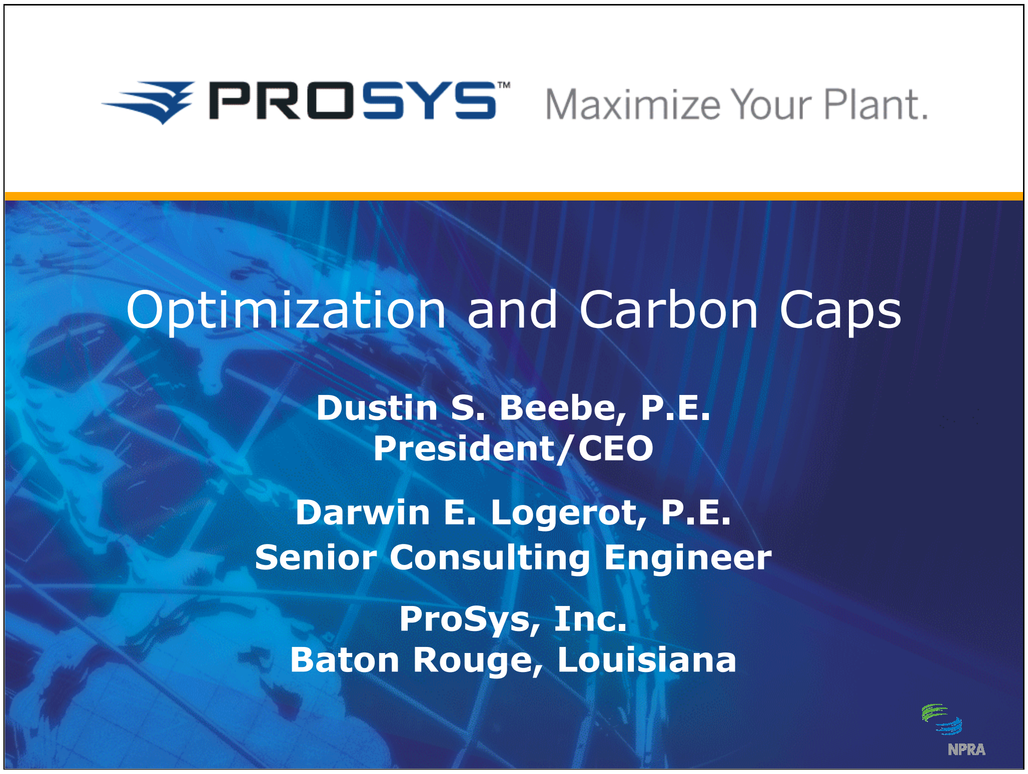


Presented 2009 October 13 at the NPRA 2009 Q&A and Technology Forum in Fort Worth, Texas.

Introduction

- **ProSys, Inc.**
  - Process Controls Consultants
  - Basic/Advanced Controls, Alarm Management, DCS upgrades, HMI

Introducing who we are.

Introduction

- **Carbon Cap and Trade**
- **Carbon Capture and Sequestration**
- **Impacts of Requirements on Refining**

We will concentrate on refinery controls and optimization, assuming that cap-and-trade legislation does pass in the U.S. This is not a political discussion on the merits/demerits of the legislation.

Waxman-Markey Bill (HR 2454)

- **American Clean Energy and Security Act of 2009**
- **Passed by the U.S. House**
- **Placed on Senate calendar**

Current status of HR 2454 (as of 10/01/09): Passed by the House. On the Senate calendar. Also referred to as HR 2998, which was a comprehensive amendment to the bill.

The United Nations Climate Change Conference in Copenhagen will take place in December. Some speculate that there will be a push to pass legislation in the U.S. before then.

Terms

"CO_2 equivalent" (CO_2e)

- Measure of greenhouse potential
- Includes CO_2, CH_4, and other gases

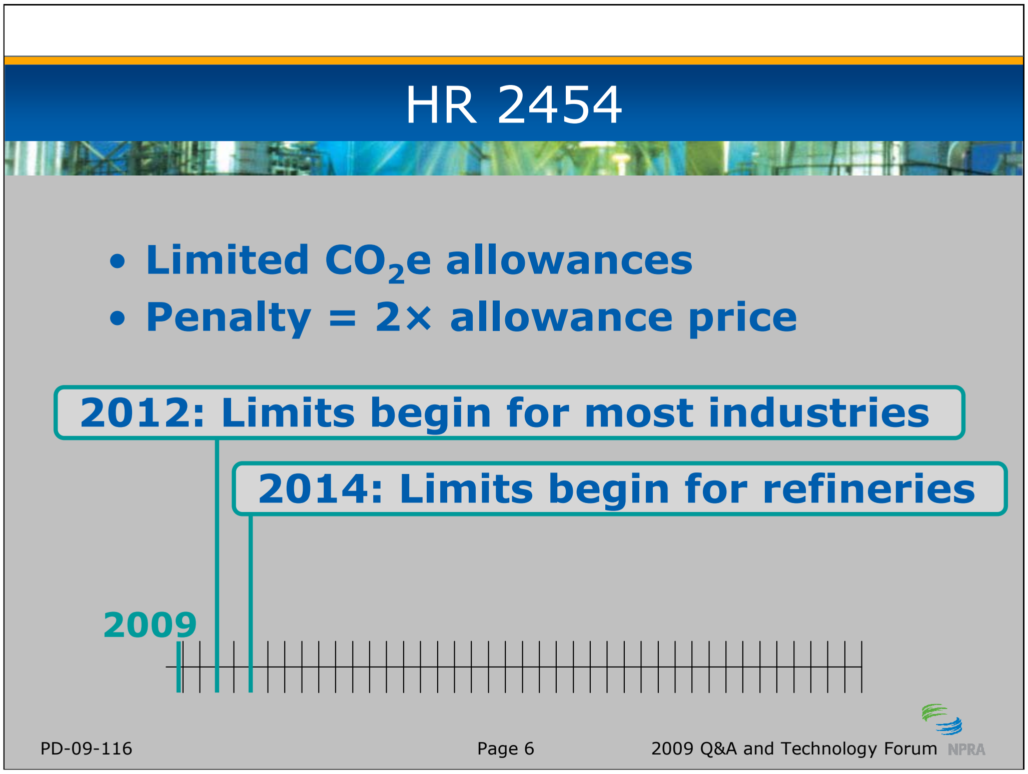
"Allowance"

- The right to emit a metric ton of CO_2e without penalty

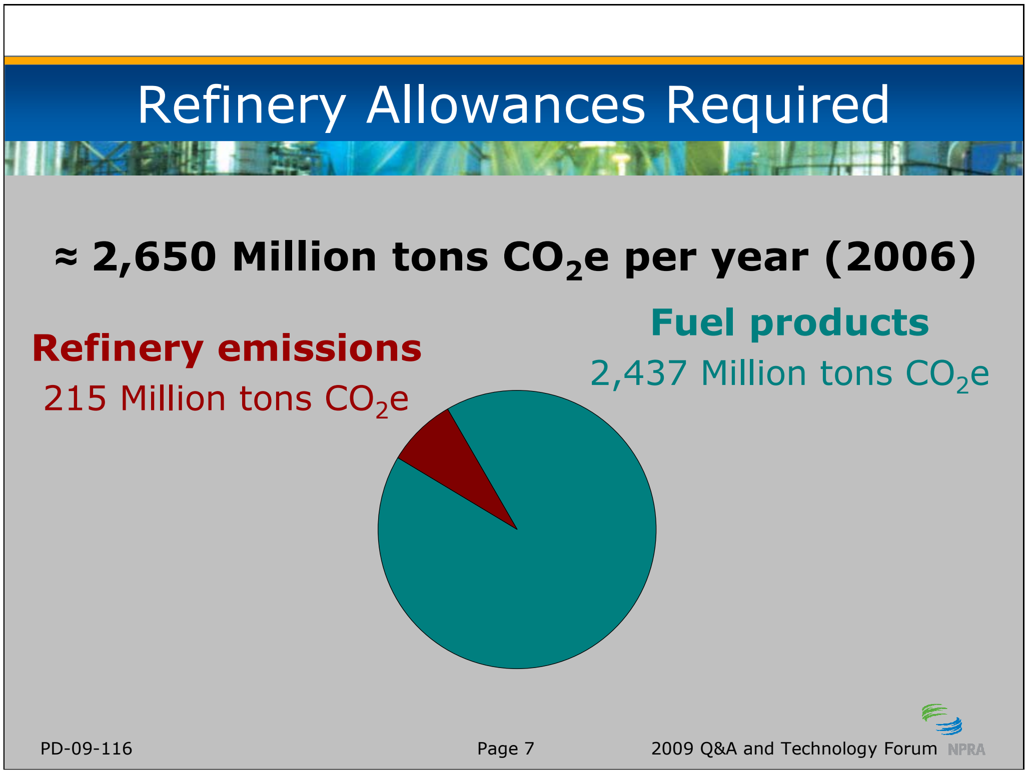
"Offset credit"

- A financial instrument representing CO_2e removed or prevented

These are some terms in the legislation that can cause confusion if used inconsistently. These definitions are our interpretation, not verbatim from the bill, and are what we will use throughout this talk.



Although limits don't directly restrict refiners until 2014, they would restrict electricity generators and other industries in 2012, so that's when the major cost impacts to refining will begin.

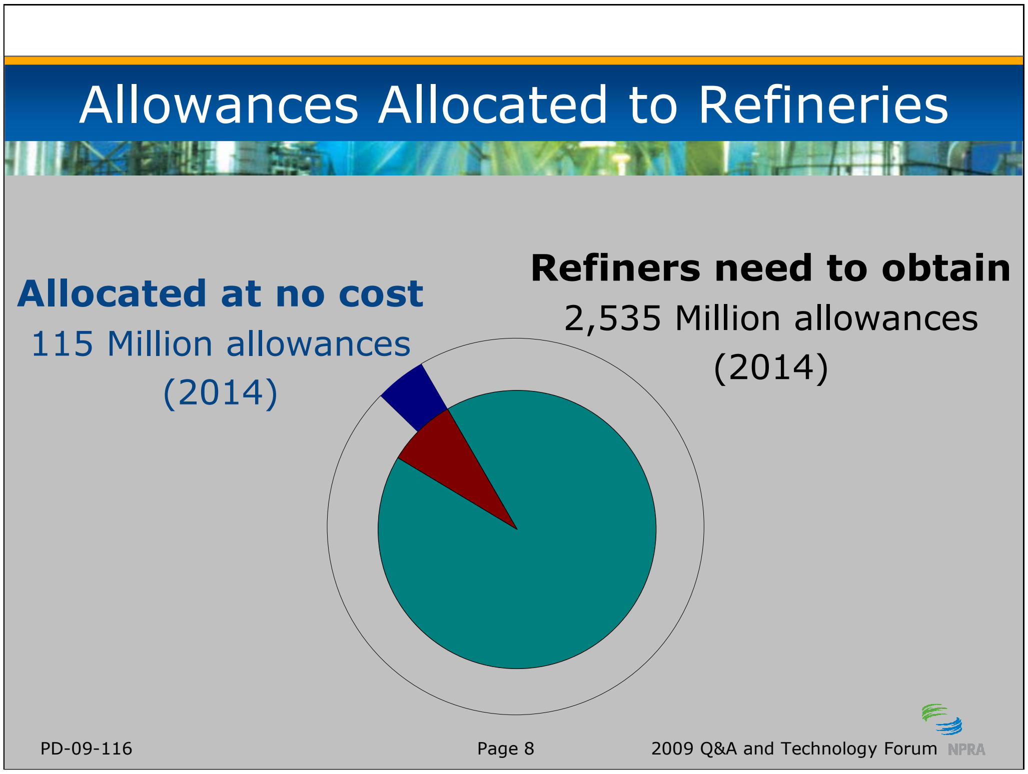


Allowances are required for both the CO2e emitted during the refining process AND for the CO2e that will eventually be emitted from combustion of the fuel products. While it is impossible to know the exact number of allowances that will be required in future years, these numbers from 2006 provide an estimate based on that year's emission and fuel production. About 90% of the allowances will be required not for emissions but for the domestic fuel product.

Allowances required for refinery products are based on 2006 emissions of CO2e from petroleum as listed in table 3-5 of the EPA 2009 U.S. Greenhouse Gas Inventory Report:
http://epa.gov/climatechange/emissions/usinventoryreport.html

Allowances required for the refining process were based on fuel consumed by petroleum refiners for energy purposes in 2006, as documented by the Energy Information Association:
http://www.eia.doe.gov/emeu/mecs/mecs2006/2006tables.html

Conversion from fuel consumed to CO2e released is based on conversion factors provided in Annex 2 of the EPA 2009 U.S. Greenhouse Gas Inventory Report



Some allowances each year will be allocated at no cost. Only a small percentage of total refining requirements can be met from this free distribution; refiners will have to find other ways to meet requirements for the vast majority of their production.

What's a Refiner to Do?

- **Pay for allowances and offsets**
- **Reduce emissions**
  - Optimize processes
  - Capital investment; optimize again
- **Capture CO_2**
- **Capture and optimize**

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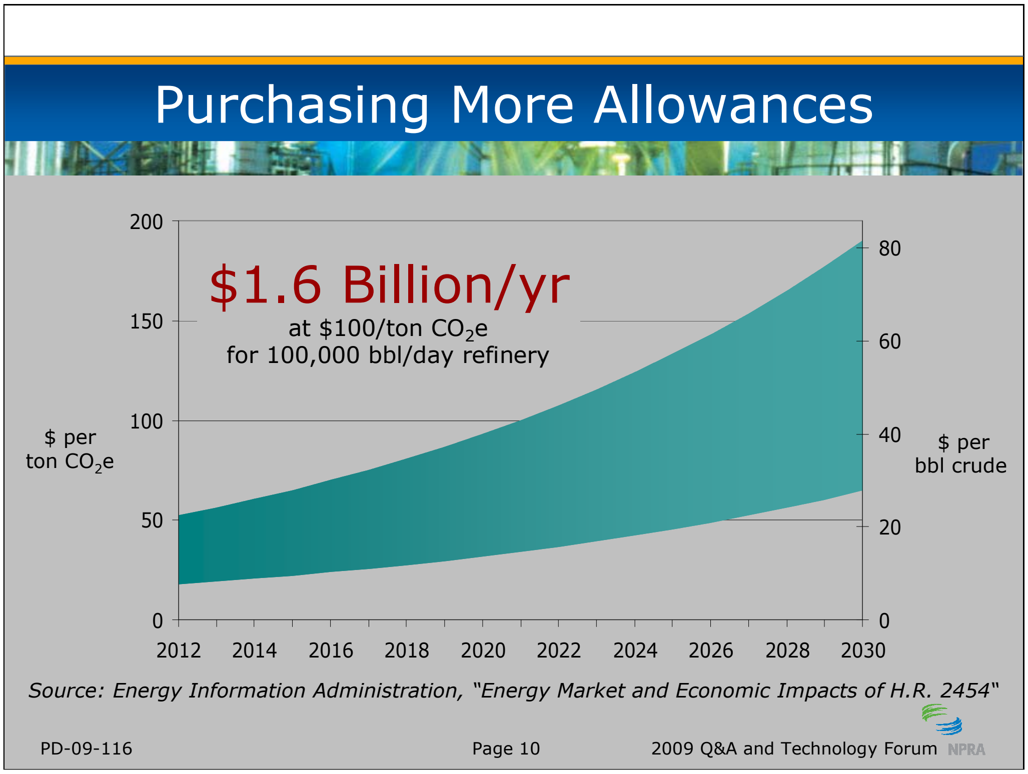
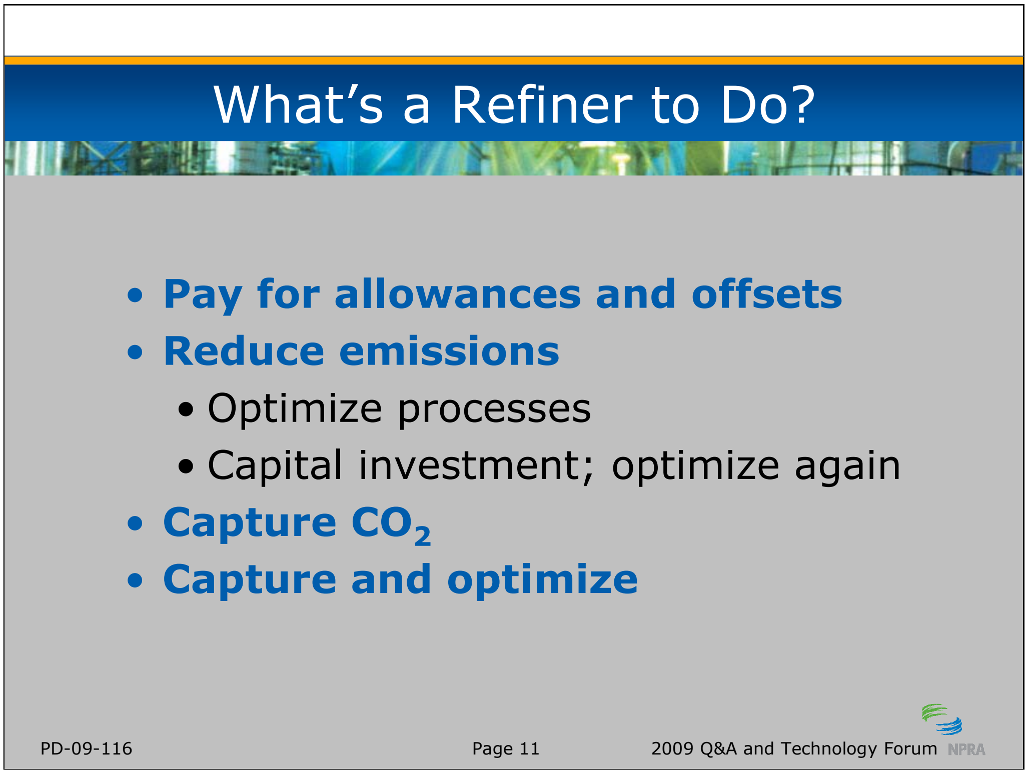
We'll discuss each of these options in a little more detail. First we'll talk about buying more allowances to meet the requirements.



Prices of CO2e allowances cannot be precisely predicted yet. The range of prices depicted here is based on several different estimates from the EIA, which make a variety of different assumptions regarding offsets and technology advances. Regardless of the exact numbers, it is widely expected that prices will increase over time. If a refiner's strategy is to just buy allowances each year then eventually the allowances will reduce the profitability of refining. What else could be done with $1.6 billion per year?



Next we'll discuss ways that refers can optimize their processes to reduce the number of CO2e allowances they will require.

Receiving a Larger Allocation

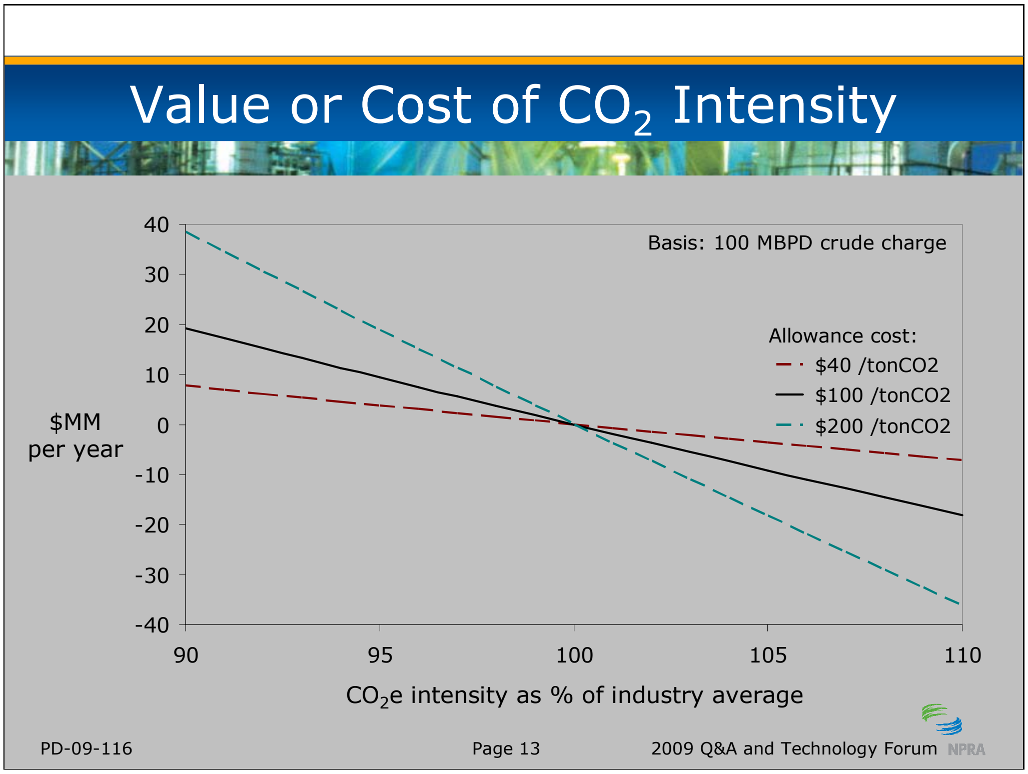
Among refiners, allowances distributed based on:

- **Quantity of fuel produced**
- **Intensity**

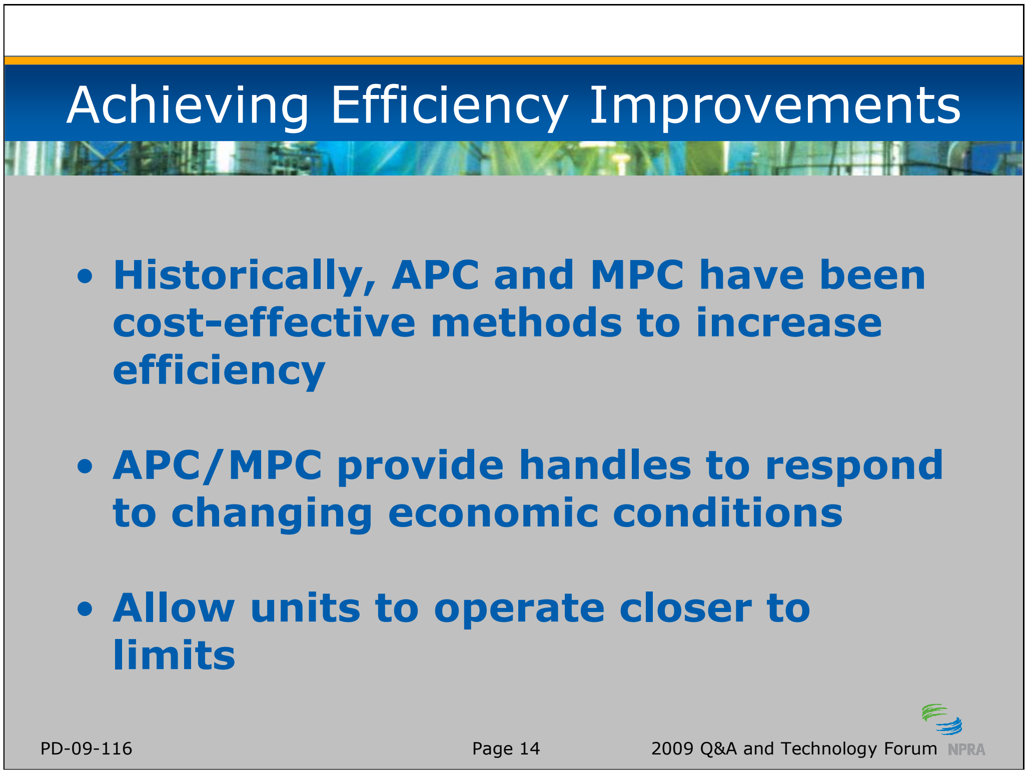
$$\frac{CO_2e\text{ emitted} + CO_2e\text{ from electricity}}{\text{Fuel production}}$$

Efficient refiners **receive more** allowances and **require fewer**

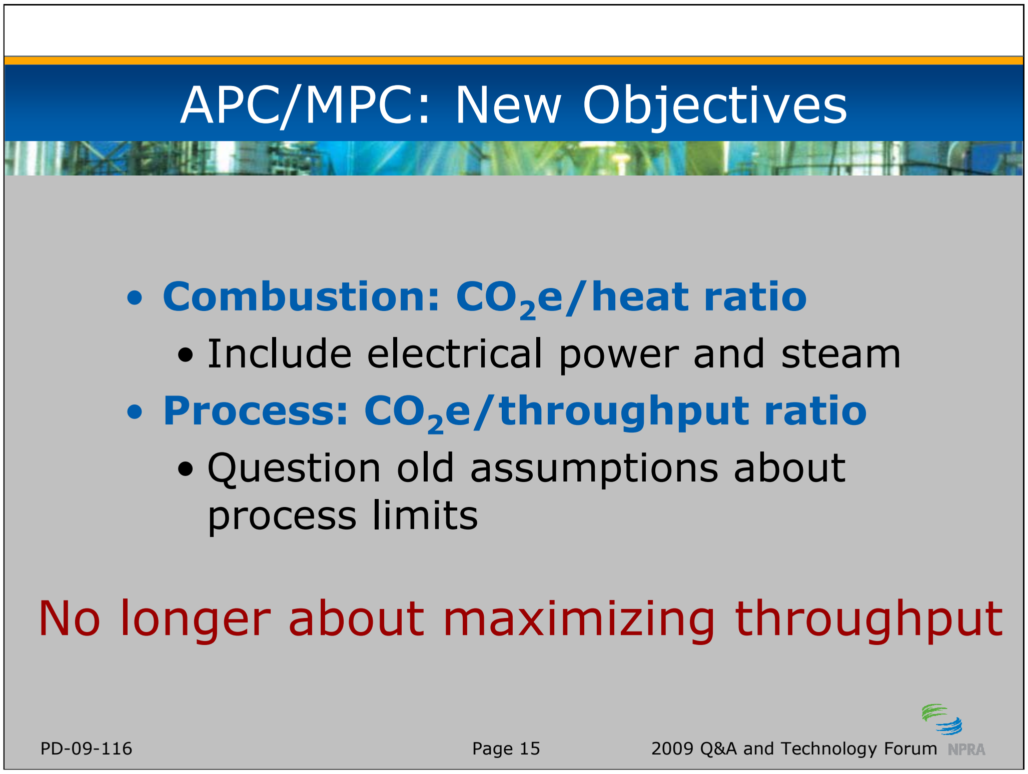
A formula in the original HR 2454 awarded more free allowances to efficient refiners and fewer allowances to less-efficient refiners. While that formula has been removed from the version passed by the House, the bill does still state that there should be incentives for efficiency and it is reasonable to expect that a similar formula could be used. To get more allowances, a refinery would need to decrease their CO2e intensity while increasing their fuel production.



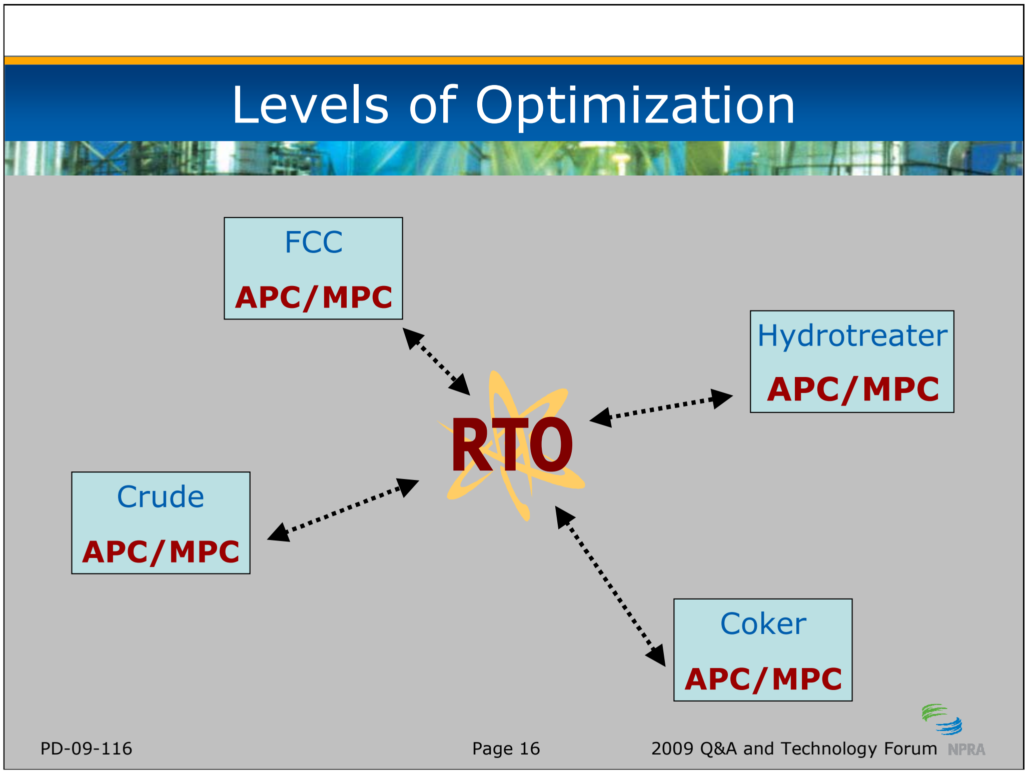
This shows the effect of being more efficient relative to the industry average for the purpose of receiving free allocations, based on the original formula. What if you improve your intensity and everybody else does, too? Well, it's better than not improving your intensity because it keeps you away from the right side of the graph. If you improve your intensity more than the industry average then there's value to be gained from the extra allowances that won't have to be purchased.



APC and MPC are the first step. These methods provide optimization for each unit so that each unit can be run more efficiently.



When emitting CO2e is not free, objective functions change. Depending on the prices it is possible that extra production beyond a certain point reduces profitability due to the added costs. If the goal is to maximize profit then it may be necessary to reduce production throughput to find that optimum point.

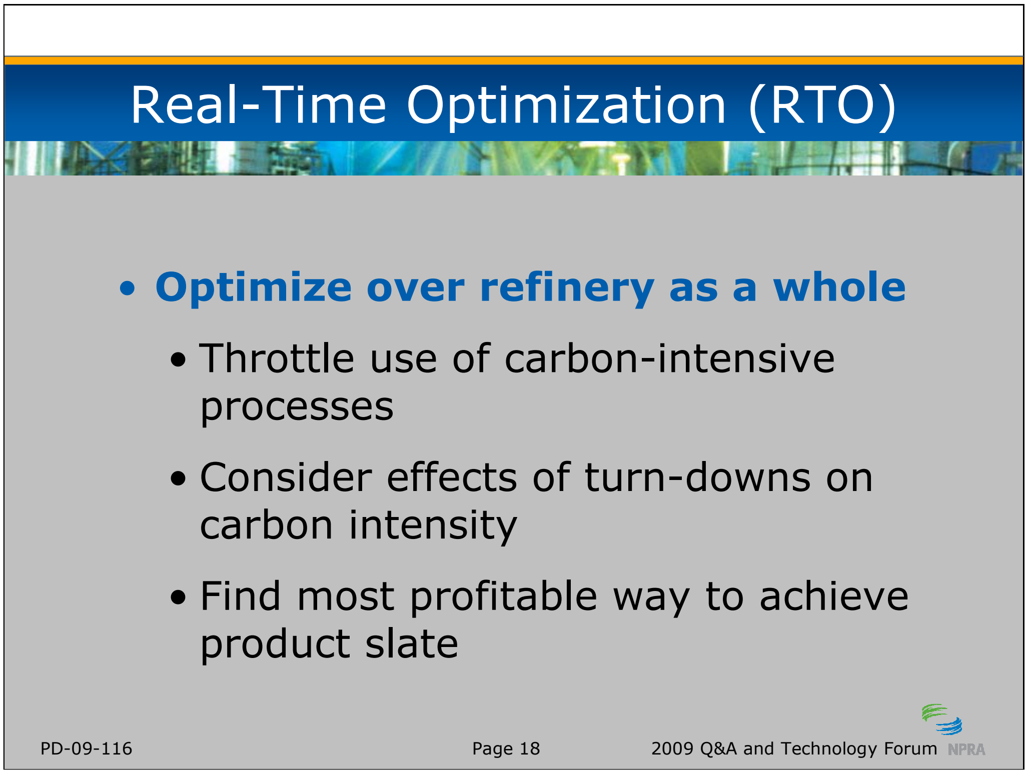


After APC/MPC have been implemented in each unit, real-time optimization can provide a layer of optimization at the plant level.

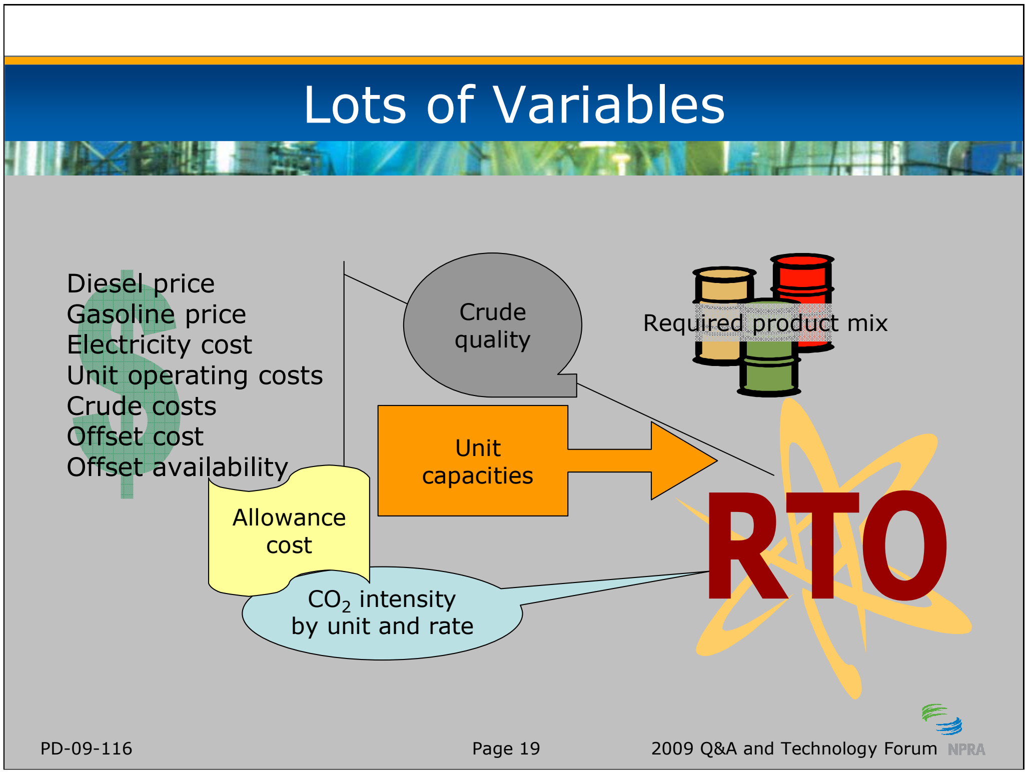
Real-Time Optimization (RTO)

- **Process optimization model incorporating intra-day adjustments**
- **Capable of modeling interactions among units**

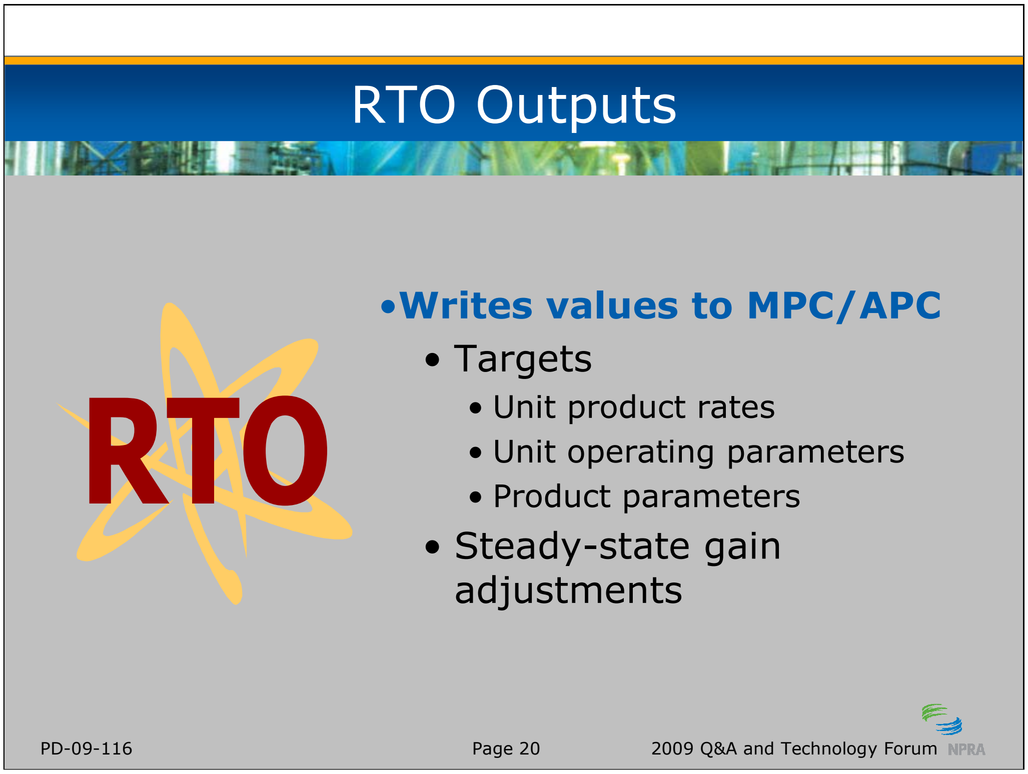
RTO hasn't caught on in a big way yet, but this legislation may push refiners toward that point.



Some units are more carbon-intensive than others, and that carbon intensity will carry a cost. It might pay to run some low-carbon units at a higher rate and high-carbon units at a lower rate. RTO can help by determining the rates at which various units should run, taking into consideration the process interactions between the units.



The inputs to RTO are varied and complex, and will become more complex when CO2e allowances are factored in.



RTO performs calculations based on the inputs and writes targets to MPC/APC.

Real-Time Optimization (RTO)

RTO can:

Bias forecasts

Follow market trends

Set medium-term refinery targets

What’s a Refiner to Do?

- **Pay for allowances and offsets**
- **Reduce emissions**
  - Optimize processes
  - Capital investment; optimize again
- **Capture CO_2**
- **Capture and optimize**

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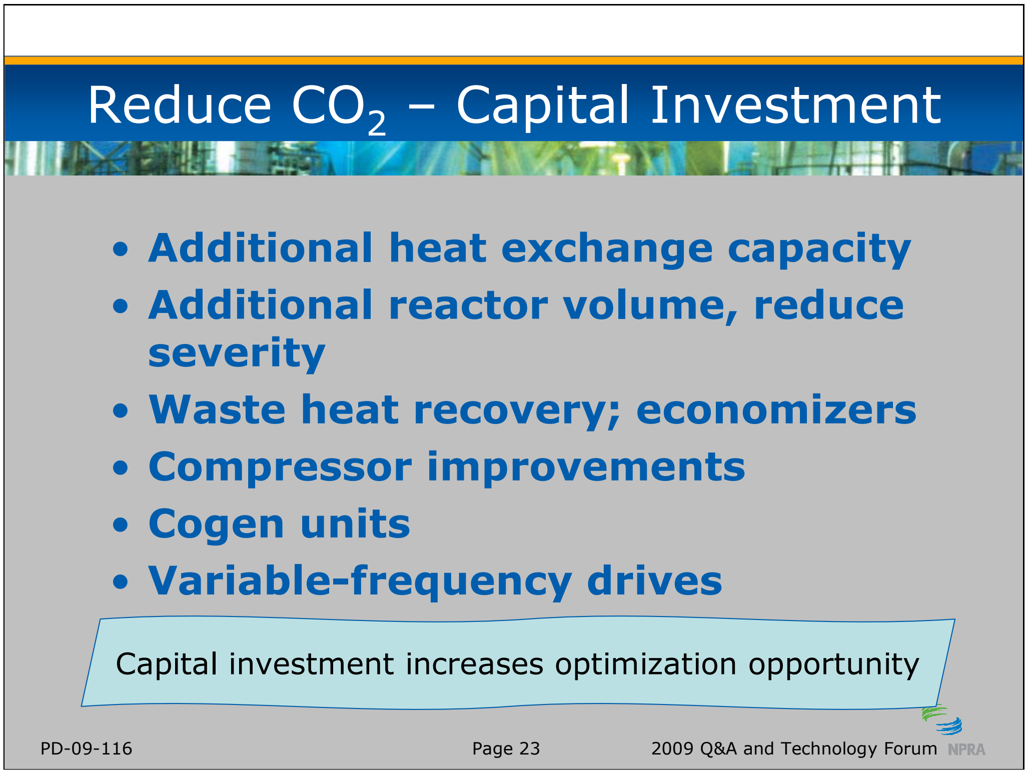
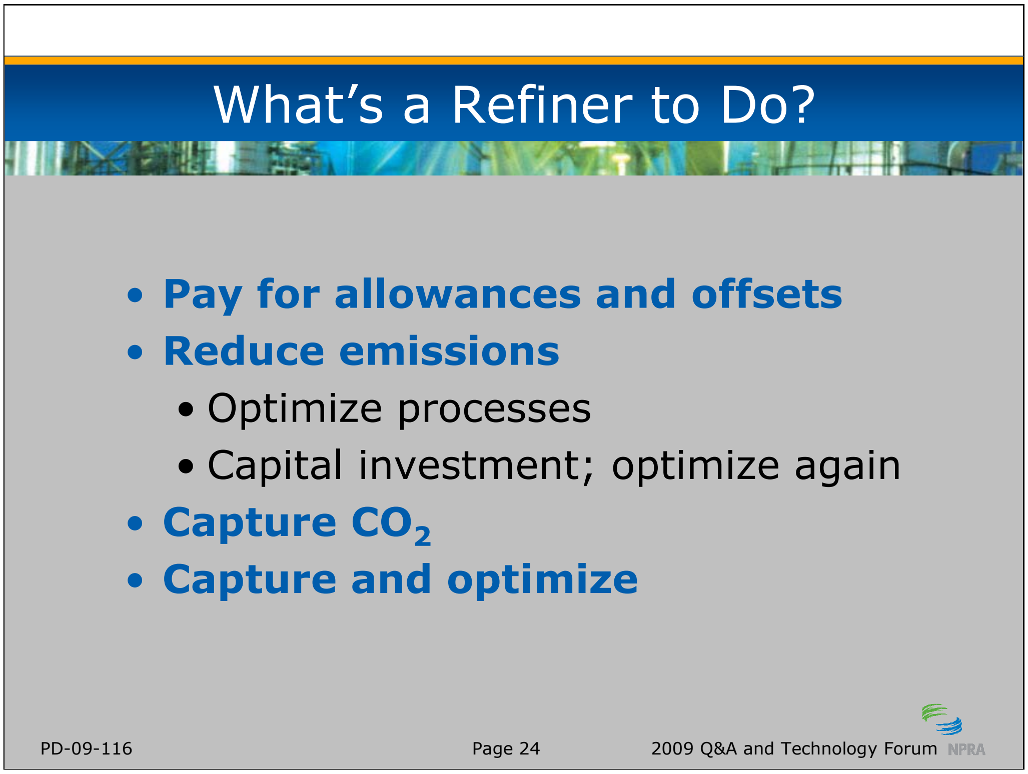
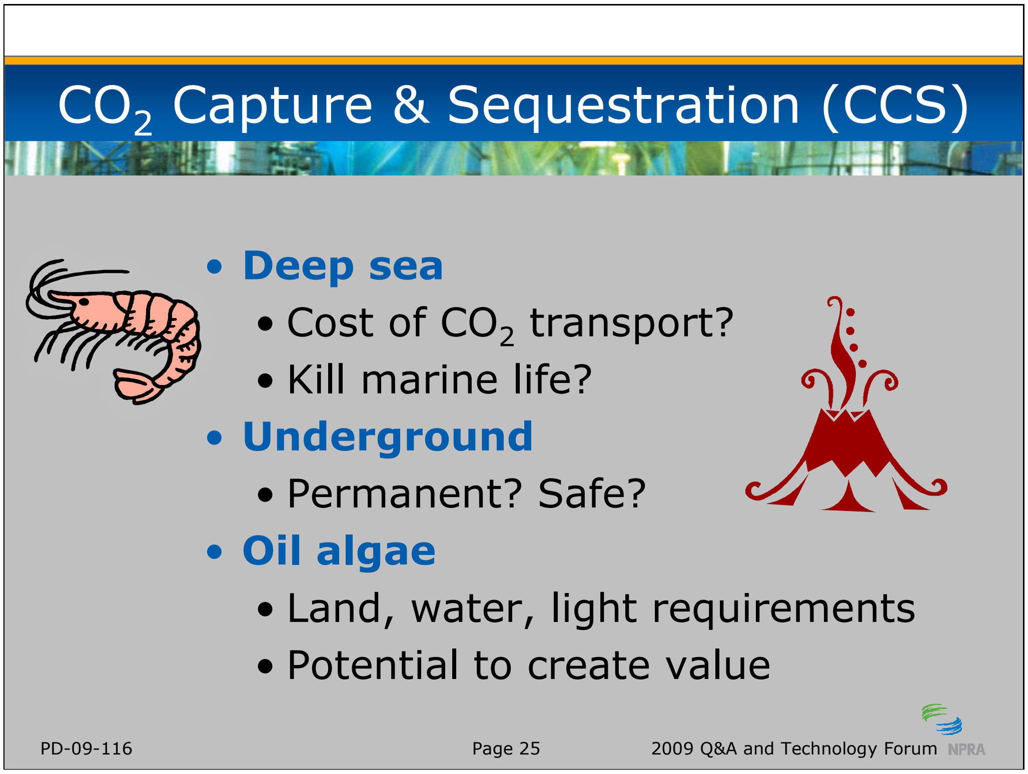
Next we’ll look at capital investments that can be used to reduce CO2e emissions.



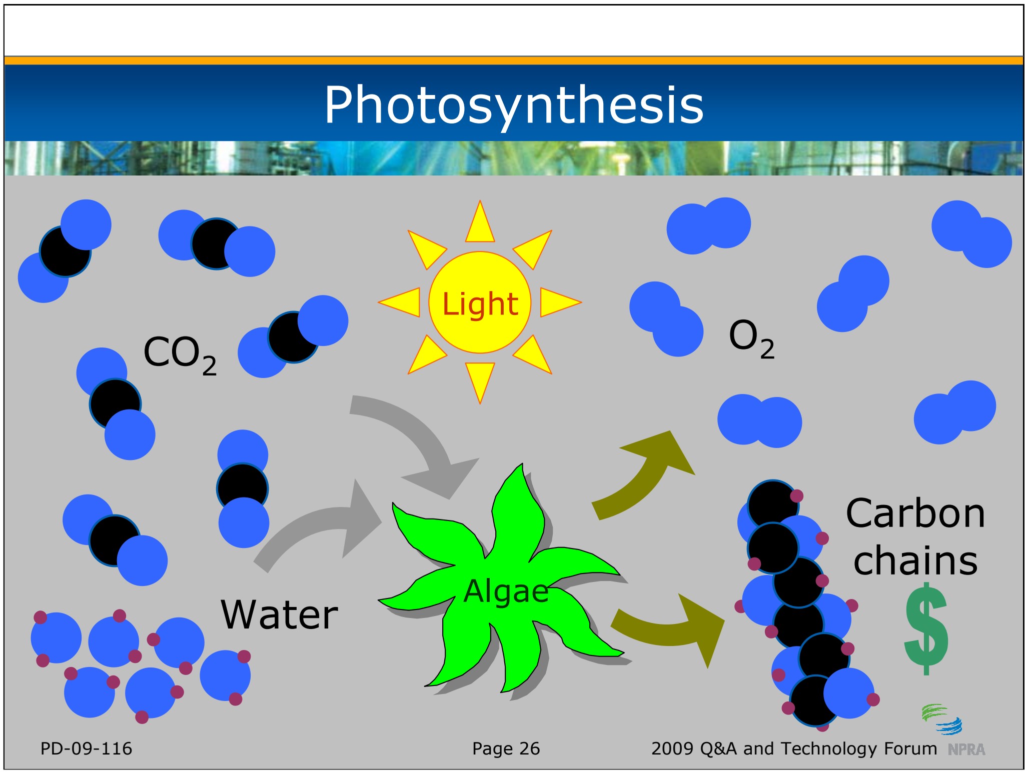
These energy conservation techniques are already available, but the economics of implementing them may change when there is a cost to CO2e emission and when electricity costs increase.



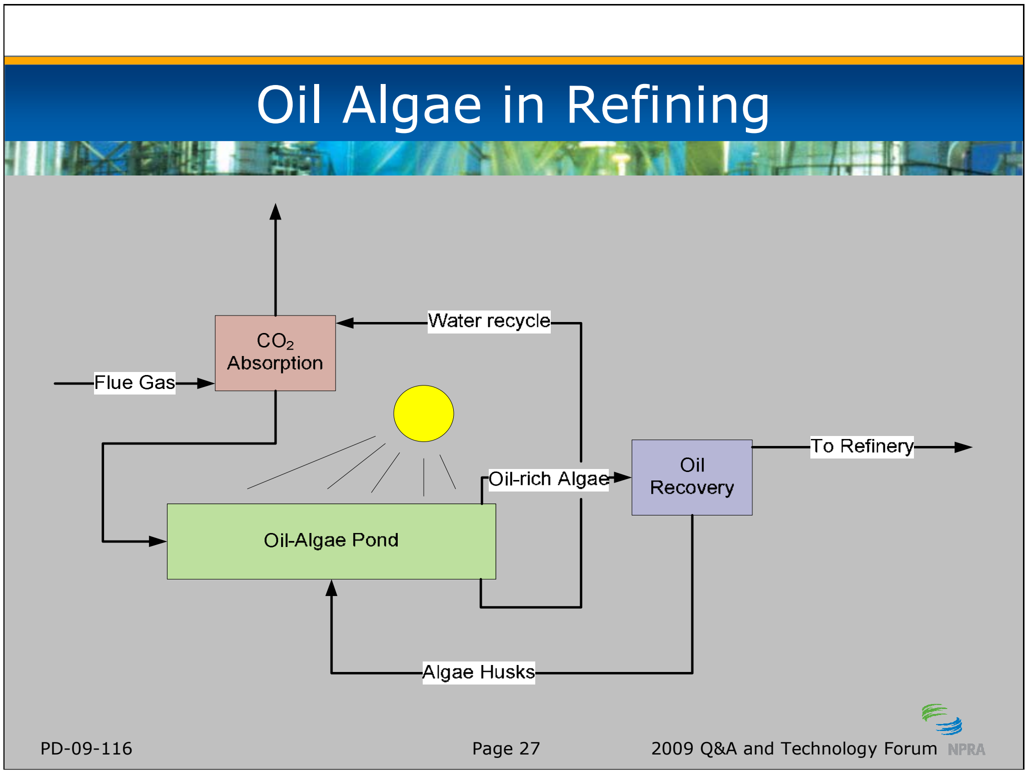
Some capital investment opportunities are still being researched and may be available in the future.



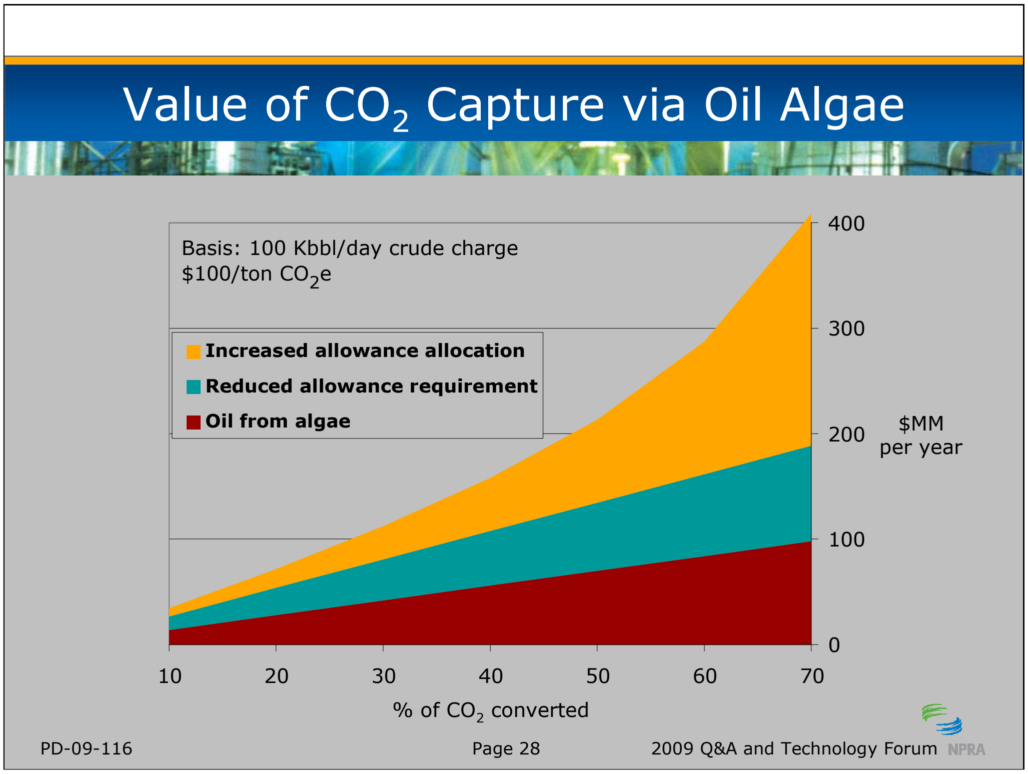
These are the major carbon capture and sequestration techniques that have been discussed in recent years. Oil algae seems to be the most practical for long-term use, since it manages CO2 on a continual basis rather than filling up a pre-defined carbon sink. With deep sea sequestration there are concerns about disruption to ecosystems and the seafood industry due to acidification of water. With underground sequestration there are concerns about safety and leakage.



Algae are plants, so the basic concepts of photosynthesis apply. Different species of algae produce different types and quantities of carbon chains (sugars and oils), and research is ongoing to discover/create algae varieties that can produce oil on a large scale. Major challenges of the technology are sunlight and water – how can ponds/reactors be designed in a way to maximize availability of photosynthetic light, and how can sunny locations get enough water to make the process work?

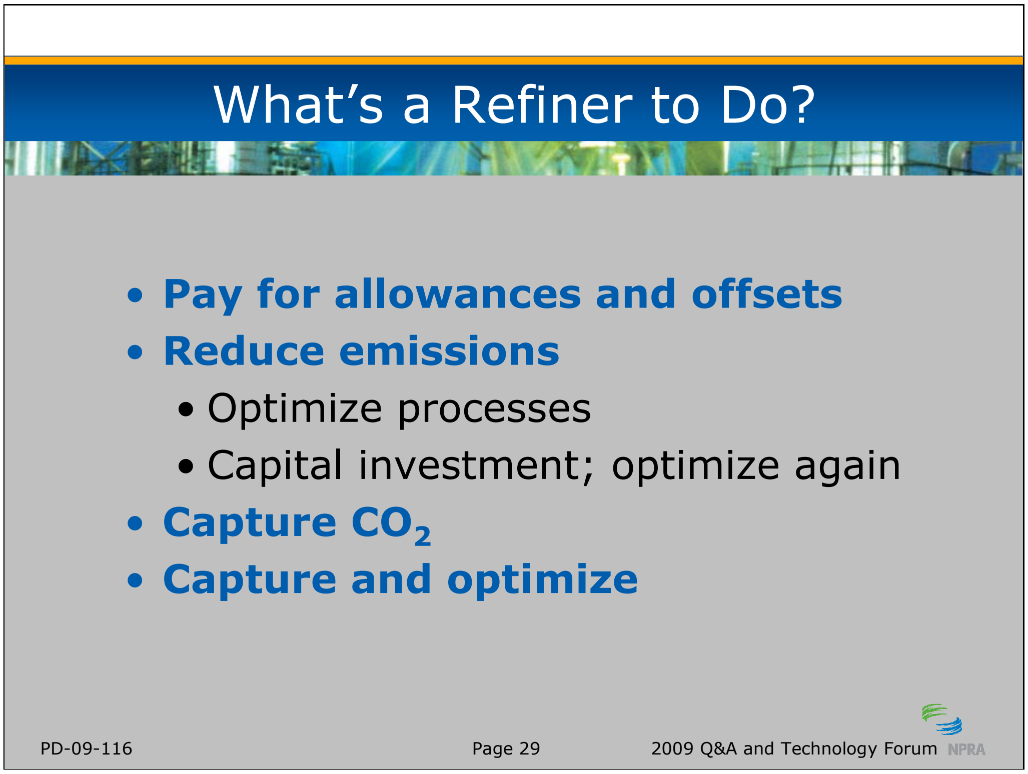


Greatly simplified flow diagram. The oil algae unit would use CO2 as its feed and produce oil that can be fed back to the refining process.

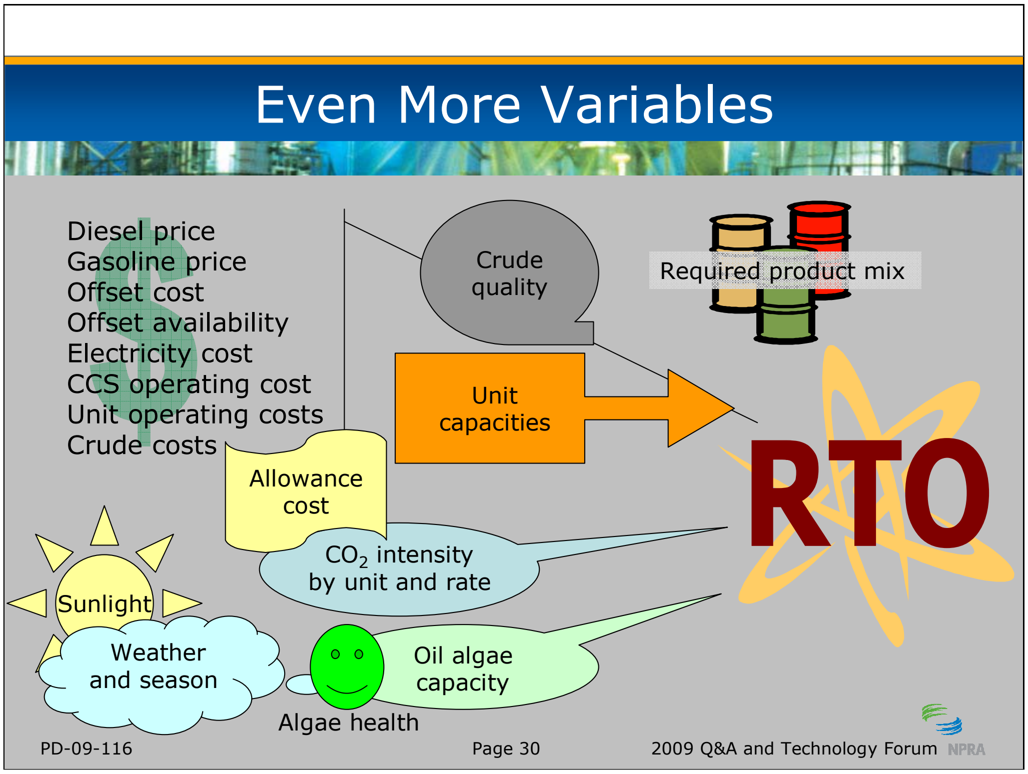


Capturing CO2 reduces the number of allowances required. Producing more fuel while emitting less CO2 improves carbon intensity, resulting in more free allowances. The oil itself has value since it can be used to create more fuel product without having to buy more crude.

The original formula asymptotes to infinity at 100% CO2 recovery, so it will likely be changed; we stopped the plot at 70%. Other CCS methods reduce allowance requirements but don’t earn value from increased fuel production.



If a CO2 capture technology such as oil algae is implemented, there are more opportunities for optimization.



As before, the inputs to RTO are complex, and are made even more complex when algae is factored in. Daily and seasonal variations affect algae capacity, which would affect the amount of CO2 that can be converted, resulting in adjustments to the economics of running the plant.

RTO Outputs

- **Writes values to MPC/APC**
  - Targets
    - Unit product rates
    - Unit operating parameters
    - Product parameters
    - Oil algae targets
  - Steady-state gain adjustments

Algae targets are one more handle that RTO can set targets for.

Real-Time Optimization (RTO)

RTO can:

Bias forecasts

Follow market trends

Set medium-term refinery targets

Set shorter-term targets based on algae or sequestration capacity

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With oil algae, shorter-term variations become important.

After CCS and Optimization

- **How long can fuel producers utilize optimization and CCS alone?**
  - About 15 years
  - Year 2024, total allowances available fall to 96% of current emission levels
  - Year 2050 and later, only 22% of current CO_2 emissions will be allowed

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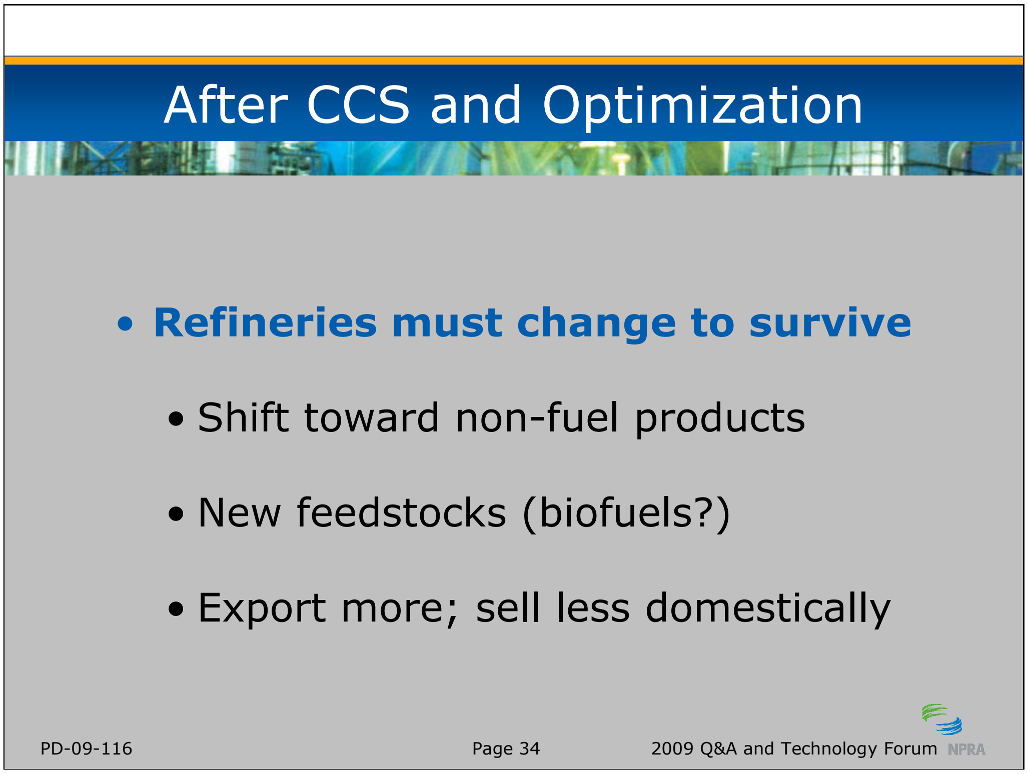
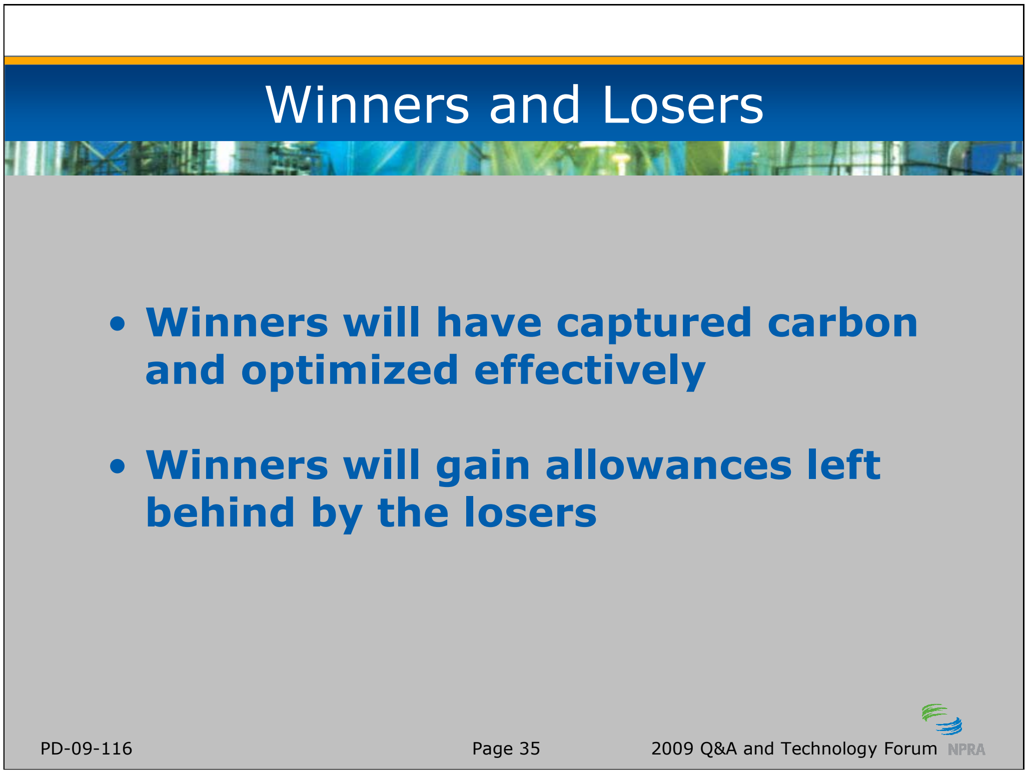
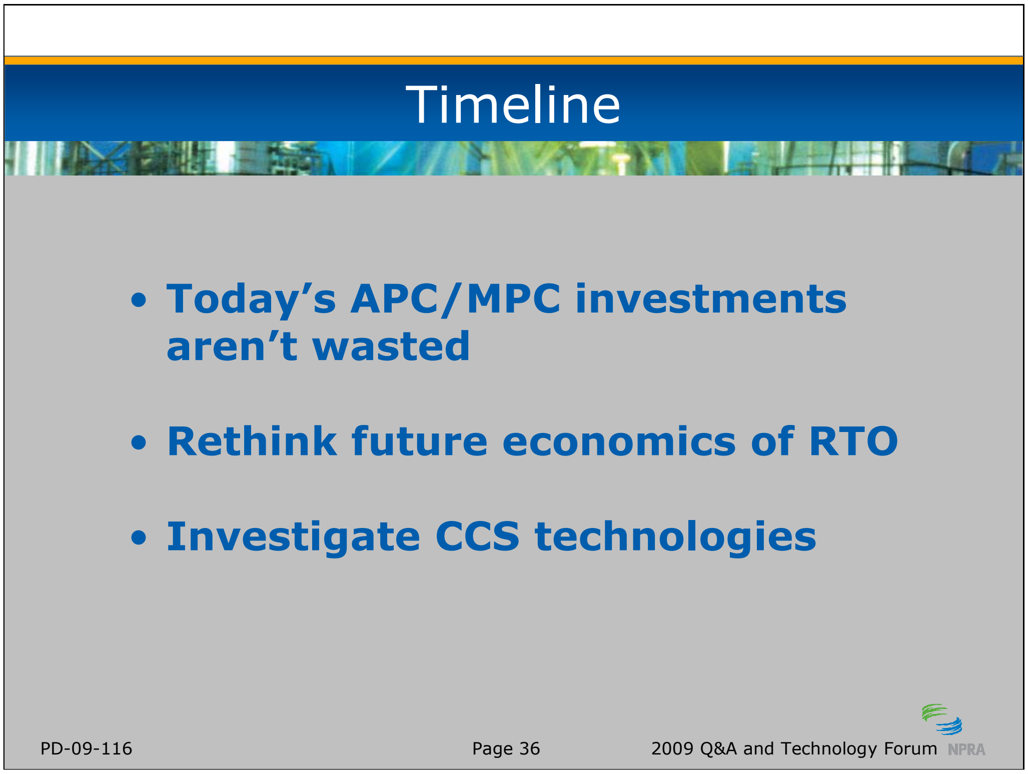
If the legislation passes as-is, eventually we'll be using more non-petroleum-based energy. Present-day levels of fuel production and CO2 emission would not be profitable as restrictions become more stringent over time.



If crude-based fuel is less profitable to produce, what will refineries do with the processing equipment that they've invested in? Non-fuel products aren't subject to the same allowance requirements as fuels. Feedstocks from renewable sources wouldn't be subject to the same restrictions and could become more profitable. Fuel that is refined in the U.S. for export won't be subject to allowances for the products, which is the major portion of allowance requirements (although it may be subject to restrictions set by the importing country).



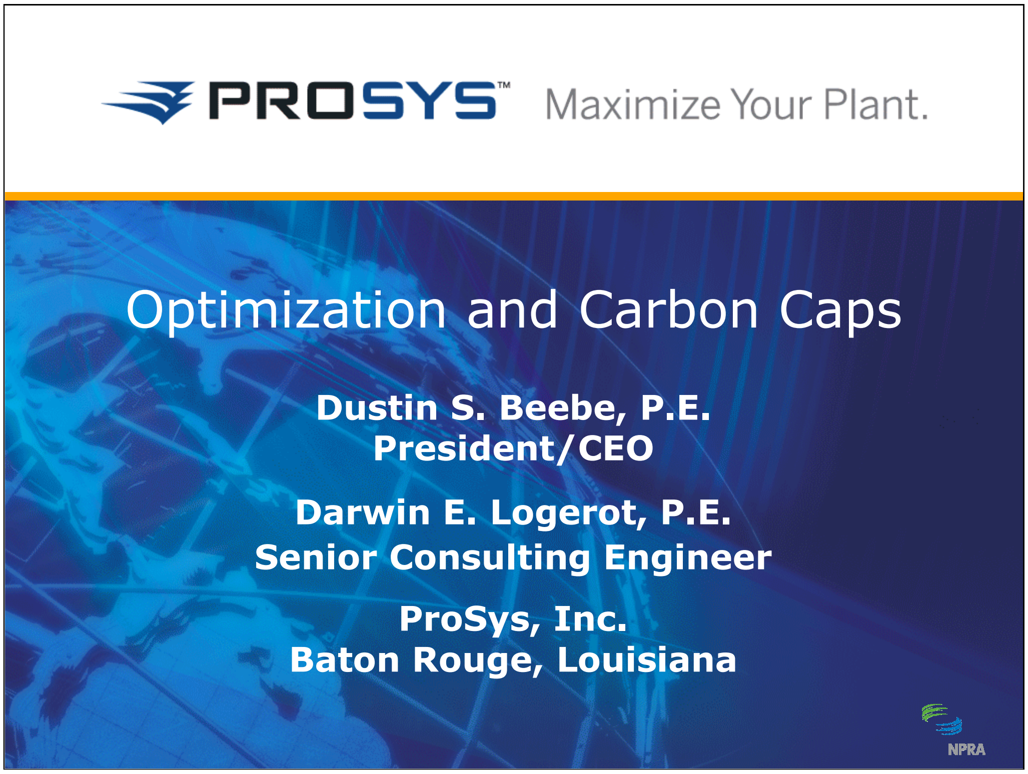
Inefficient refiners will find that their carbon emissions are too costly to justify processing more fuel. As the number of refiners decreases, more allowances will become available for the others since the pool of allowances is fixed.



Even though a cap-and-trade system is not in place yet, it is possible that some sort of cap-and-trade system will eventually be passed. Investments now to make the refinery more carbon-efficient will provide a head start when there is competition for a limited number of allowances.

Conclusion

You don’t need to outrun the bear; you just need to outrun the guy next to you!



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