### Energy and the Built Environment CRP 470.004 /570.004



### Christian E. Casillas

### Lecture 13 Global energy trends

## Document submitted to UN

**U.S. EMISSIONS UNDER 2020 AND 2025 TARGETS** 



## **EPA Clean Power Plan Targets**





### Source: www.nmenv.state.nm.us

### NM CO2 Emissions 2012



#### Source: www.nmenv.state.nm.us



Total emissions reduced to 34% below 2005 emissions. Project emissions growth equal to population growth, of 0.64% per year

# 5 near-term wedges (18 yrs) of 45 Mt CO2



5 Mt CO2/yr

# How to calculate a solar wedge

- Current grid emissions: 0.66 kg CO2/kWh
- Want to reach 5Mt CO2/yr by 2030
- Total kWh reduction by 2030:  $\frac{5x10^{6}tCO_{2} / yr}{0.00066tCO_{2} / kWh} x \frac{GWh}{1x10^{6}kWh} = 7576GWh / yr = 21GWh / day$ 
  - Equivalent PV installed capacity in 2030 (ave CF of 0.23)

$$\frac{21GWh}{24hr*0.22} = 3.8GW$$

## Example: solar PV

5 near-term wedges (18 yrs) of 45 Mt CO2 eq (.5 x 18yrs x 5 Mt/yr)







# Rate of installation

- 3.8 GW of PV installations in 18 years
- 210 MW/year
- If ave household installation is 2kW, then this would be 210,000 kW / 2kW = 105,000 households/year.
  - There were only 905,000 housing units in NM in 2013!!
- Or twenty-one 10 MW solar PV plants per year...
  - Pretty fast!

## Cost

- 210 MW/year
- 4 \$/W ave installed cost (2013)
- 210 e6 W/yr x 4 \$/W = 840 million \$/yr
- Ave annualized lifetime cost per "system" per year (assuming 20yr payback, 7% discount)
  - 840e6 \$/yr x ( .07/(1-1.07^-20)) = 79 million \$/yr
  - 79 million \$/yr for 210 MW installations per year

# Mitigation cost

- 79 million \$/yr for 210 MW installations per year
- Annual emissions reductions from 210 MW/yr – 0.278 MtCO2/yr
- 79 M\$/yr / 0.278 MtCO2/yr = 284 \$/CO2

## What is the comparative advantage?

- Who saves money from the investment?
- Who does this cost?
- Is there job creation?
- Are there other life-cycle environmental implications (not just CO2 – what about water, other pollutants)

# Mitigation sources (McKinsey)

Abatement

### U.S. MID-RANGE ABATEMENT CURVE - 2030



# What are policies that can encourage this...

- PACE (only in SF county)
- Net metering (less than 10 kW)
   Additional paper work up to 80 MW
- NM State tax rebate: up to \$9,000 or 10% of installation cost
- Federal tax credit: 30%
- RPS

# Emissions from reforestation?

- 27% of NM is forestland (5.3 million ha)
- Annual estimated Mt CO2 absorption
  - 16.7 Mt CO2/yr
  - 3 tCO2/ha yr
- How much land would need to become forested to reach an additional 5Mt CO2/yr by 2030?
  - 16,042 sq km of land reforested
  - An additional 5% of land area in NM

Emissions reference: <u>http://www.nmenv.state.nm.us/cc/documents/CCAGFinalReport-</u> <u>AppendixD-EmissionsInventory.pdf</u>

# How do we impact market transformation?

- Does fire suppression lead to long term, increased carbon sequestration?
- Can we encourage reforestation?
- Can we utilize wood overgrowth for power generation/heating?
- What are co-benefits to greater forest management/protection/hands-off?

# Emissions from chickens?

- 1.4 Mt of CO2 emissions associated with 1 Mt of chicken production (Pelletier, 2008)
- For 5 Mt/yr reduction, need to replace 3.6 Mt of chicken consumption in 18yrs.
- Ave US consumption/yr: 45 kg/person
- NM pop: 2.068 million people
- tons of chicken consumption in NM: 0.1 Mt

# What are the co-benefits?

- What are other benefits from reducing reliance on factory-farmed chicken?
- Raising chickens at home?

# **Key Points**

- Carbon mitigation analysis tools should emphasize strengthening vulnerable communities.
- Policy makers need continued exposure to tools of analysis that simplify connections between social, economic, and environmental impacts of carbon mitigation projects.







### Marginal abatement cost (MAC) curve



# Inclusion of welfare metrics

- Poverty Headcount Ratio
  - The fraction of the population that is living below
     \$ 1.25 per day
- Income Gini coefficient (ranges from 0 to 1)
  - 0 indicates perfect income equality
  - 1 indicates total inequality



Casillas, C. E. & Kammen, D. M. 2012. Quantifying the social equity of carbon mitigation strategies.



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#### Fig. 1. Proposed visual to simultaneously communicate GHG mitigation potential and development benefits of technology options

			seesSocial ↔	Economic		Implementation		
MAC Curve		Technologies	HART COLOR AND TO TO A CONTRACT	CR . LONG THE CONTRACT	were waterwart	A Start Start Start Start		
	1 	1. Lighting	• •		- •	- • • •		
		<ol><li>Smart Grid – Automated Residential Systems</li></ol>	• • • -	- •				
		<ol><li>Smart Grid - AMI with Visual Display</li></ol>	• • • - •	• •		•		
		4. Building Management Systems	• - • •		• •			
		5. Hybrid Vehicles		• • •	• •	• - • •		
		6. Geothermal		•		- • •		
E E		7. Landfill Gas Power Generation	<b></b>	• • • •	• •			
		8. Wind (low-cost)	- • • •	• •	• -	- • • •		
500 -		<ol><li>Industrial Improvements (retrofits, new builds)</li></ol>	▽ ▲ ● ▽ −	<b>•</b> • • •	<b>–</b>	• - • -		
		10. Soil Sequestration (mid-cost)	- • - • -		• •			
		11. Soil Sequestration (high-cost)	•		• -	•		
		12. Crop Rotations	• • • • •	• • • -	• -			
		13. Afforestation (low-cost)		• • • •	- •	• •		
		14. Forest Management (mid-cost)	• •	• • • •		• • • -		
		15. Efficiency-Commercial Retrofits			• •			
		16. Efficiency-Residential Retrofits	• • • -		• •			
1.000		17. Wind (high-cost)	•	• • • •	<b>v</b> •			
1,000		18. Afforestation (mid-cost)		<del></del>	• -	- • •		
		19. Forest Management (high-cost)		• - • •	<b>•</b> •	🗸		
-		20. Plug-in Vehicles	$\bullet$ $\bullet$ $\bullet$ $ \bullet$	• 🚽 🌥 •	<del></del>			
		21. Ethanol-fueled Vehicles	· · · · · -	<b>•</b> • • -		· ·		
		22. Solar PV (utility scale)	- •		<del>.</del> –	<del>.</del>		
		23. Nuclear		• • • •	- •	• •		
		24. CCS (new build, post-combustion coal)	■	* • • <del>.</del>	· ·	• - •		
-		25. Efficiency-Residential New Builds		• - • •	• •	• • • •		
1,500 -		26. Landfil Projects (high-cost)		• - • •	· · ·	• •		
		27. Biomass	· · · · ·	• • • 🚽	<b>•</b> •	• • • •		
		28. Gas Industry Projects		• • - 🗢		0 0 0		
	25	29. Electric Vehicles			· · ·			
-		30. CCS (retrofit, post-combustion coal)	U A O U A			· · · ·		
		31. Afforestation (high-cost)	- • • - •		• -	• • •		
		32. Solar PV (residential)	· •	😈 🌒 🌨 —	• -	v – • •		
		33. CCS (new build, oxyfuel, coal)	• - •	• • • •	<del></del>	• • - •		
		34. Coal Mine, Oil Industry, High GWP, Wastewater Projects	• • • • •	- • • •	- •	- • • -		
2,000 -	34	35. Coal-gas Fuel Switch for Installed Fleet		· · · ·		• • •		
		36. CCS (new build, pre-combustion IGCC)	👦 - 🔺	• • • -	<del>.</del> –			
Annual Abatement		37. CCS (retrofit, oxyfuel, coal)(\$107)	• • • •	• - • -	• -			
Potential (MtCO2e)	37	38. Solar Thermal (\$140)	• • •			• - • •		
	38	39. Gas Industry Project (high-cost)(>\$1,000)	- • - • •	• • - •		U		
-\$50 \$0	0 \$50 \$100 Cost							

The randomized data inserted in this table is for purposes of demonstration only and does not represent actual research.

A visual Development Impact Assessment (DIA) tool was applied to support an analysis of mitigation options for Kenya's National Climate Change Action Plan (NCCAP)

<ul><li>High Positive</li><li>Positive</li></ul>	Climate			Sustainable Development				
<ul> <li>Neutral / Minor impact</li> <li>Negative</li> <li>Uncertain</li> </ul>	Abatement potential in 2030 (MtCO <sub>2</sub> e)	Abatement cost 2030 (US\$/tCO <sub>2</sub> )	Adaptation impact	Energy security	GDP growth	Employment / Rural livelihoods	Improved land management	Environmental benefits
Agroforestry	4.16	13.25						$\bullet$
Conservation Tillage	1.10	14.36						
Limiting Use of Fire in Range and Cropland Management	1.00	21.00		-	-	-	•	

Figure 3. Overview of mitigation potential, costs, and adaptation and sustainable development impacts of low-carbon development options in the agriculture sector in Kenya