Offsets

The macro consequences of project-based programs

JAE EDMONDS
21ST AIM WORKSHOP
TSUKUBA, JAPAN

November 14, 2015

This work was performed with support from Electric Power Research Institute.

U.S. DEPARTMENT OF ENERGY | Office of Science

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

UNIVERSITY OF MARYLAND

PNWD-SA-10213

Motivation

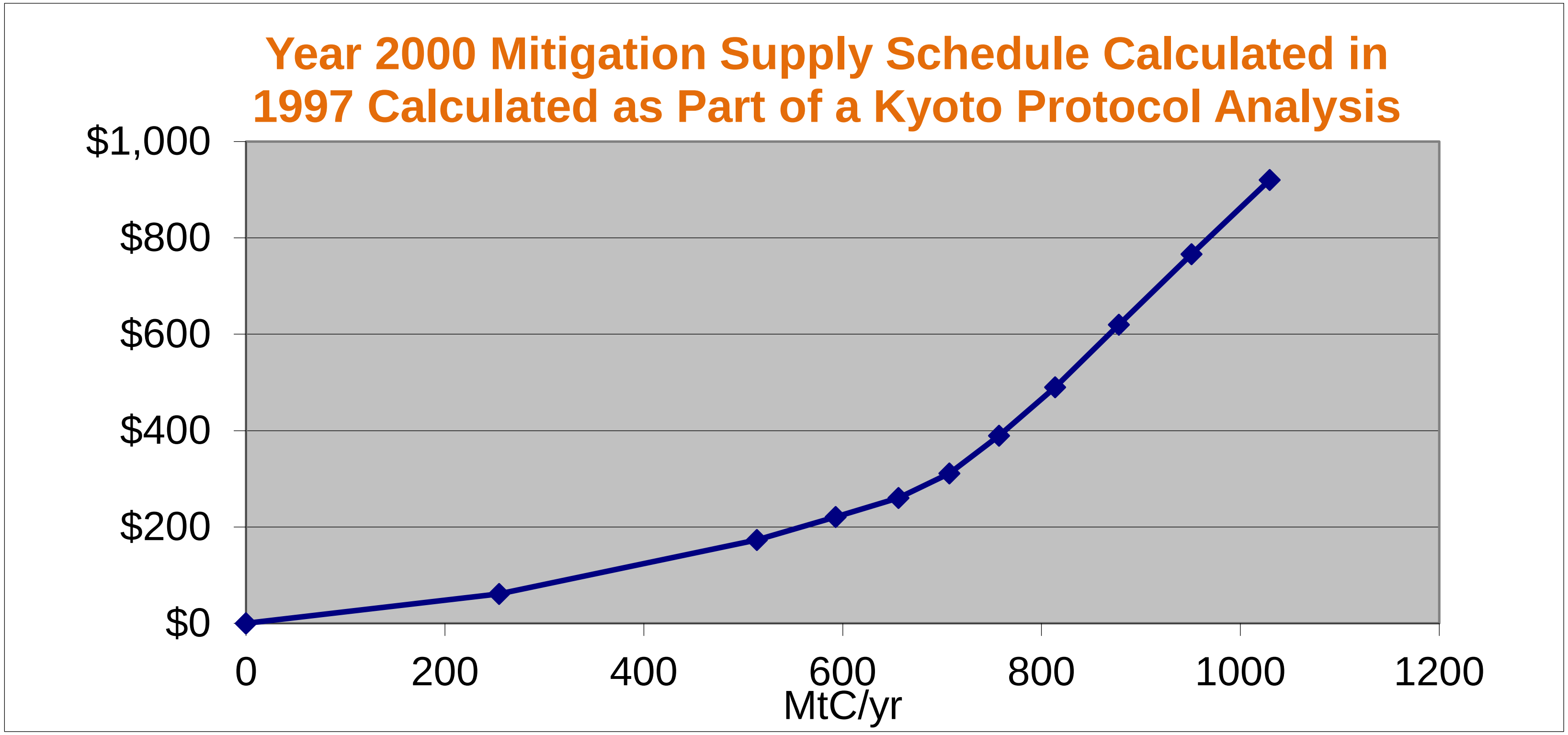
- ***Motivation**: Offsets were an important element of the Kyoto Protocol (KP) where they were called the Clean Development Mechanism (CDM), and many emissions mitigation proposals (e.g. McCain-Lieberman) include them.*
  - *They were designed to lower the overall cost of emissions mitigation, while expanding the scope of participation.*
  - *As we move into the Post-KP world they are worth another look.*

- Today's presentation is based on work performed as part of an EPRI program designed to improve our ability to quantify the potential of offsets programs. It was published recently in *Climatic Change*:
  - Calvin, Katherine, Steven Rose, Marshall Wise, Haewon McJeon, Leon Clarke, and Jae Edmonds. "Global climate, energy, and economic implications of international energy offsets programs." *Climatic Change* (2015): 1-14.

BACKGROUND

Supply Incentives for Offset Suppliers

- Past estimates of offset supply potential was based on the assumption that offsets programs, behaved more or less like tax programs.
- They were modeled by applying a carbon price to an economy or sector and then scaling the result based on judgement.



- **But this approach is inconsistent with how offset markets operate in practice.**

Supply Incentives for Offset Suppliers

- In offset sectors, economic agents are rewarded for undertaking qualifying activities.
- Emissions are not priced, and there is no emissions cost for non-participants. (In contrast to a carbon tax or permit price)
- **Qualifying activities are assigned a level of emissions mitigation based on rules**
  - Intended to ensure that only activities that truly reduce emissions are credited for sale in the carbon market.
  - This is called the additionally criterion.
  - Additionally is tested at the project scale.

The Bottom-up Offsets Literature

- There is a large literature looking at offsets and their implementation, particularly in the context of the Clean Development Mechanism under the Kyoto Protocol.
- The core question of the bottom-up offsets literature is, “additionality”
- How do we know that the a party, seeking compensation for a desired action, e.g. installing a wind turbine, would not have undertaken the action had there been no offsets program?
- In the work that we have done, *additionality* is **NOT** an issue. We use a model that provides us with perfect information about what would have happened in the absence of an offsets program. So, we never issue any offsets that do not satisfy additionally.
- However, we can compare the sum of emissions credits issues (the bottom-up calculation) to global emissions reductions.

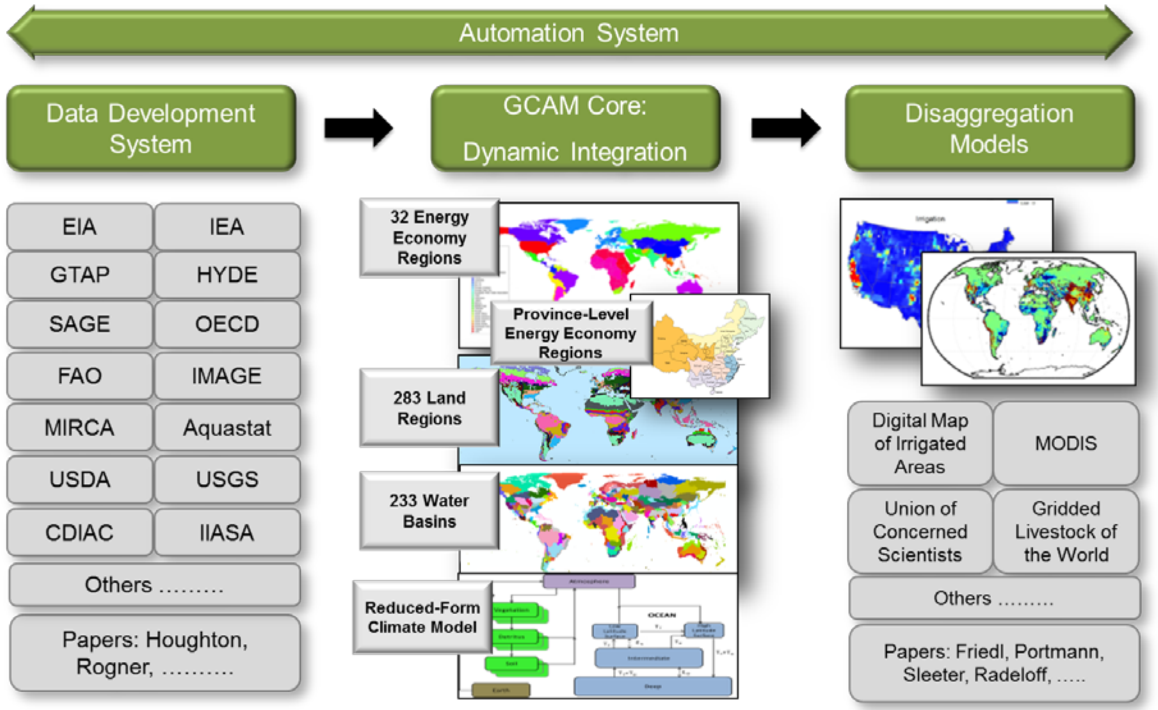
Our question

- Our question is more fundamental: How does the perfect implementation of an offsets program change the behavior of the global energy-economy system and its emissions?
  - How close do offsets programs come to delivering economic potential?
  - How well do offset credits reflect emissions mitigation?
- Our principle conclusion is that global system emissions mitigation is not equivalent to either
  - The sum of individual offset credits, or
  - A cap-and-trade system.
- This is because offsets are a subsidy for deploying desired technologies, which is different than a tax, which penalizes undesired technologies.

Numerical experiments use GCAM

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by **Battelle** *Since 1965*

- The Global Change Assessment Model (GCAM) couples representations of the economy, energy system, agriculture and land-use system, water, and climate system.
- Significant technology detail within energy supply and demand



- A Community Model, download at: http://www.globalchange.umd.edu/models/gcam/download/

APPROACH

Focus and Approach

Focus: **Offsets program for electric power in non-Annex I regions plus the former Soviet Union**

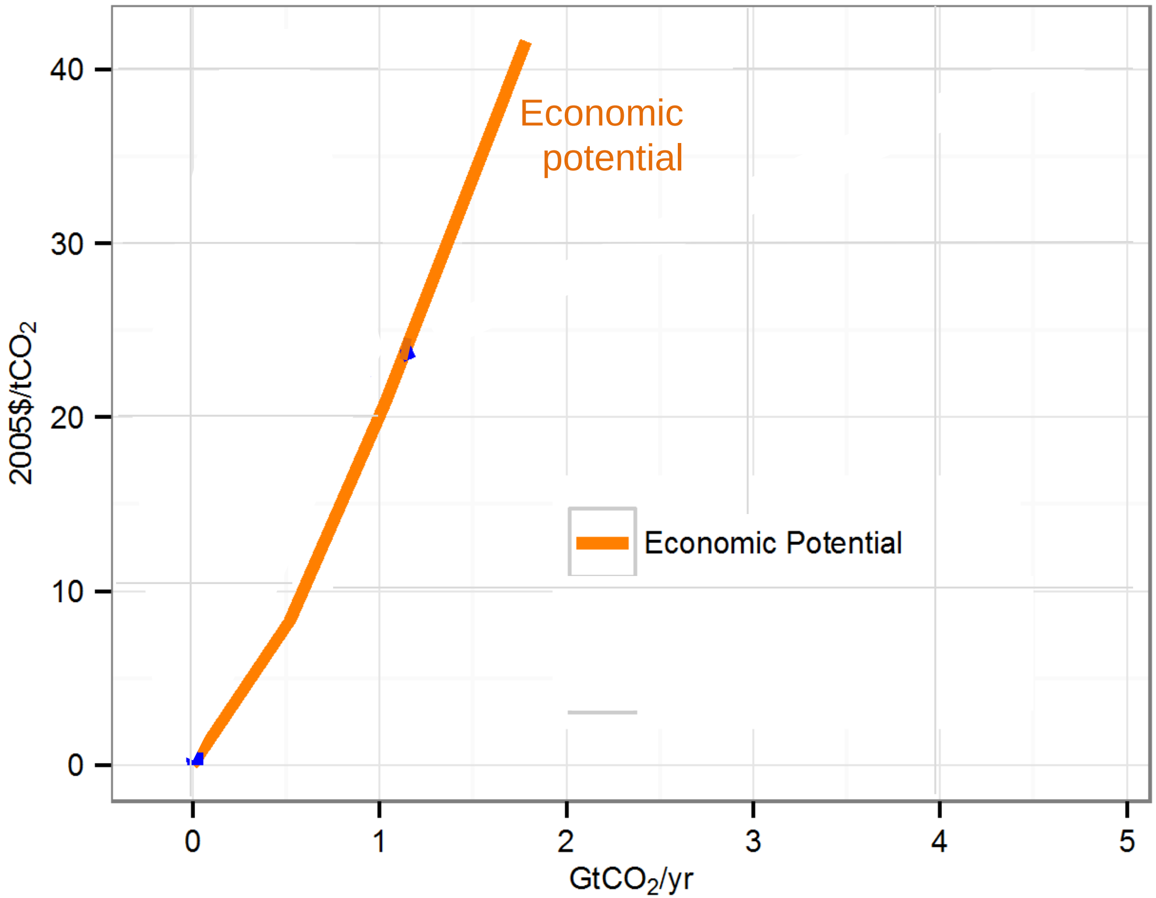
- **And non-electric energy as a sensitivity**

Approach: Run GCAM to produce the following pathways

- **Baseline**, no offsets program (update of RCP 4.5 Ref)
- **Conventional mitigation supply schedule** (use carbon taxes to map out a conventional mitigation supply schedule)
  - **At each point in time, with a focus on 2020**
- **Offsets program**—at each point in time with a focus on 2020
  - Credits supplied to the market (the bottom-up estimate of mitigation)
  - Net change in global emissions (relative to baseline)

International Energy Offsets 2020

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle *Since 1965*



International Offsets Supply

Offset Crediting

- Prescribed abatement credits for each technology relative to its crediting baseline.
- Only above baseline deployment is eligible for credits & payment.
- Crediting baselines considered
  - *Operating Margin (OM)*: better than average energy mix emissions factor
  - And as sensitivity cases:
    - Operating Margin variant with no crediting for advanced fossil fuel technologies
    - *Build Margin*: Better than the average for recent builds
    - *Combined Margin*: Weighted combination of Operating & Build Margins

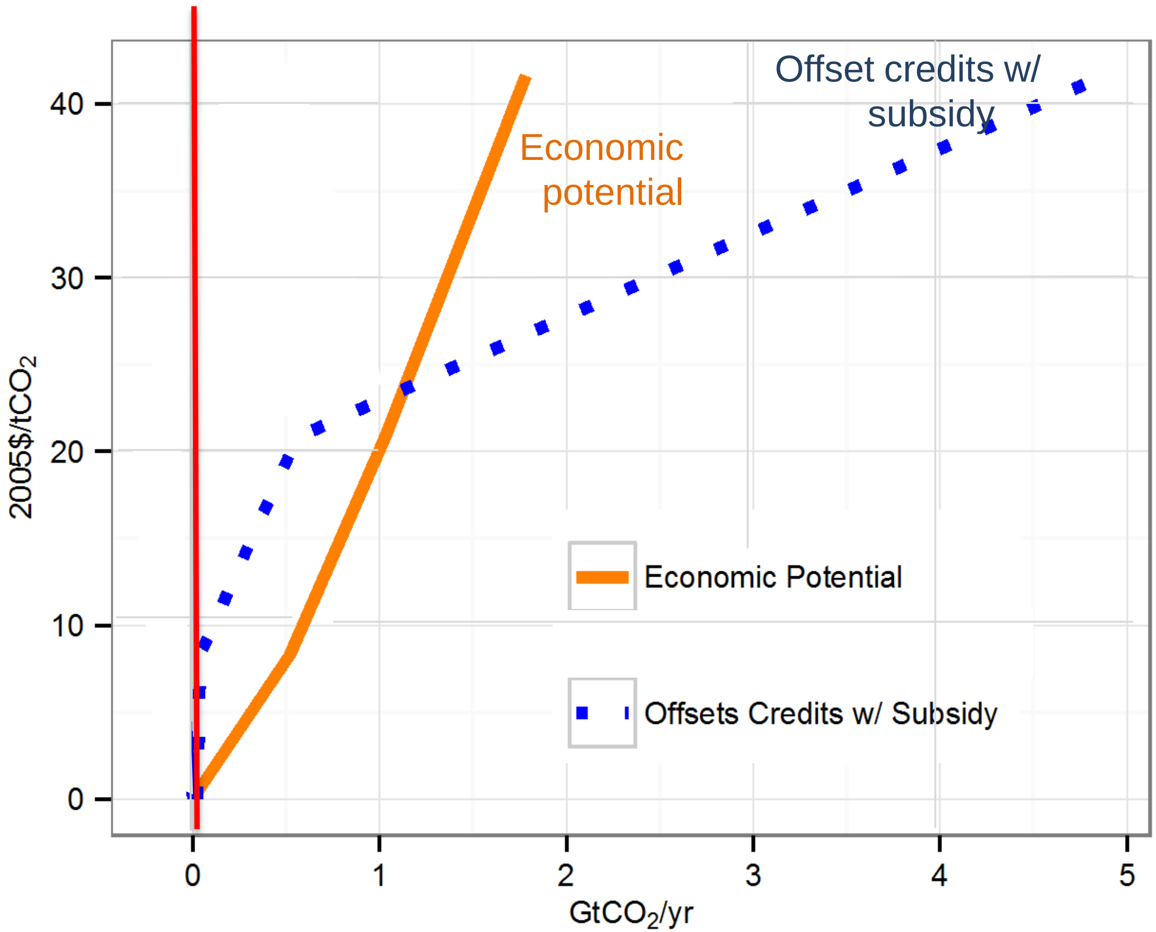
Start here

Offset Crediting Protocol for 2020 Using Operating Margin (OM) Method

Operating Margin Method	
Sector Coverage	Electric Utilities
Eligible Activities	New power generation facilities for which CO_2/kWh is lower than the average for the power sector in the GCAM reference scenario (without offsets). Only technology deployment above the GCAM reference scenario is eligible.
Offset Supplying Regions	China, India, Other south and east Asia, the former Soviet Union, Mideast, Africa, Latin America
Program Start Date	January 1, 2015
Year for which potential supply is estimated	2020
Offset Calculation	Difference between facility emissions (CO_2/kWh) and power sector average in the reference scenario, times the power produced by the facility.

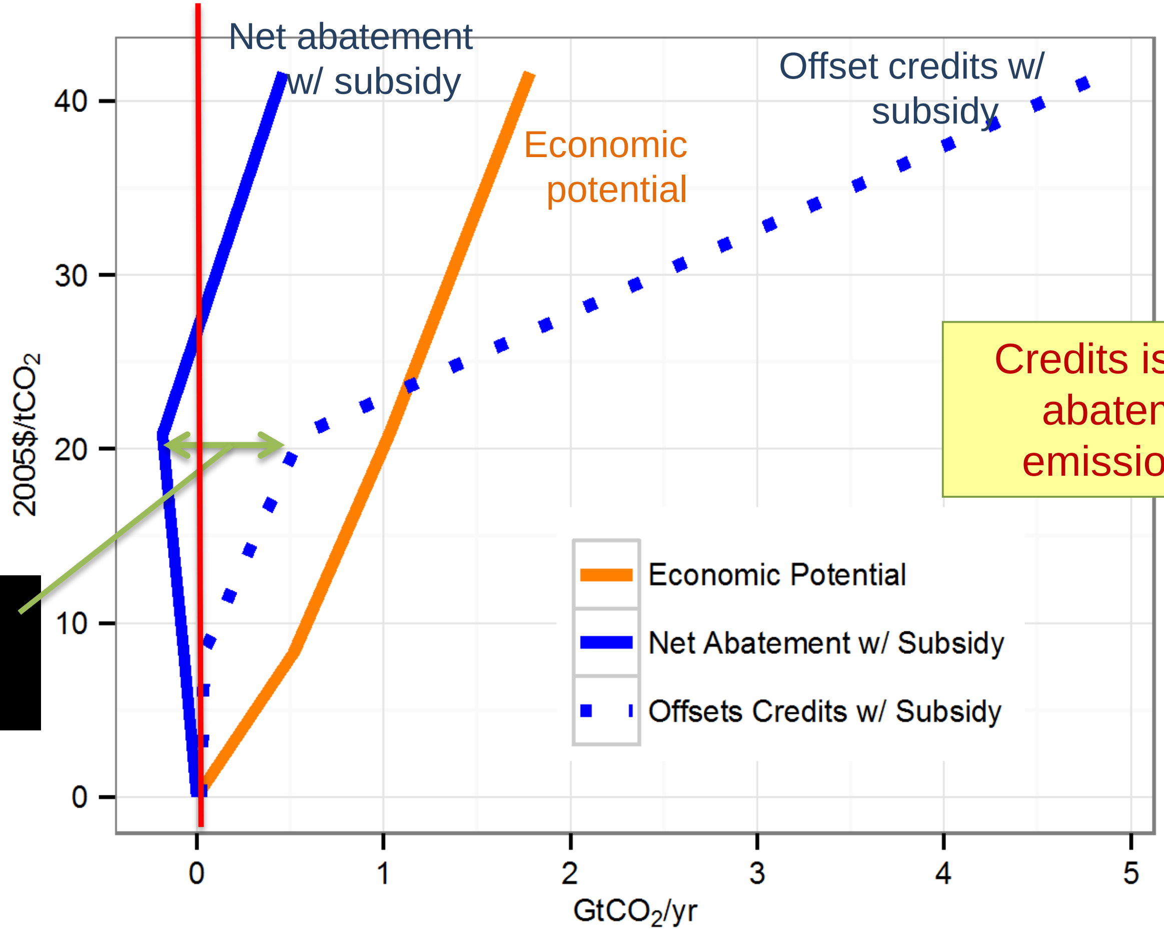
International Energy Offsets 2020

Operating Margin: crediting for above baseline deployment and better than average energy mix emissions.



International Energy Offsets 2020

Operating Margin: crediting for above baseline deployment and better than average energy mix emissions.



Credits issued exceed abatement (and net emissions increasing)

Overpayment ~$12 billion at $20/t$CO_2$

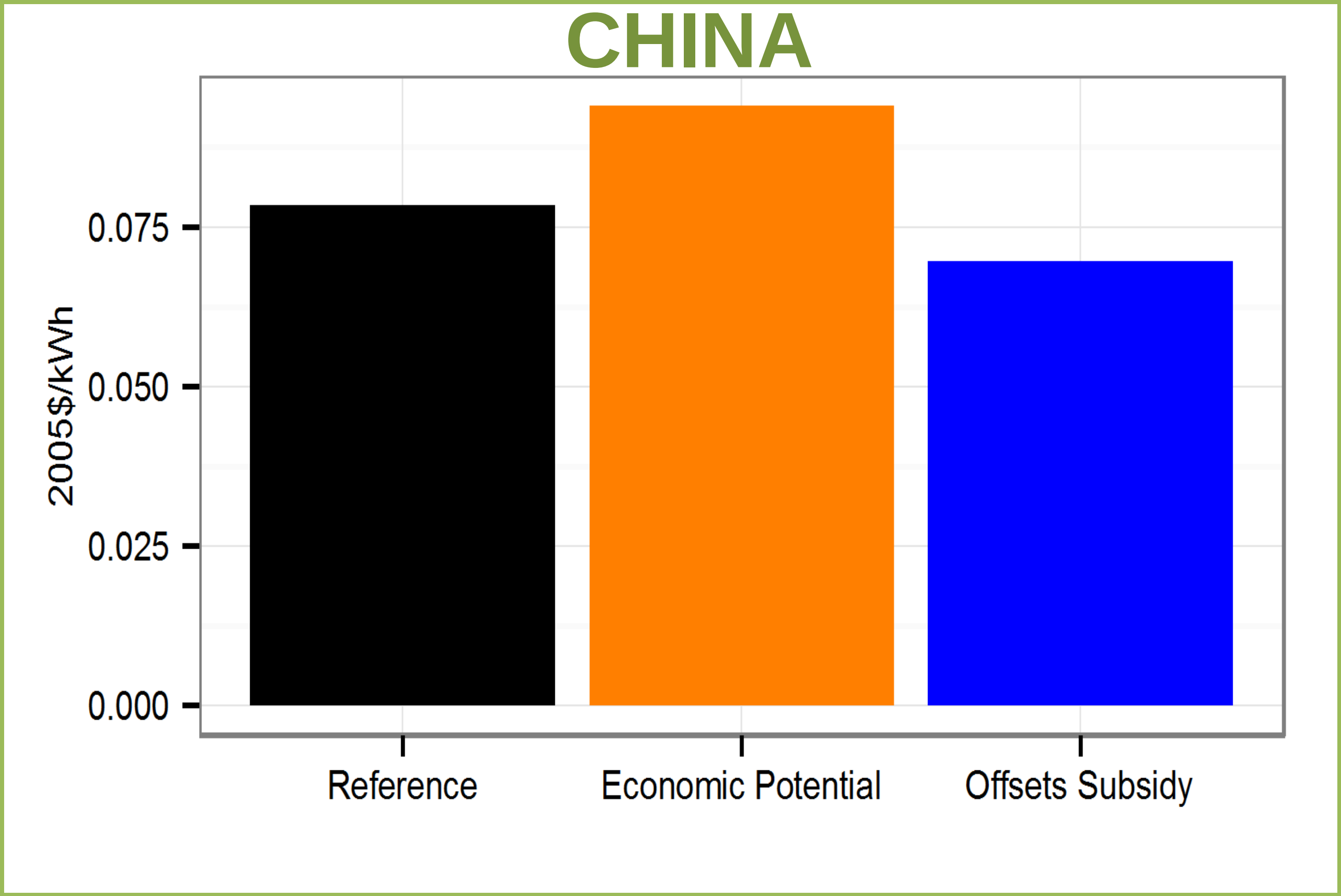
Factors driving results

- Offsets act as a subsidy to lower-emission investments
- Subsidies and taxes are not interchangeable.
  - Relative price effects of subsidies and taxes are the same, BUT
  - Scale effects are opposite in sign.

- Relative Price Effect
  - The offset subsidy shifts the relative price and power mix in favor of non-emitting technologies.
  - In that way the effect is the same as a carbon tax.

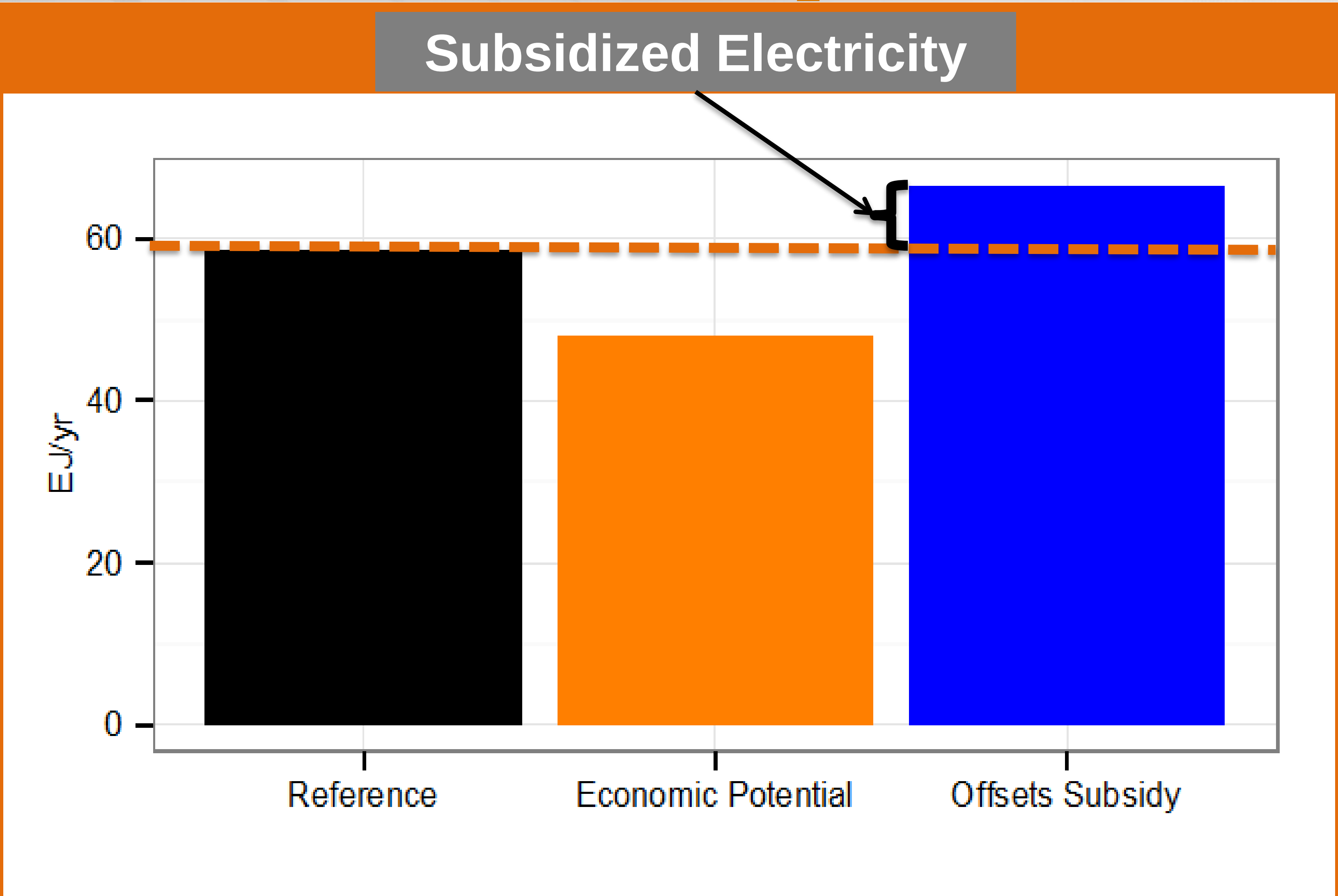
- The Scale Effect
  - The subsidy lowers the cost of electricity, which **increases** electricity demand.
  - The carbon tax has exactly the opposite effect.
  - The tax raises the cost of electricity, which **decreases** electricity demand.

Electricity Prices in 2020 with a $20/tonCO_2$ Price



Comparison of Power Generation Characteristics in 2020 with a $20/tonCO_2$ Price in Three Cases: Reference Scenario, Economic Potential, and the OM Method of Offsets Creation

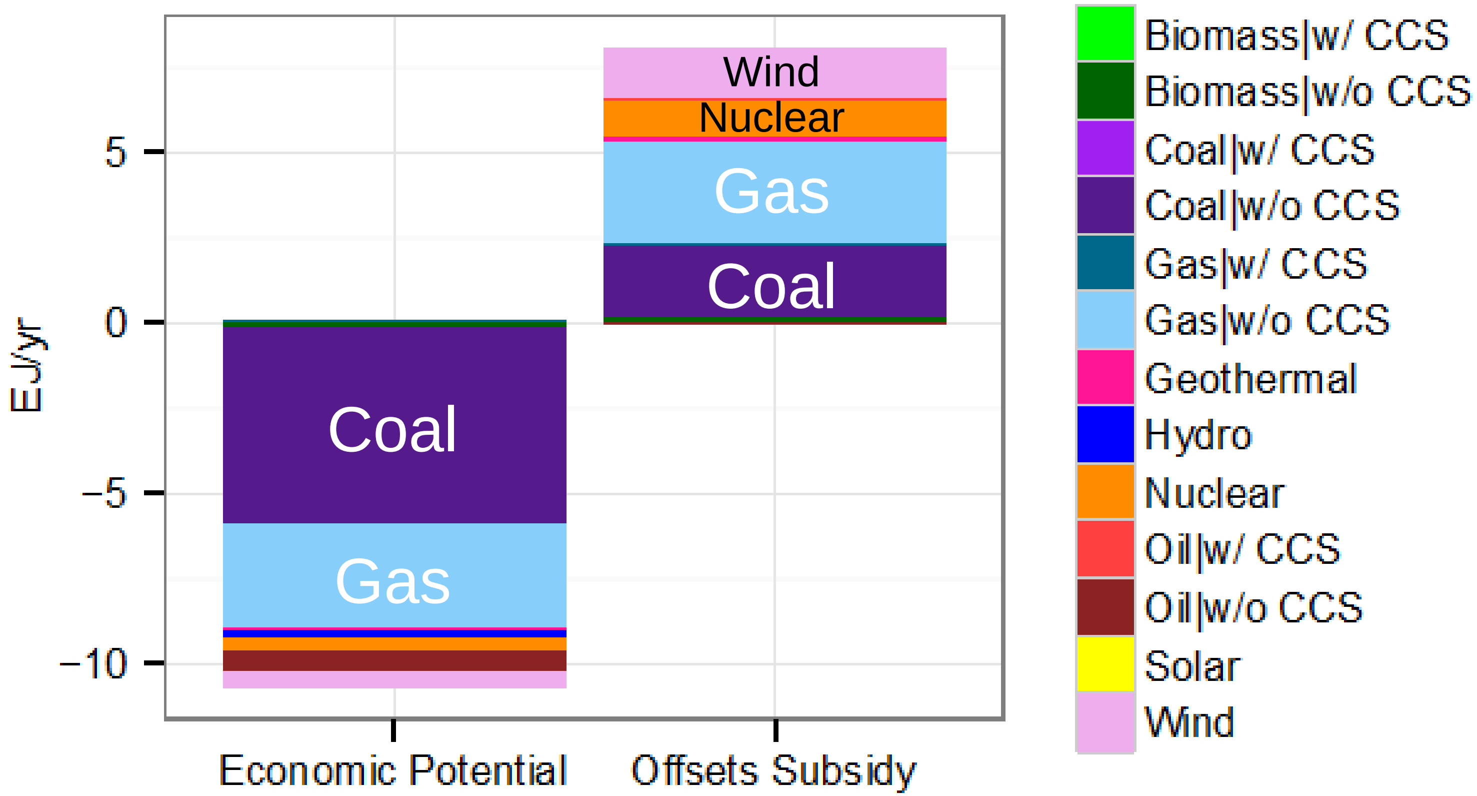
International Electricity Generation in 2020 with a $20/ton$CO_2$ Price



Total Electricity Generation in Offset-Supply Regions in 2020 with a $20/ton$CO_2$ Price in Three Cases: Reference Scenario, Economic Potential, and the OM Method of Offsets Creation

International Generation 2020 Differences from Baseline (with $20/t$CO_2$)

- Change in Electricity Generation by Fuel Type in Offset-Supply Regions in 2020

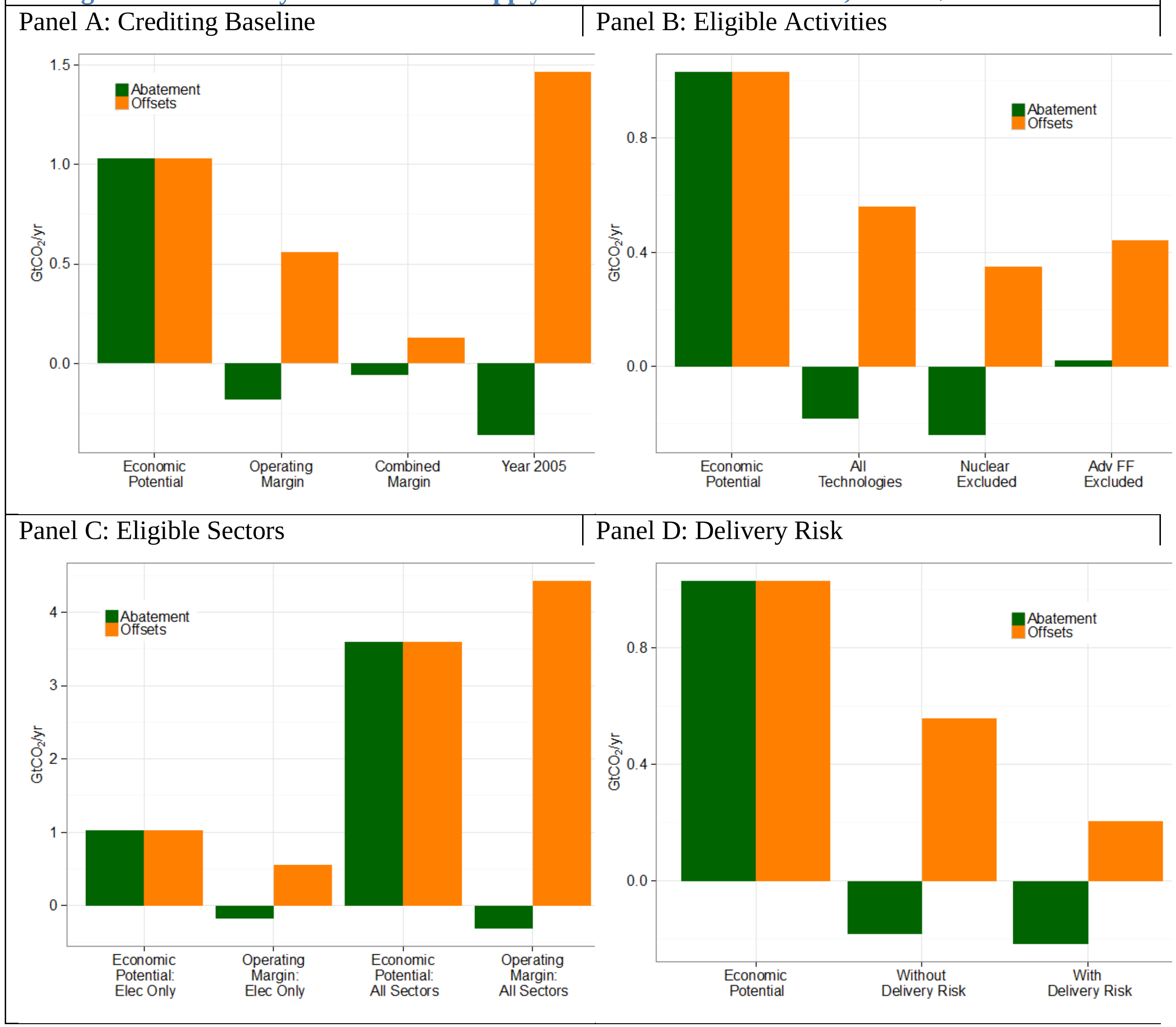


Four Offset Program Design Sensitivities

- Crediting baseline
- Technology eligibility
- Sectoral inclusiveness
- Delivery risk reduces

- *No program design delivers the economic potential and*
- *Credits never equal net mitigation.*

Figure 3: Sensitivity of 2020 Offset Supply and Emissions Abatement, with a $20/tCO2 Price



Pacific Northwest NATIONAL LABORATORY

Proudly Operated by Battelle *Since 1965*

OFFSETS IN A HYPOTHETICAL INTERNATIONAL MITIGATION PROGRAM

GHG Market Implications of International Energy Optional Participation?

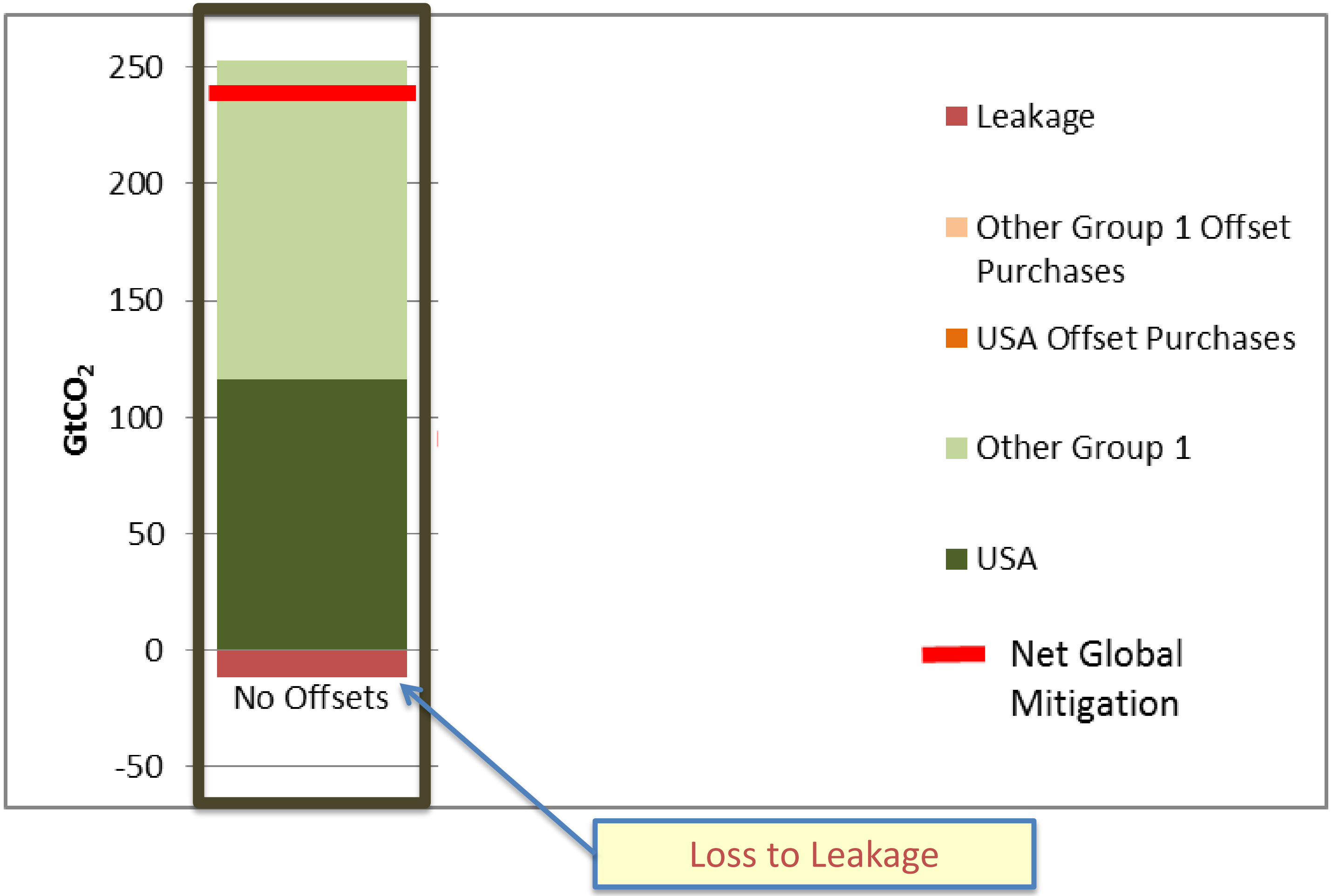
- Group 1 (Annex1 less FSU) emissions constraint scenario
  - Energy CO_2 emissions limited to 80% below 2005 levels in 2050
  - No banking
- International demand for offsets
  - Kyoto group (less FSU) energy CO_2 emissions limited to ~80% below 2005 in 2050.
- "Rest of world" optional participation offset suppliers with international energy CO_2 only. No annual limit on offset use.
- Operating margin offset crediting for above baseline deployment.

GHG Market Implications
(Int'l energy offsets & mitigation)

US, Other Group 1 and Global cumulative mitigation, Offsets, and Leakage: 2020-2050

GHG mkt scenario

- US + Other Group 1 energy CO_2 80% below 2005 in 2050



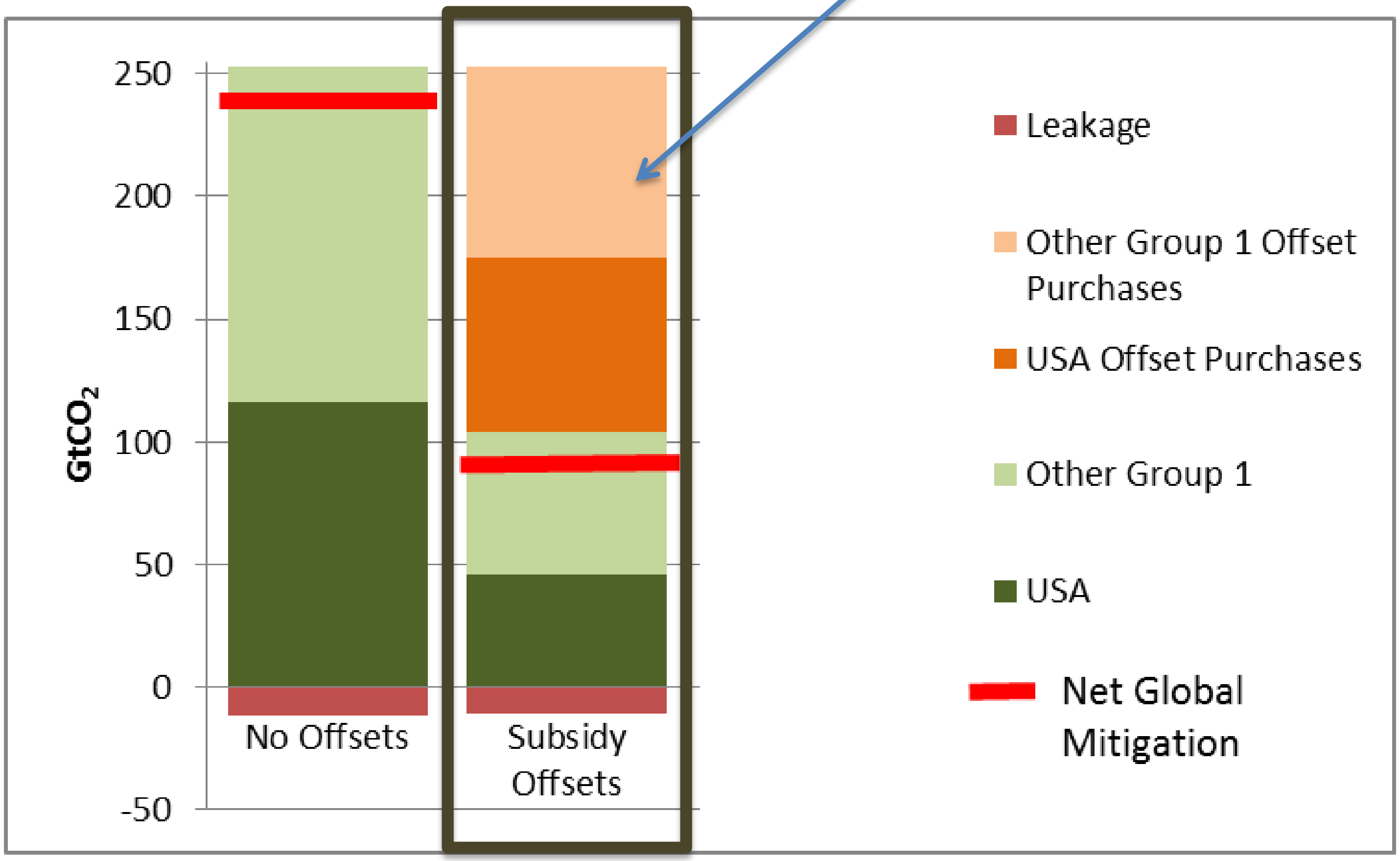
GHG Market Implications
(Int'l energy offsets & mitigation)

Significant use of offset credits

US, Other Group 1 and Global cumulative mitigation, Offsets, and Leakage: 2020-2050

<u>GHG mkt scenario</u>

- •US + Other Group 1 energy CO_2 80% below 2005 in 2050
- •International energy offsets permissible
- •KP ratifying countries (less Russia) similar CO_2 targets

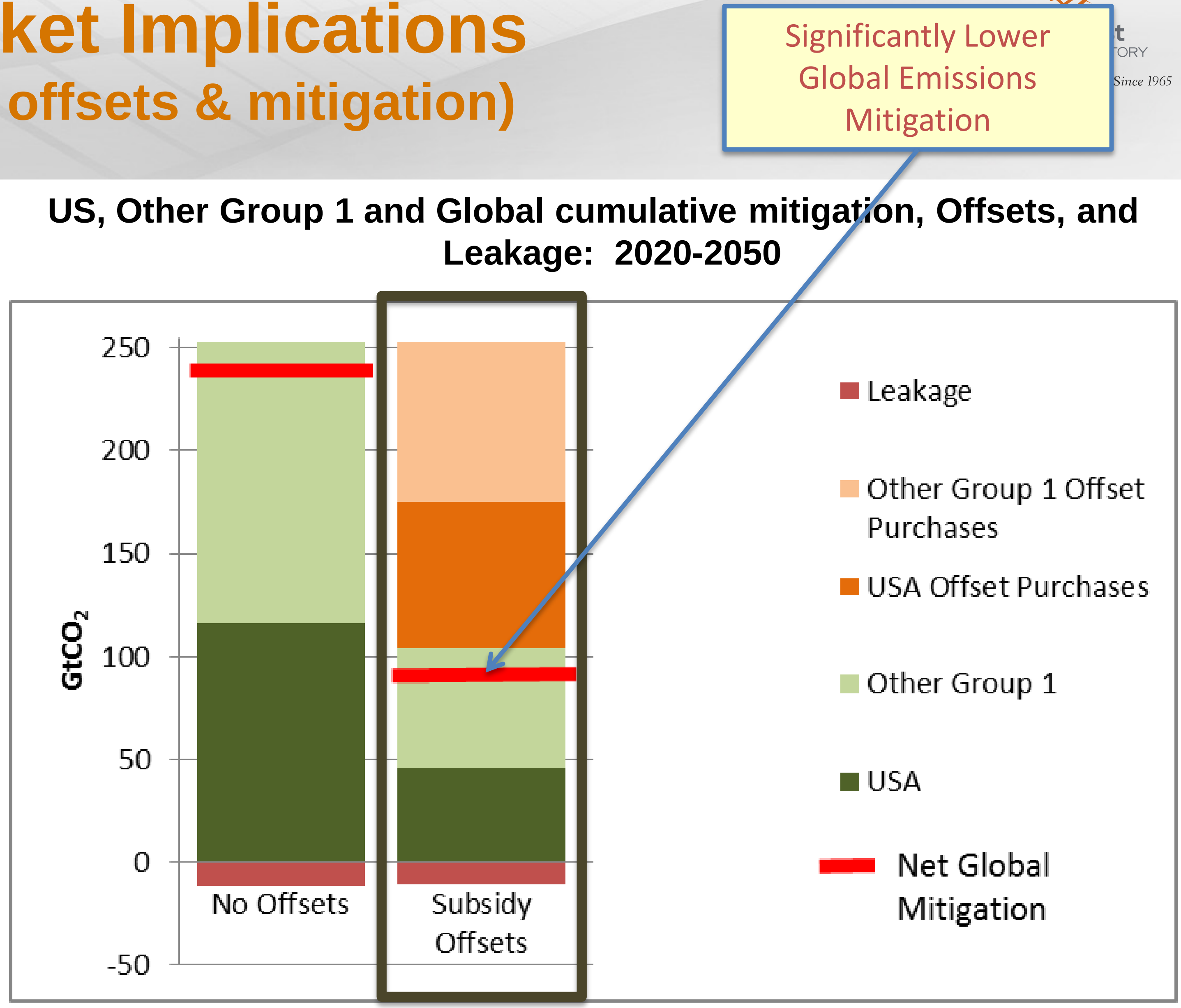


GHG Market Implications
(Int'l energy offsets & mitigation)

US, Other Group 1 and Global cumulative mitigation, Offsets, and Leakage: 2020-2050

GHG mkt scenario

- US + Other Group 1 energy CO_2 80% below 2005 in 2050
- International energy offsets permissible
- KP ratifying countries (less Russia) similar CO_2 targets



GHG Market Implications
(Int'l energy offsets & mitigation)

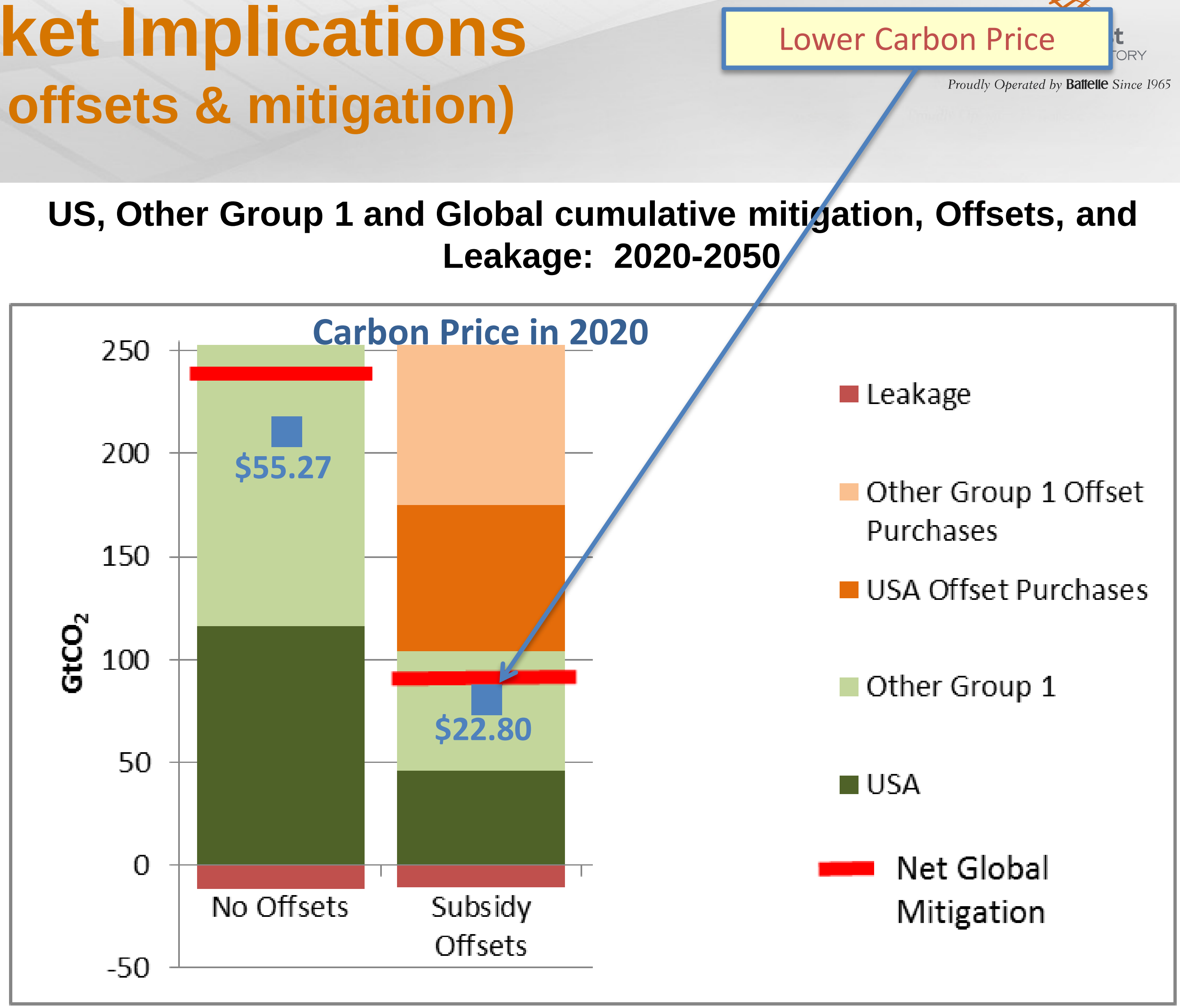
US, Other Group 1 and Global cumulative mitigation, Offsets, and Leakage: 2020-2050

GHG mkt scenario

•US + Other Group 1 energy CO_2 80% below 2005 in 2050

•International energy offsets permissible

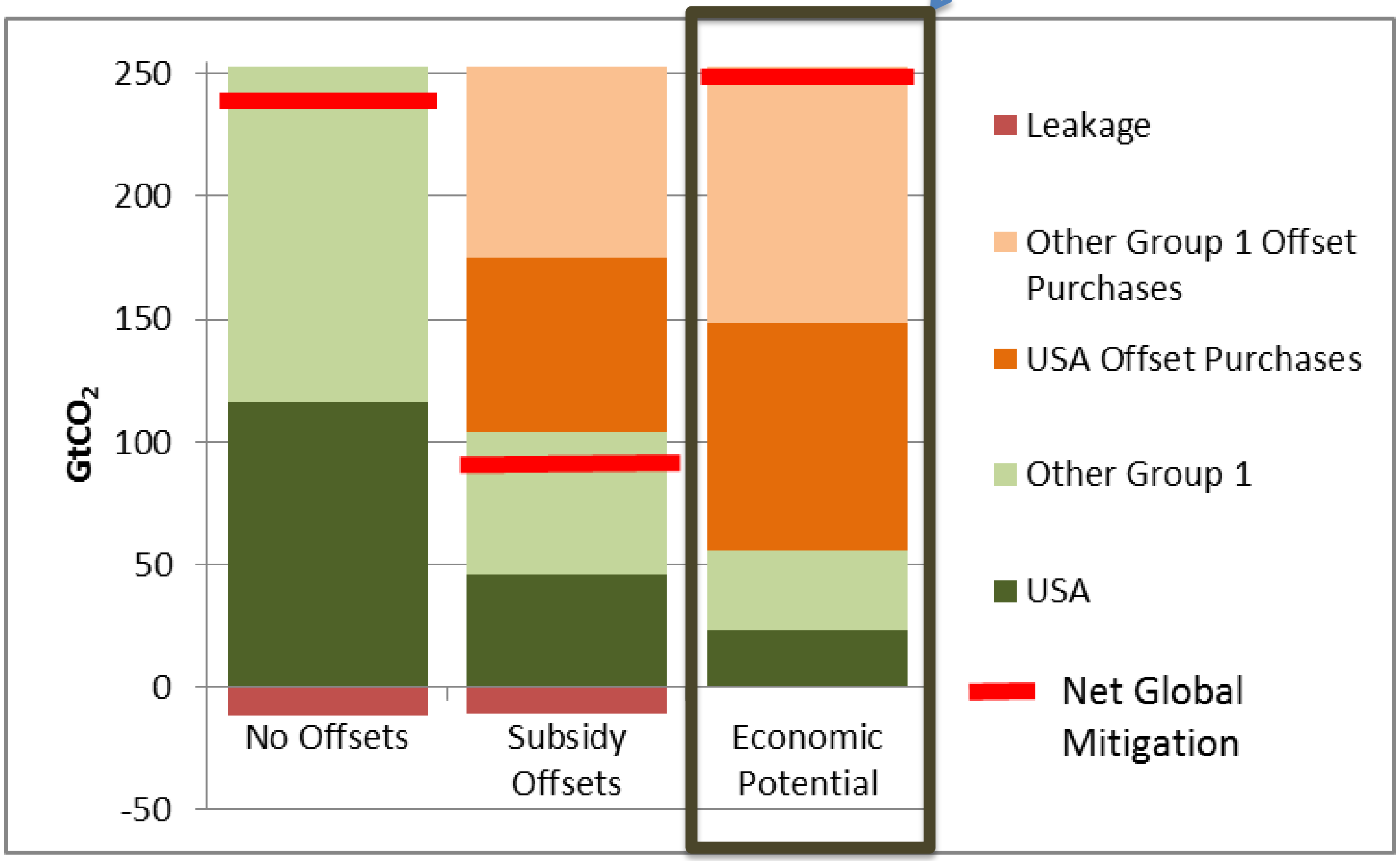
•KP ratifying countries (less Russia) similar CO_2 targets



GHG Market Implications
(Int'l energy offsets & mitigation)

Very Little Mitigation Potential Captured

US, Other Group 1 and Global cumulative mitigation, Offsets, and Leakage : 2020-2050



GHG mkt scenario

•US + Other Group 1 energy CO_2 80% below 2005 in 2050

•International energy offsets permissible

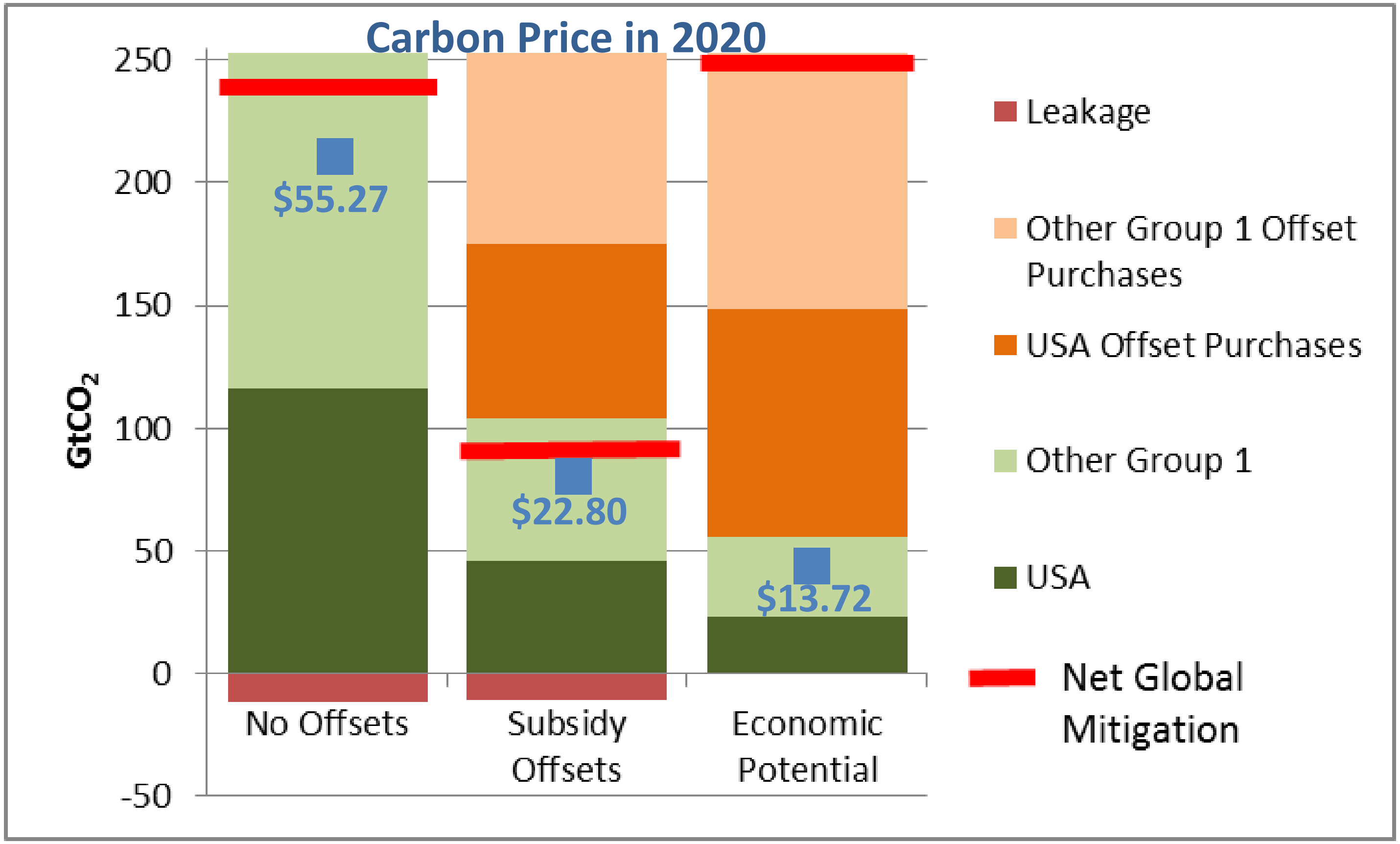
•KP ratifying countries (less Russia) similar CO_2 targets

GHG Market Implications
(Int'l energy offsets & mitigation)

US, Other Group 1 and Global cumulative mitigation, Offsets, and Leakage: 2020-2050

GHG mkt scenario

- •US + Other Group 1 energy CO_2 80% below 2005 in 2050
- •International energy offsets permissible
- •KP ratifying countries (less Russia) similar CO_2 targets



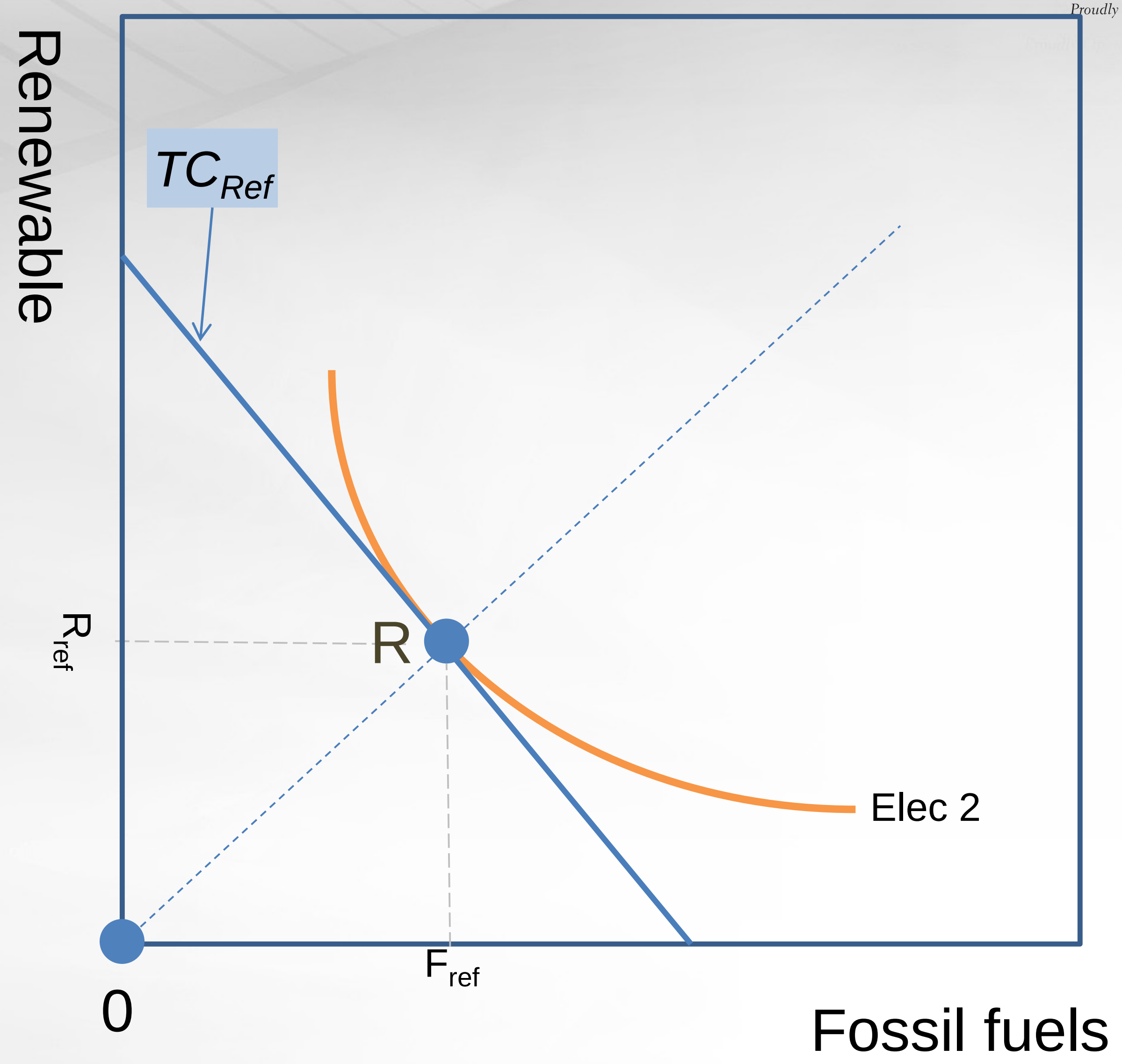
Key Messages

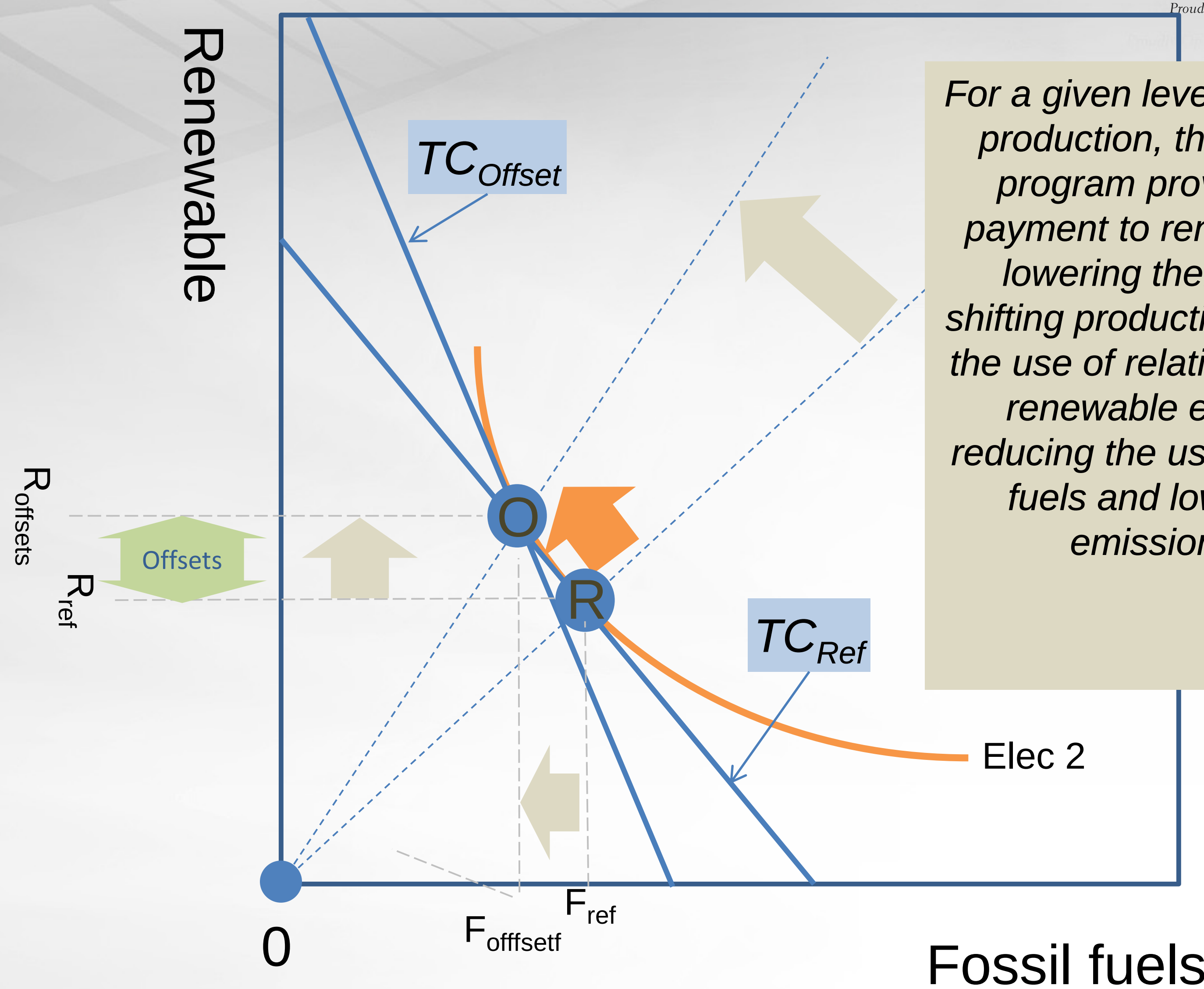
- Offset supply incentives should be modeled in estimating offset supplies
  - Responses to offset supply participation incentives can be very different from responses to the pricing of emissions
  - Actual GHG emissions abatement achieved in response to offset supply incentives could be less than the offset credits issued, or even negative
- Possible policy design ramifications
  - Integrity implications for emissions caps/targets and linked trading systems.
  - Crediting scheme is important, but practical effective design needs to be done with great care.
- Investment risks and transaction costs also important issues for supply – e.g., investment risks reduce near-term aggregate supply over 50% (80% for some sectors)
- This study is relevant to offsets writ large and other market contexts

DISCUSSION

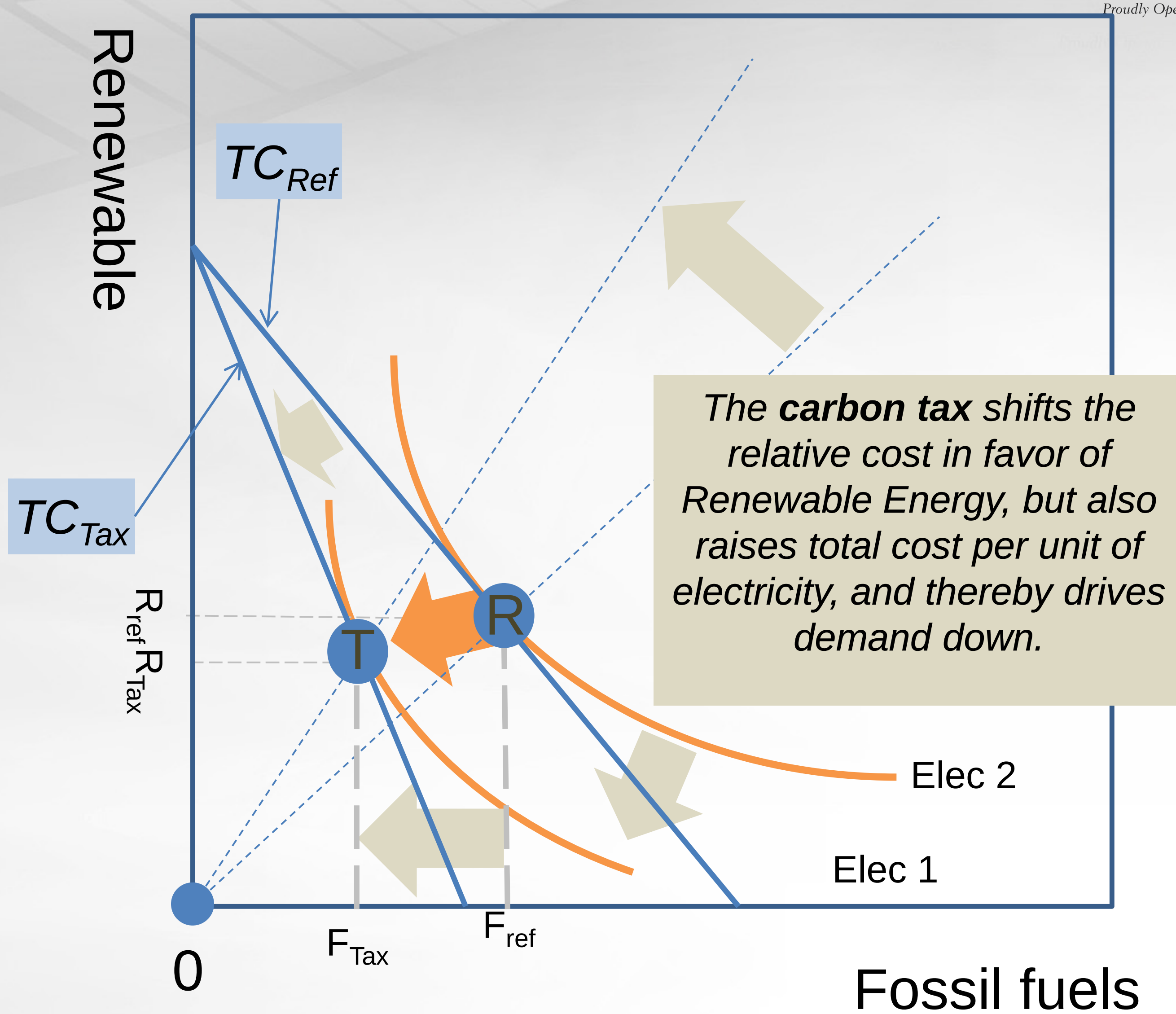
Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

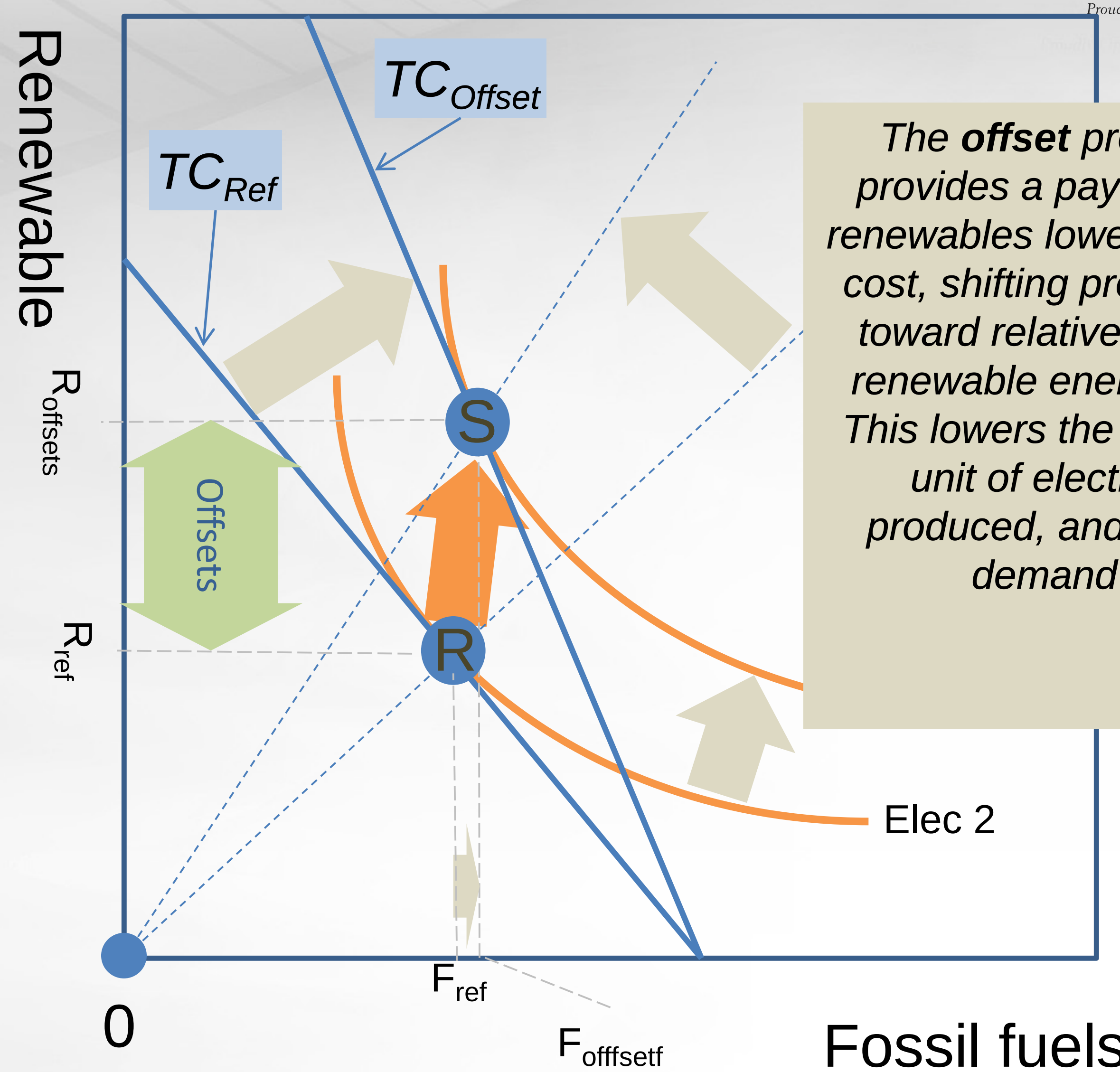
BACKUP SLIDES


Renewable
TCRef
Rref
R
Elec 2
Fref
0
Fossil fuels

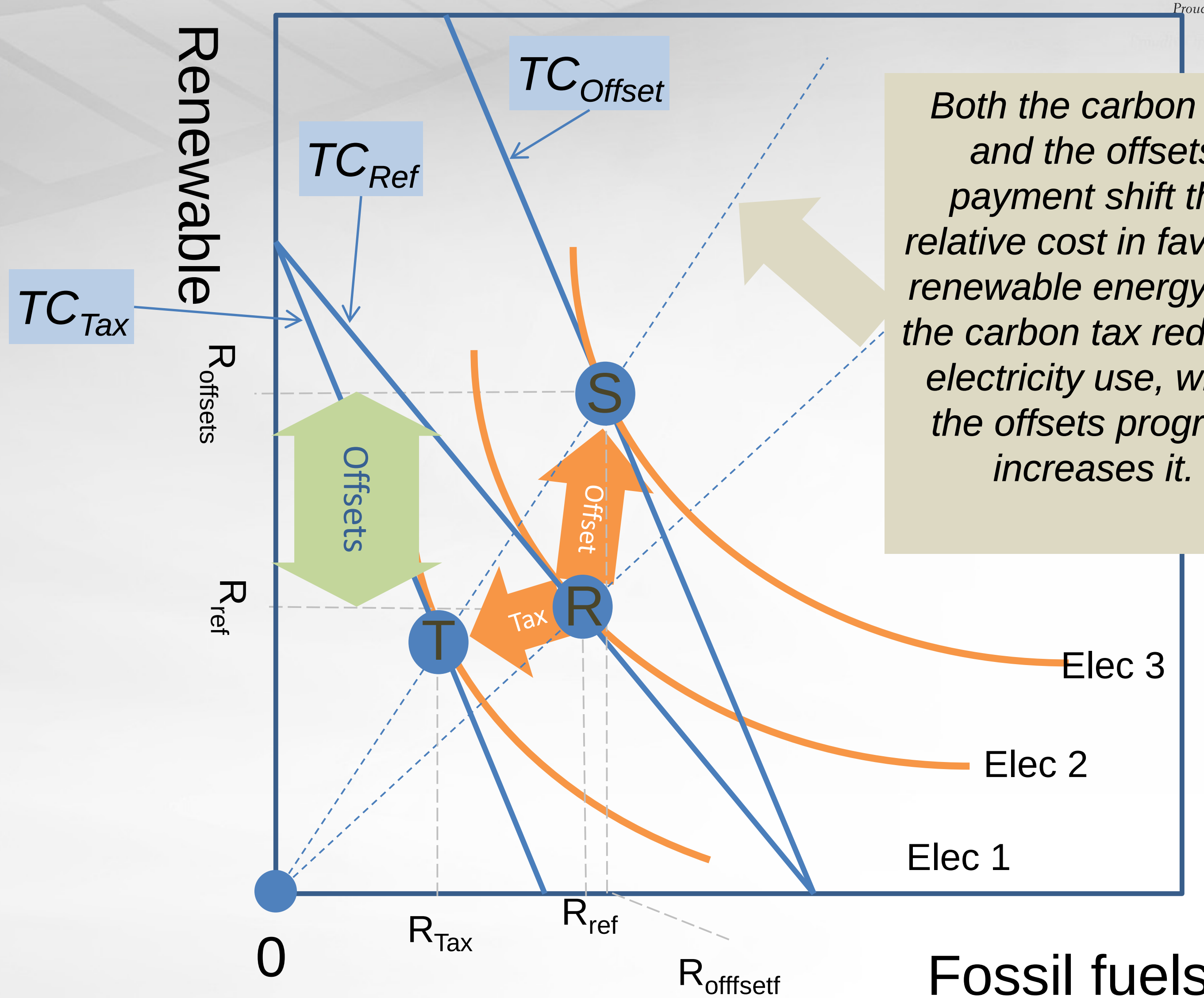


*For a given level of power production, the **offset** program provides a payment to renewables lowering their cost, shifting production toward the use of relatively more renewable energy, reducing the use of fossil fuels and lowering emissions.*


Renewable
TC_{Ref}
TC_{Tax}
R_{ref}
R_{Tax}
T
R
The **carbon tax** shifts the relative cost in favor of Renewable Energy, but also raises total cost per unit of electricity, and thereby drives demand down.
Elec 2
Elec 1
0
F_{Tax}
F_{ref}
Fossil fuels



*The **offset** program provides a payment to renewables lowering their cost, shifting production toward relatively more renewable energy use. This lowers the cost per unit of electricity produced, and raises demand .*



Both the carbon tax and the offsets payment shift the relative cost in favor of renewable energy, but the carbon tax reduces electricity use, while the offsets program increases it.

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

SENSITIVITY SLIDES

Pacific Northwest NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

Sensitivity to CREDITING BASELINE

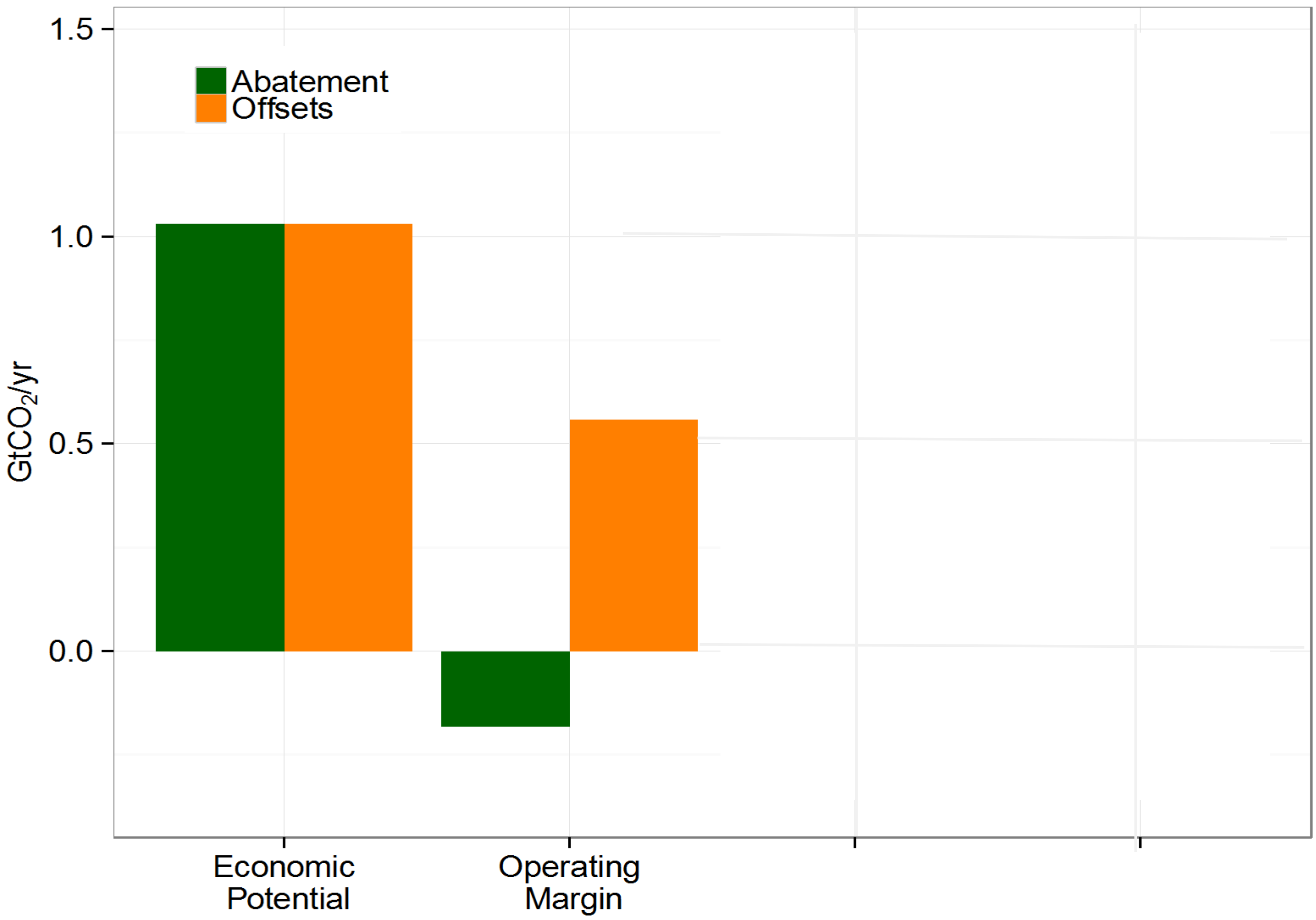
Alternative Crediting Baseline Assumptions

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by **Battelle** *Since 1965*

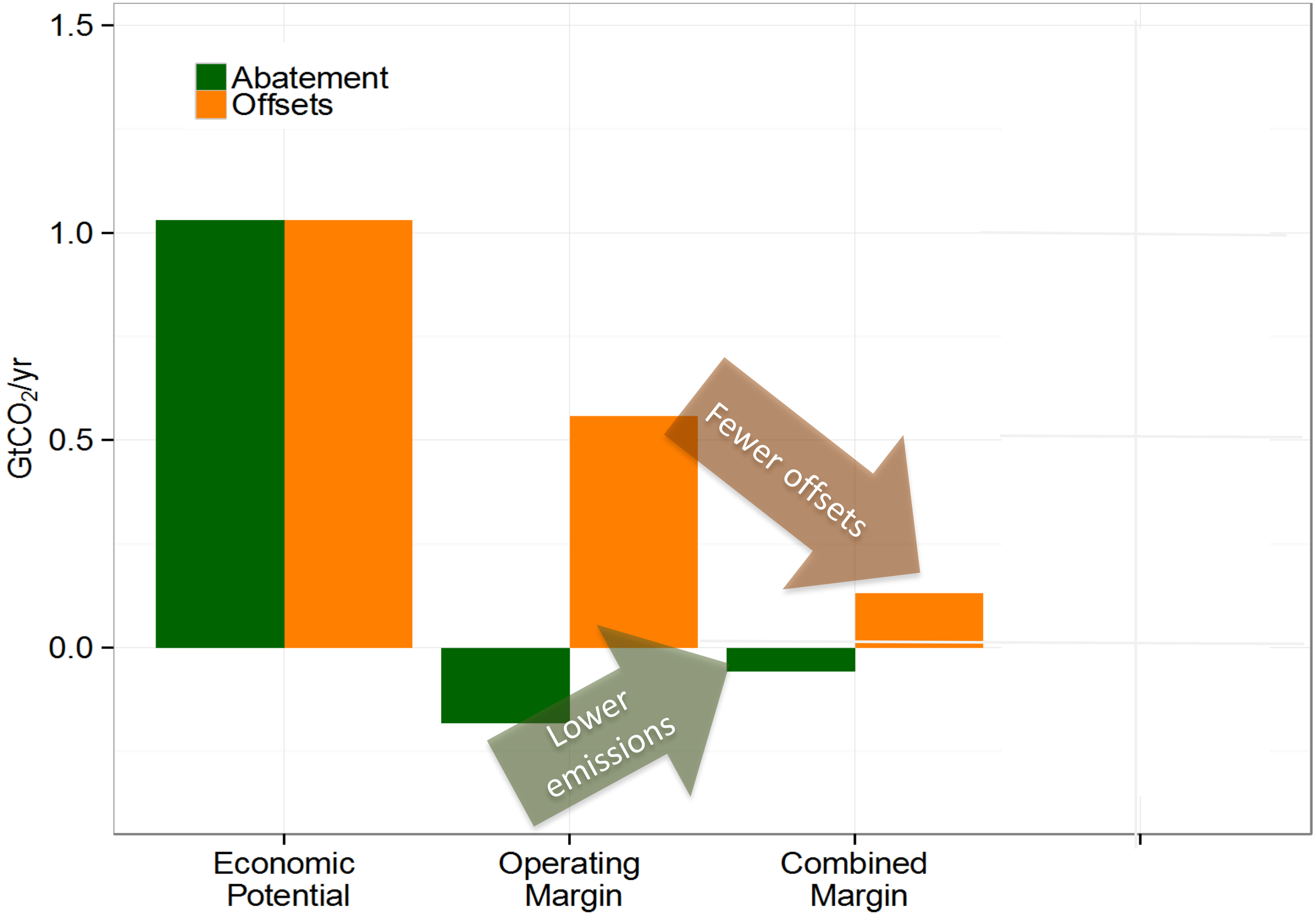
Crediting Baseline Method	Implementation
Operating Margin	Difference between facility emissions (CO_2/kWh) and power sector average in the reference scenario, times the power produced by the facility.
Build Margin	Difference between facility emissions (CO_2/kWh) and power sector average investment in new plant and equipment, times the power produced by the facility.
Combined Margin	Weighted combination of Operating & Build Margins
2005 Operating Margin	Difference between facility emissions (CO2/kWh) and power sector average in **2005**, times the power produced by the facility.

OM Net Global Emissions Reductions (Abatement) and Value of Offsets, \$20/tCO_2 Price

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

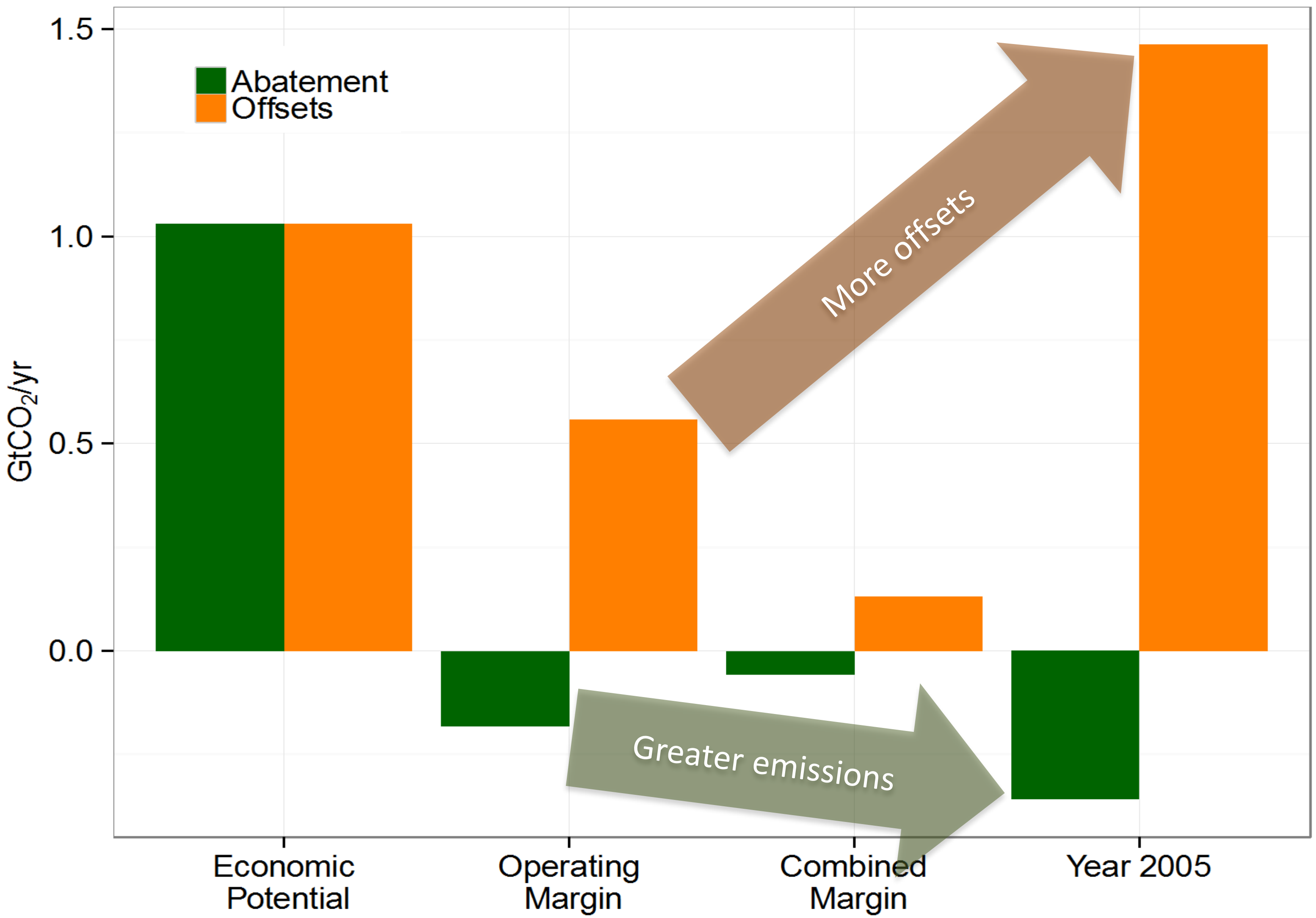


OM Net Global Emissions Reductions (Abatement) and Value of Offsets, \$20/tCO_2 Price



OM Net Global Emissions Reductions (Abatement) and Value of Offsets, $20/tCO$_2$ Price

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965



Pacific Northwest NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

Sensitivity to
TECHNOLOGY ELIGIBILITY

Alternative Technology Eligibility Assumptions, $\$20/tCO_2$ Price

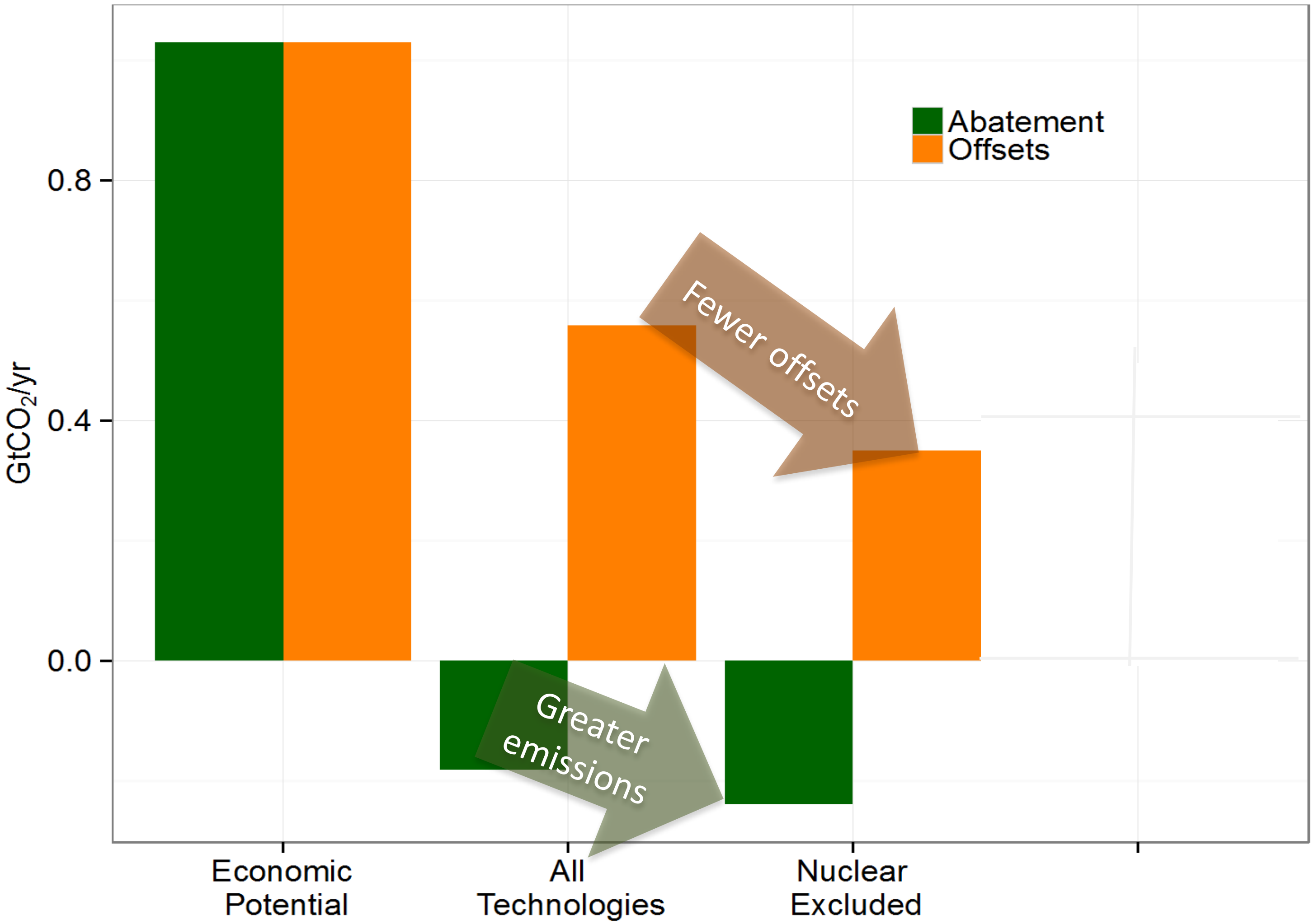
- We consider the sensitivity of our results to two alternative technology eligibility assumptions compared to All technologies better than the OM are eligible—our initial assumption:

1. Nuclear Power Exclusion

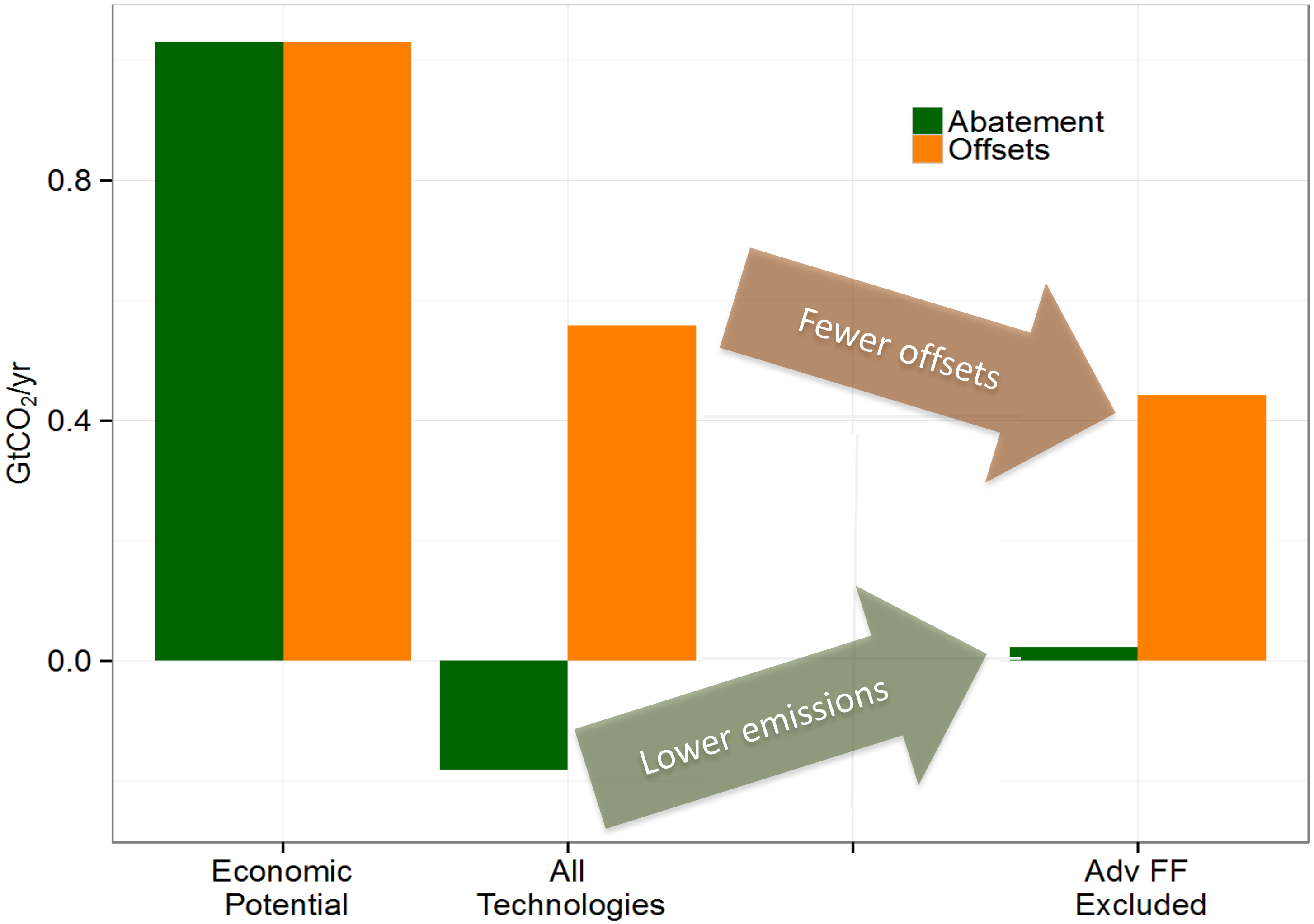
2. Advanced Fossil Fuel Technologies Exclusion (renewables and nuclear only)

Sensitivity to technology eligibility assumptions, $20/t$CO_2$ Price

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by **Battelle** *Since 1965*



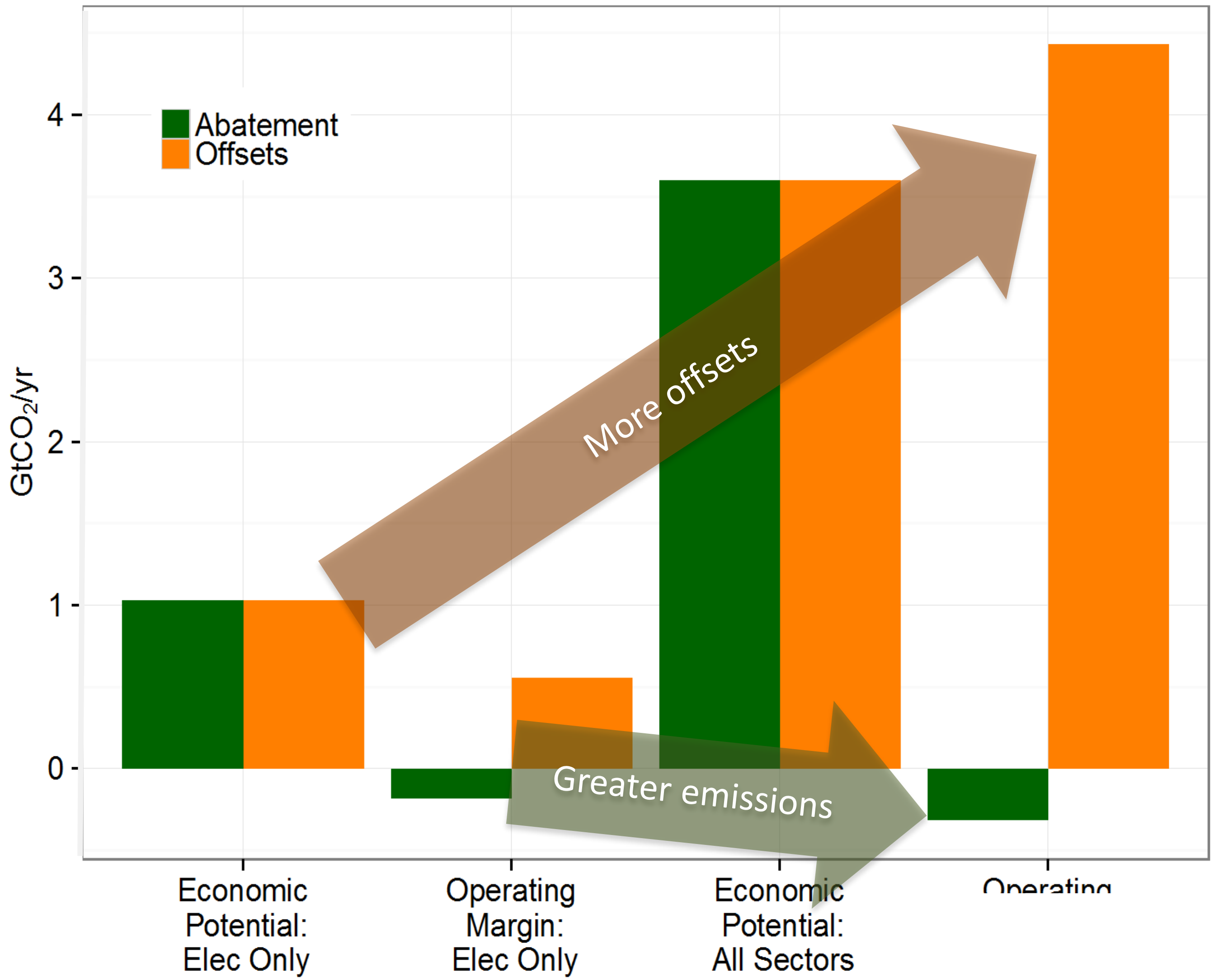
Sensitivity to technology eligibility assumptions, \$20/tCO_2 Price



Sensitivity to

SECTORAL COVERAGE

Sensitivity to technology eligibility assumptions, $\$20/tCO_2$ Price



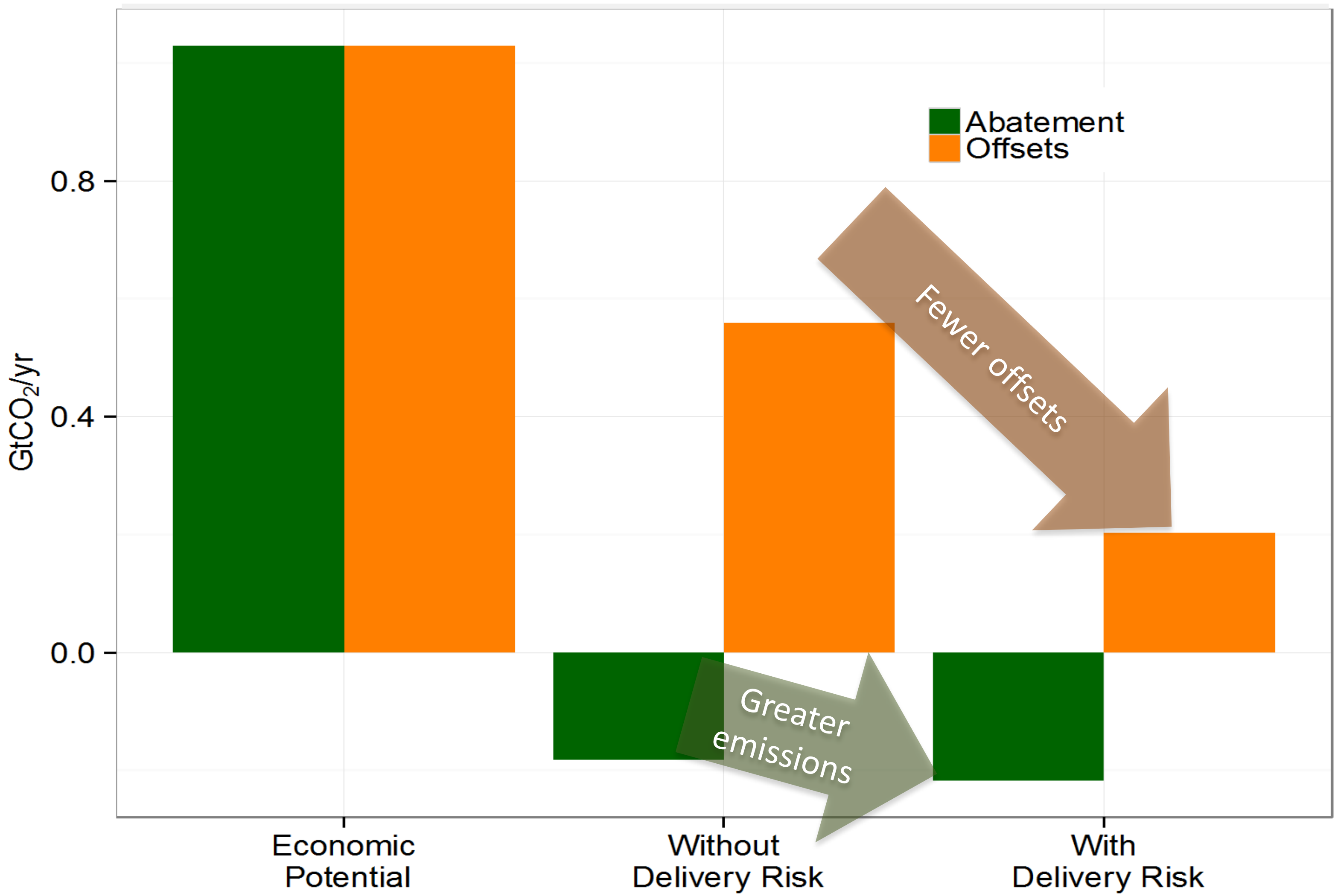
Sensitivity to

DELIVERY RISK

Delivery Risk

- Incorporating deliver risk into the analysis results in a reduction in the amount of offsets credits generated by a particular project
  - Reflects the possibility that such a project will not deliver its promised abatement.
- We have taken quantitative estimates from Rose, et al. (2013) and applied them to our estimates of offset supply.
- These estimates, which differ by region and technology, are multiplied by the credit calculated previously.
- The result is a smaller volume of expected offsets at any price, or equivalently, any bundle of offsets sells at a corresponding discount.
- Results in higher electricity subsidy for renewables at a given carbon price, driving emissions up still further than in the “no risk” case.

Sensitivity to technology eligibility assumptions, $20/t$CO_2$ Price



Overview of the Global Change Assessment Model

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by **Battelle** *Since 1965*

Automation System

Data Development System → GCAM Core: Dynamic Integration → Disaggregation Models

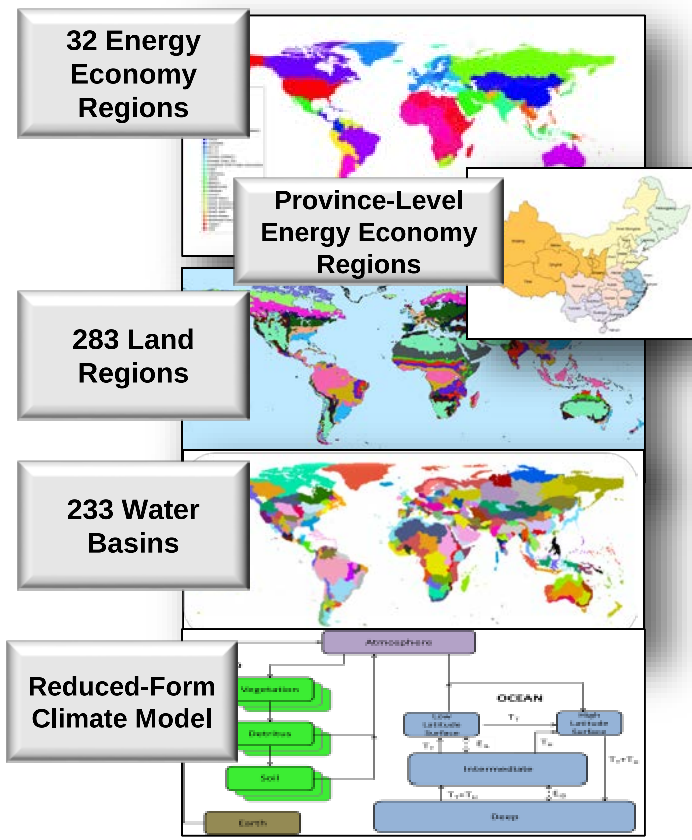
Data Development System

EIA	IEA
GTAP	HYDE
SAGE	OECD
FAO	IMAGE
MIRCA	Aquastat
USDA	USGS
CDIAC	IIASA

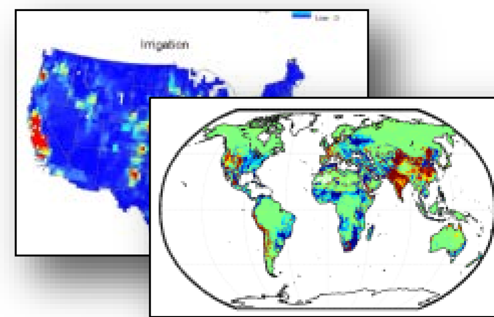
Others ………

Papers: Houghton, Rogner, ……….

GCAM Core: Dynamic Integration



Disaggregation Models



Digital Map of Irrigated Areas	MODIS
Union of Concerned Scientists	Gridded Livestock of the World

Others ………

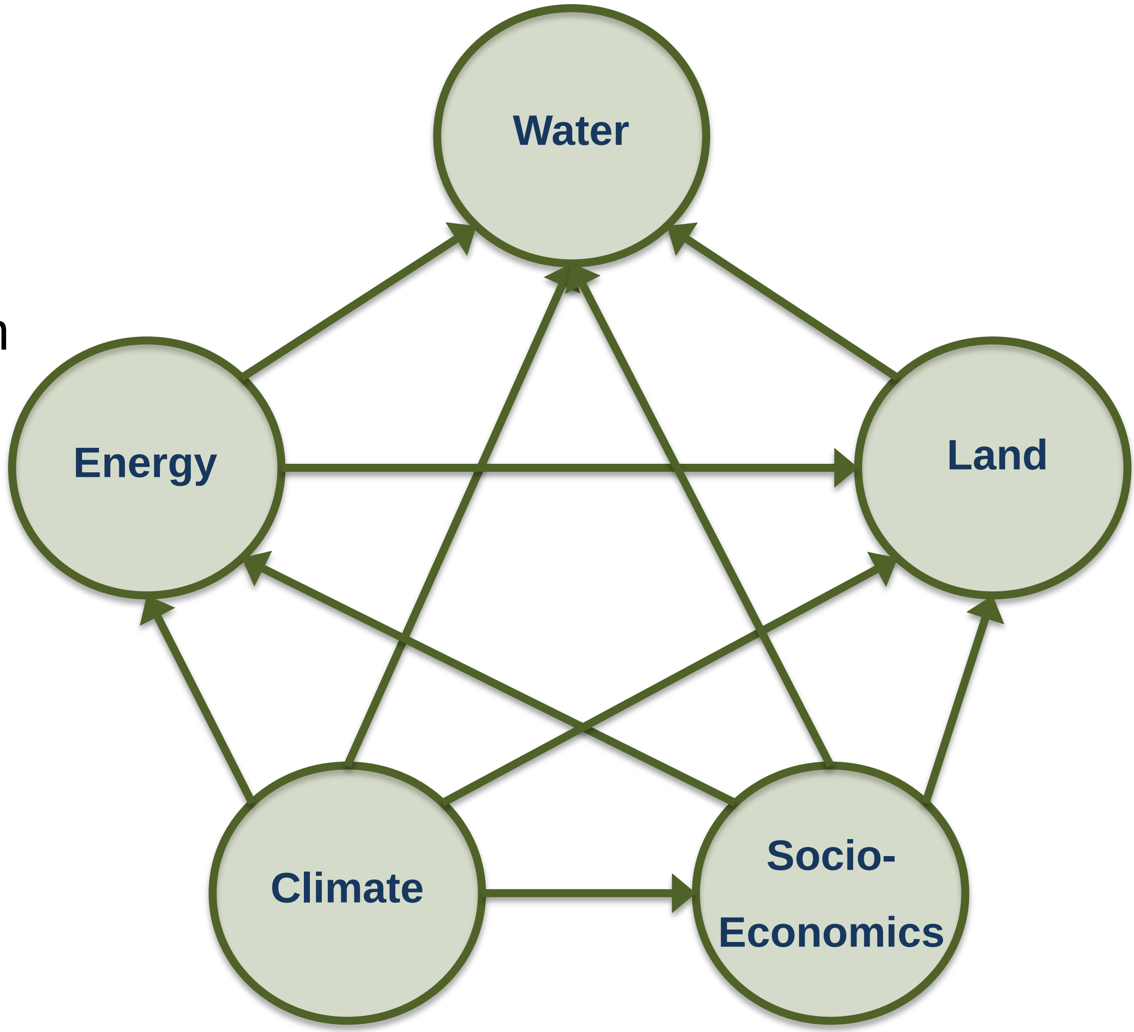
Papers: Friedl, Portmann, Sleeter, Radeloff, …..

The Global Change Assessment Model

We can think of GCAM as having five major components, which are closely coupled

1. The socioeconomic system
2. The energy system
3. Agriculture, land use & bioenergy
4. Water
5. Atmosphere, oceans, & climate systems

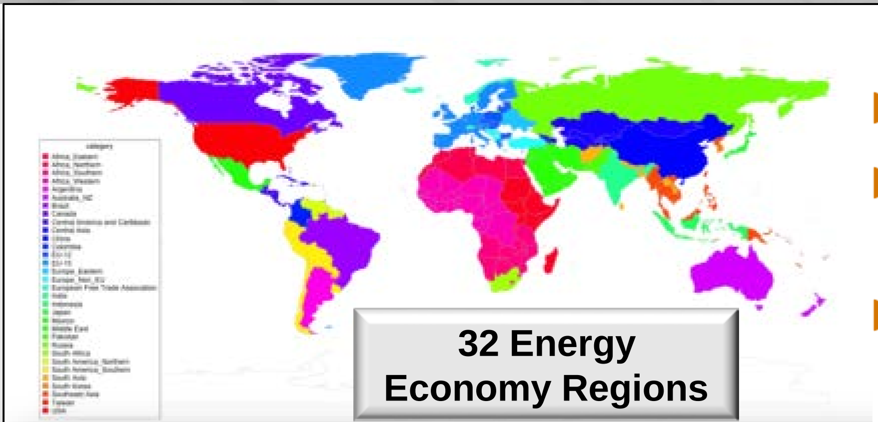
These systems are strongly interactive in GCAM.

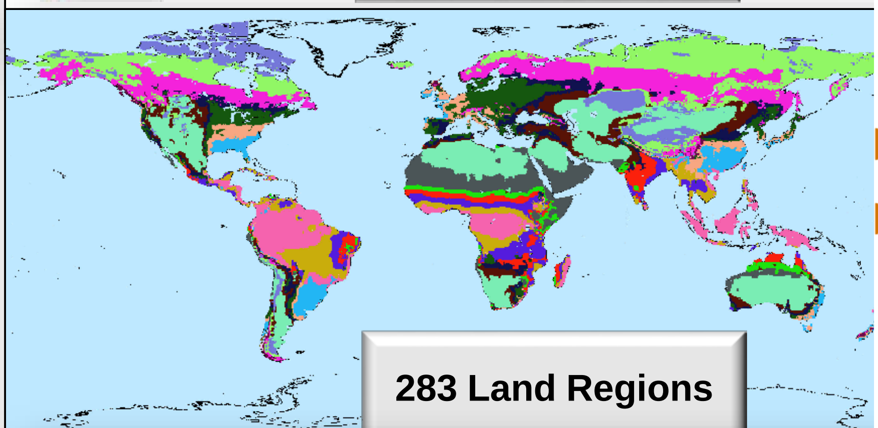


Emissions tracking and time step

- GCAM tracks 24 greenhouse gases and short-lived species including
  - CO_2, CH_4, N_2O
  - Halocarbons
  - Carbonaceous aerosols
  - Reactive gases (e.g. CO, NOx, VOCs) &
  - Sulfur dioxide
- Default time step is **5 years**
- Default time horizon is **2100**

The Core Global Change Assessment Model: A Community Resource

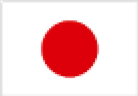
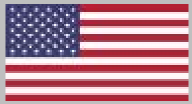
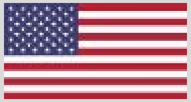
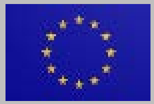
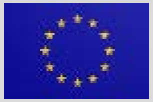
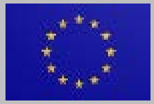




- GCAM is a **global integrated assessment model**
- GCAM links **Economic**, **Energy**, **Land-use**, and **Climate** systems
- Typically used to examine the effect of technology, policy and climate change on the economy, energy system, agriculture and land-use
- Technology-rich model
- Emissions of 16 greenhouse gases and short-lived species: CO_2, CH_4, N_2O, halocarbons, carbonaceous aerosols, reactive gases, sulfur dioxide.
- Runs through **2095** in **5-year time-steps.**
- A Community Model, download at: http://www.globalchange.umd.edu/models/gcam/download/
- Documentation at: http://wiki.umd.edu/gcam/

GCAM is member of the class of Higher Resolution IAMs

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle *Since 1965*

Model	Home Institution	
AIM Asia Integrated Model	National Institutes for Environmental Studies, Tsukuba Japan	
GCAM Global Change Assessment Model	Joint Global Change Research Institute, PNNL, College Park, MD	
IGSM Integrated Global System Model	Joint Program, MIT, Cambridge, MA	
IMAGE The Integrated Model to Assess the Global Environment	PBL Netherlands Environmental Assessment Agency, Bildhoven, The Netherlands	
MESSAGE Model for Energy Supply Strategy Alternatives and their General Environmental Impact	International Institute for Applied Systems Analysis; Laxenburg, Austria	
REMIND Regionalized Model of Investments and Technological Development	Potsdam Institute for Climate Impacts Research; Potsdam, Germany	

The Core Global Change Assessment Model: A Community Resource

- GCAM is a **global integrated assessment model**
- GCAM links **Economic**, **Energy**, **Water**, **Land-use**, and **Climate** systems
- Technology-rich model
- Emissions of 16 greenhouse gases and short-lived species: CO_2, CH_4, N_2O, halocarbons, carbonaceous aerosols, reactive gases, sulfur dioxide.
- Runs through **2095** in **5-year time-steps.**
- A Community Model, download at: http://www.globalchange.umd.edu/models/gcam/download/
- Documentation at: http://wiki.umd.edu/gcam/