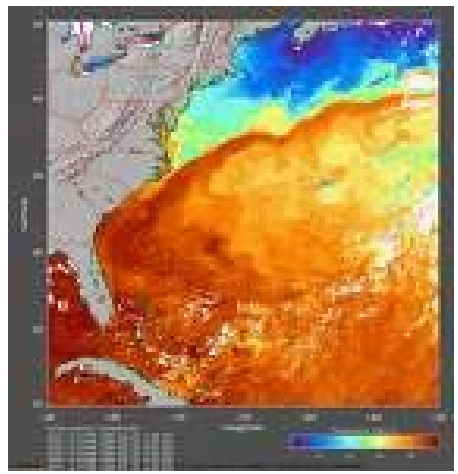
Alan Blinder from Princeton
Many curves have scale economies:
lower costs as volume increases

	Option 1: Obselete Technology (Still Currently Used)	Option 2: Standard High Efficiency Technology	Option 3: Better Effciency Technology
	4 T-12s	3 T-8s	3 T-5
	Magnetic Ballasts	Electronc Ballasts	Electronic Dimming Ballast
	Standard Fixture	3 Lamp trouffer	Optimized Fixture
	Manual On/Off	Timers	Occupancy Sensor and Light Sensor
Estimated Cost as standard	not available in new	$72.00	$72.00
Lamps wattage	160	96	84
Ballast energy	32	12	8
Ballast factor	0.95	0.9	0.8
Lumen watt ratio	60	85	105
Lumen Output	9120	7344	7056
Watts	182.4	97.2	73.6
Fixture efficiency	0.6	0.8	0.9
Delivered lumens to work surface	91.2	69.12	60.48
Switching off when not needed/On Hours	5000	3000	2500
kWh peak price Washington DC (includes demand charge)	$0.25	$0.25	$0.25
kWh charge off peak	$0.06	$0.06	$0.06
Desired Lumens to Work Surface	60	60	60
Overlighting	52%	15%	1%
Peak Hours	3000	3000	2500
Peak Hours Operating Cost per Year	$136.80	$72.90	$46.00
Off peak charges	$21.89	$0.00	$0.00
Cost of Operating	**$158.69**	**$72.90**	**$46.00**
kWh Saved/Yr	**0**	**620,400**	**728,000**

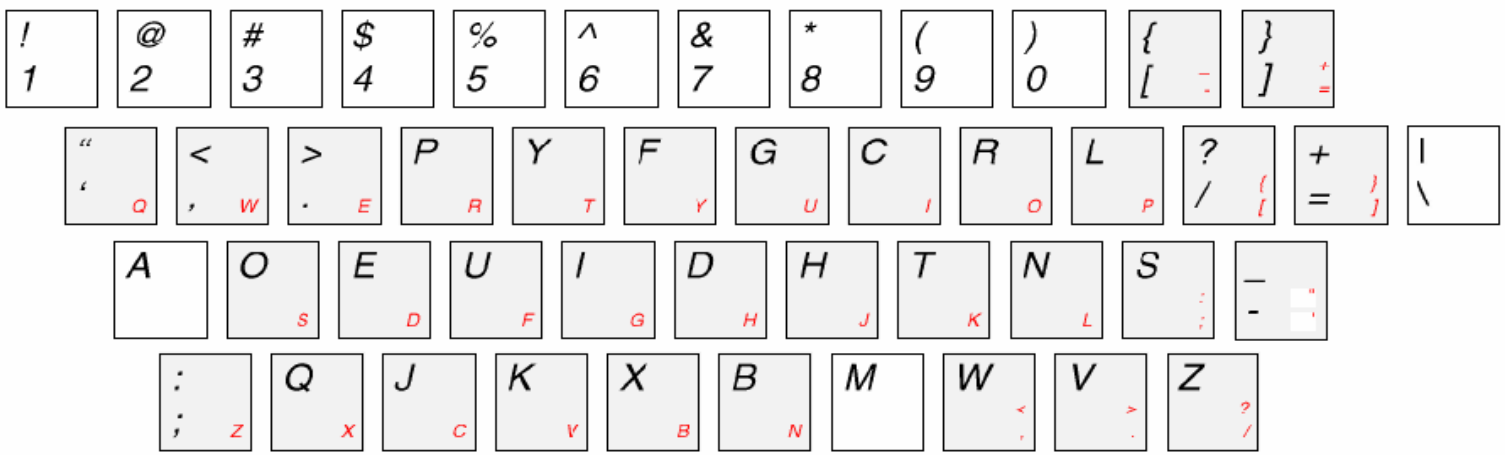
Transactions Bridge in Auto Sector
(go to www.mpgplus.org)



Lock Out: New Energy Supplies



Note
80% keystrokes on home row
vowels on left, consonants on right



Dvorak Keyboard Layout

Historical lock in causes:

Typists needed to be flexible

OEMS did not want to produce extra machines

Current:

Out of box use for adults, kids start learning on QWERTY

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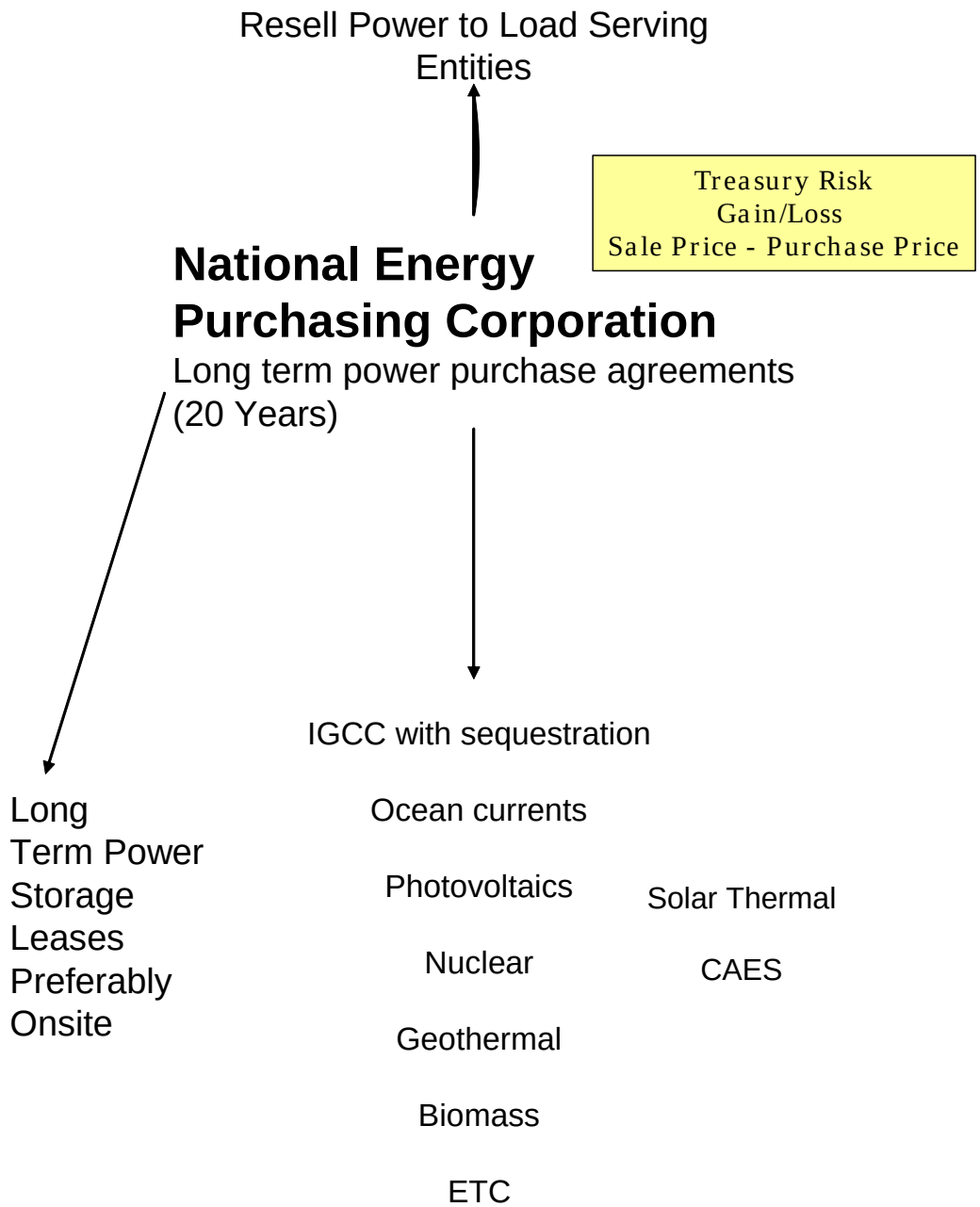
Obstacles for Low or No Carbon Options

- Lack of long term market for purchasing energy
  - Financing billion dollar projects without long term buyer almost impossible
  - Other obstacles cascade, creating lock in
    - Lack of commitment from manufacturers to create new technology
    - Lack of insurance
    - Lack of long term service agreements
    - Lack of experienced engineers


Resell Power to Load Serving Entities
Treasury Risk
Gain/Loss
Sale Price - Purchase Price
National Energy Purchasing Corporation
Long term power purchase agreements (20 Years)
Long Term Power Storage Leases Preferably Onsite
IGCC with sequestration
Ocean currents
Photovoltaics
Solar Thermal
Nuclear
CAES
Geothermal
Biomass
ETC

New Idea
Infrastructure Parity

- PVC Pipe: Natural gas companies pay for its installation to carry gas
  - Electric utilities do not pay for its installation to gather solar energy from ground
- Idea: Create Parity by expanding Electric Utility Payment on rate base for solar collecting ground loops
  - With loops geoexchange: 1 unit of electric energy moves up to 5 units for heating, hot water, cooling
  - With a 55% efficient combined cycle plant = 275% ‘Efficiency’
  - Best gas furnances/95% efficient
  - **NET: 67% Reduction in use of natural gas when powered by combined cycle power plants**

New Idea
Utilities finance efficient systems

- Green Credit Card
  - Super efficient houses etc
- Overcomes budget issues for buyers
- Supplements transaction bridges for system of products working together

New Concepts: Consistent with 60 Years of Prize Winning Economic Research

- Herb Simon (1957 Nobel Prize Winner)
  - Buyers satisfice not optimize
- Alan Blinder: Gordon S. Rentschler Memorial Professor of Economics at Princeton University;
  - former Vice Chairman of Federal Reserve and former member of Council of Economic Advisors
  - 90% industries declining or flat marginal costs
- Kahneman (2002 Nobel Prize Winner)
  - Decisionmakers make many errors in making decisions
  - Far from having capacity to make 'rational decisions
- Coase (1991 Winner of Nobel Prize)
  - Transaction costs always exist
  - Important: finding, evaluating, contracting, monitoring performance etc
  - One cannot understand existence of firm without transaction costs
- Oliver Williamson and many others
  - Expanded scope of work to show many imperfections within and between firms
- Brian Arthur: Increasing returns and path dependency
- Paul Romer, Stanford Professor
  - New growth theory
  - Technological change does not magically appear
  - Product of economic system
  - Much of the change outside market: scientists
  - Institutional issues dominate
- Learning by doing (Arrow: Nobel Prize Winner 1972)
- Douglas North (1993 Nobel Prize Winner)
  - Institutions, Institutional Change and Economic Performance
  - Economic transactions depend on myriads of
    - Laws
    - Customs
    - Organizations
    - Standards
    - Property rights
    - Performance varies with how well institutions contend with real problem and opportunities of the transaction streams
- Richard Nelson & Sidney Winter
  - Economy always of equilibrium

Summary of Evidence

- Economists wrong
  - Costs much lower than apparent
- Economists Wrong
  - Price rises not efficient or effective by themselves
- New Policy Options Needed Based on
  - Realistic portrayal of buying and producer behavior
- Modeling must be evolutionary to be useful

Most Significant Implementation Issues

- Business as Usual Attitudes
  - Failure to recognize grave threat of global warming and climate to human future
  - Failure to overcome inertia and act decisively
  - False claims of models that extrapolate past to future

The End

Supplemental Slides

Other Potential Opportunities for Strong Attractors

- Ocean Currents
- Solar Thermal
- Advanced Wind
- Safe nuclear
- GAX heating system
- CAES

New Options
Do Not Exclude Old

- Cap and Trade Advantages
  - Creates limit on emissions
  - Brings need for emissions reductions
  -
    - To top of agenda of many organizations
  - Will raise prices
- R&D Advantages
  - Utilizes more diverse resource pool: Universities etc.

National Power Purchase Corporation (NEPC) (Strong Attractor)

- Bids for LONG TERM MWH (20 Years):
  - Output of 10,000 MW per year
  - Long term power purchase agreements (PPAs)
  - Portfolio of Low or No Carbon Options
- NEPC re-sells MWH
- Bids for Storage of kWh
- Treasury Risk
  - Difference Between Buy and Sell Price
  - Resolution Risk: Could Go in Either Direction

New Idea: Strong Attractors to Overcome Lock In/Out

- Examples of strong attractors
  - Government creates guaranteed purchase (National Energy Purchasing Corporation)
  - Corporations band together to create guaranteed purchases
  - Households band together to create guaranteed purchases
- Risks become technological, not commercial
- Cost of being strong attractor
  - Exposure limited to commercial risk
  - Profit potential may eliminate any cost

Lock In/Lock Out Common
Many Fields

- Good technology is locked in or locked out
  - Qwerty Keyboard locked in
  - Superior Key arrangement Dvorak cannot gain market share
- CFC113 Production was locked in in 1980s for electronics cleaning
  - Military specifications required CFC113
  - Other options could not compete
- Future Energy Technology Locked Out Against Proven Technology
  - By Multiple risks {financial, technical, insurance etc)

Key Concepts of proposed transaction bridges

1. Producers AUTOMATICALLY share value of energy savings

2. Resulting benefits:

   – Reduced transaction costs

   – Reduced cost of introducing new products
     - Means quicker achievement of decreasing marginal cost with scale

   – Organizations will reward energy productivity producing behavior
     - Careers made off efficiency

   – Mark-up amplification eliminated from value chain

Energy Savings Opportunities Everywhere

- Current products can reduce energy use dramatically
- Un-commercialized proven technologies can save more
  - Greater market pull
- New Technology can produce even greater savings

Benefit of Marginal Costs For Energy Systems

- Current Situation
  - Inefficient goods sell more, price becomes lower
    - Scale economies lower price more
  - Efficient goods sell less, price becomes higher
    - Lack of scale economies increases prices
  - Pricing through distribution chain raises price differential even more
    - Mark up (gross margin) at each stage multiplies manufacturing cost difference
    - Anecdotal evidence that mark ups demanded are higher for ‘niche efficient products’
- Future
  - Lower costs/prices for efficient goods
    - Result from greater sales, thereby increasing economic benefit

Producers

- Limited number
- Many options unexplored
- Large Knowing/Doing Gap
- Marginal costs decline with volume
- Change can be abrupt

Stabilizing Human Forcing Will Not Stabilize Climate

- Lag in experiencing warming
  - Past emissions will continue to raise temperature/change climate for decades/centuries just from thermal lag
- As warming occurs, biogeochemical changes will occur
  - Increased respiration of soils
  - Increased forest fires/soil fires
  - Decline in ocean circulation/ carbon emissions
  - Methane hydrate emissions
  - Methane emissions from soils
  - MORE EMISSIONS
- Hadley group considering CO2 alone
  - Suggests nature will double forcing of humans

Magnitude of Climate Change Could Be Larger than Standard Range of Uncertainty

- Climate Net: Monte Carlo using many computer runs over internet
  - Tests one by one uncertainties
  - Extends range of possible warming to much higher level
  - Needed: Monte Carlo with many uncertainties simultaneously tested

- Paleo-evidence
  - Past forcings from orbital variations
  - Led to large changes in emissions
  - Consistent with mid range estimate of sensitivity
  - But boundary conditions will be different in future

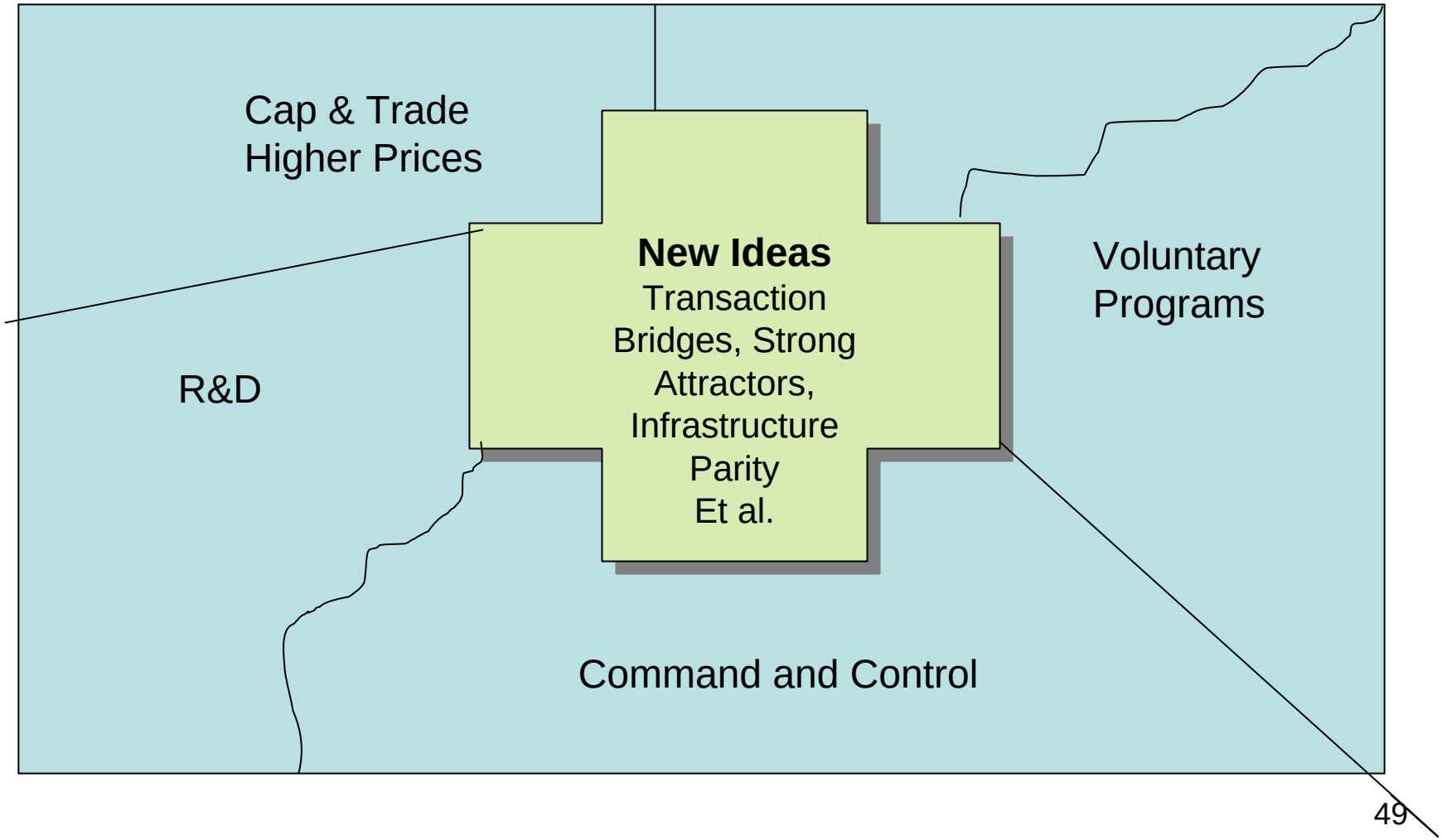
Stabilizing Human Forcing Climate

Total GHG= Sum (output* energy intensity per unit of output *GHG per unit of energy)

- Output: Economic activity including growth
- Energy Intensity per unit of economic activity
- GHG emissions per unit of energy

Probable Reductions Required
CO2: 90%
CH4: 25%
N2O: 90% (?)
HFC: 90%

New Ideas Can Work
to Make Old Solutions More Viable



IGCC: Potential Major Opportunity

- Coal widely available and inexpensive
- Gasification allows relatively inexpensive carbon sequestration
- Technologies not optimized but proven
  - Technological Improvement possible
  - Scale economies
- Power Costs could be below current average cost
- Barrel of diesel ~$30