

Reducing U.S. Greenhouse Gas Emissions: *How Much at What Cost?*



US Greenhouse Gas Abatement Mapping Initiative

RFF's First Wednesday Seminar

June 4, 2008

Government agencies forecast US emissions to rise 35% by 2030 – we addressed two fundamental questions:

How Much Abatement Potential?

- Assuming existing (and some emerging) technologies
- Recognizing constraints (e.g. supply chain, permitting)
- Ranging potential outcomes based on “national resolve”
- Holding consumer “utility/benefits” constant

At What Cost?

- Incremental capital, operating, and maintenance costs
- Levelized all costs at a 7 percent rate, 2005 dollars
- Focused on long term equilibrium costs
- Excluded implementation and related “policy” costs

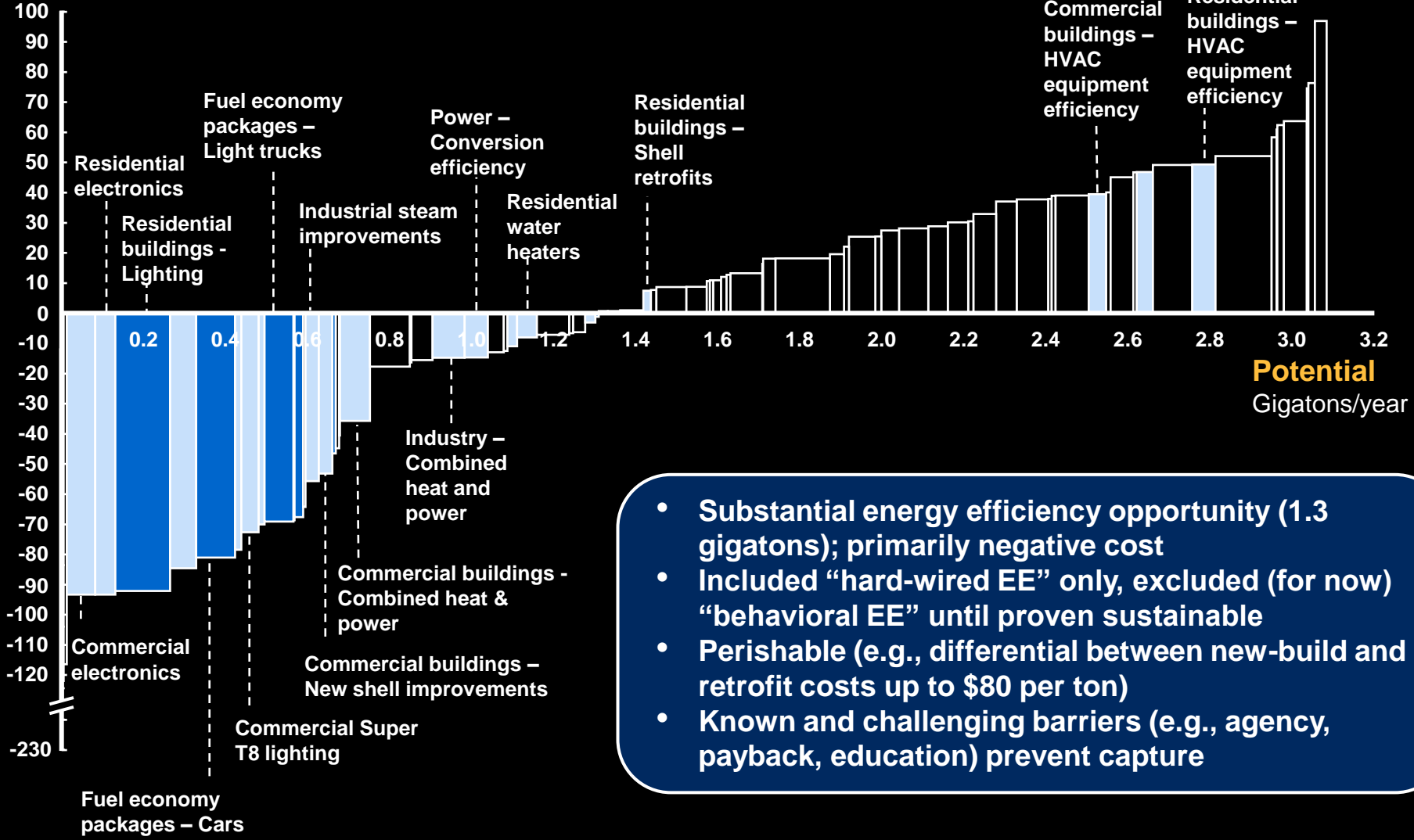
Energy efficiency/productivity opportunity profile

2030 MID-RANGE CASE

Energy efficiency-related opportunities
 Significant capture - 2007 Energy Independence and Security Act

Cost

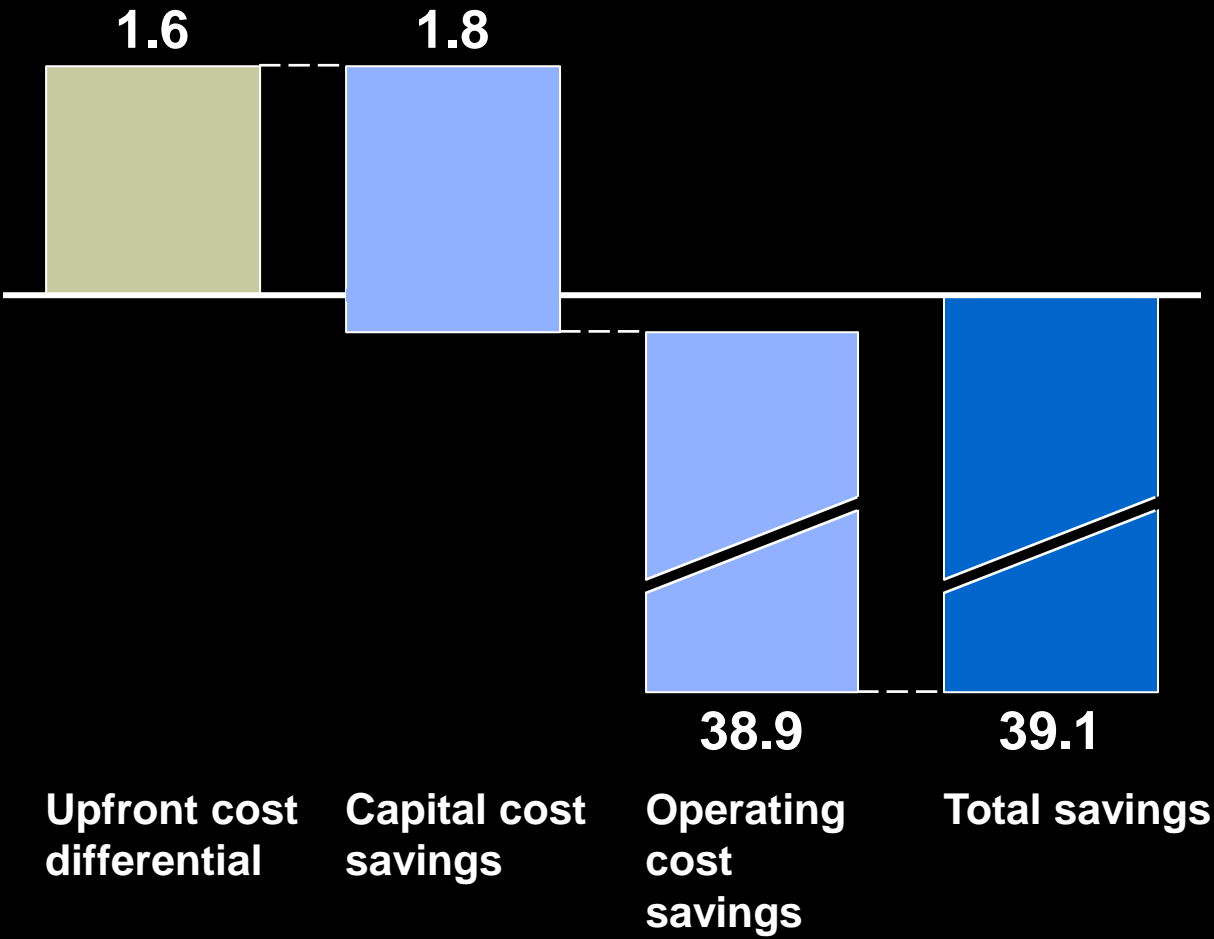
Real 2005 dollars per ton CO₂e



- Substantial energy efficiency opportunity (1.3 gigatons); primarily negative cost
- Included “hard-wired EE” only, excluded (for now) “behavioral EE” until proven sustainable
- Perishable (e.g., differential between new-build and retrofit costs up to \$80 per ton)
- Known and challenging barriers (e.g., agency, payback, education) prevent capture

Energy productivity economics – Residential general use lighting example

Total cost savings to the consumer (*present value*)*
\$ (2005 real, present value)/light bulb



Comprehensive stock and flow model used to estimate lighting potential:

		census division	bldg type	year	Number of HH	starts	sq footage stock (mm)	BAUICAD STOCK	BAUCFL STOCK	BAULED STOCK	BAUTOTAL BAU STOCK
5 South Atlantic	Single Family	5 South Atlantic	Single Family	2001	14,789,885	0	0.00	6.86E+08	0.00E+00	0.00E+00	6.86E+08
		5 South Atlantic	Single Family	2002	15,151,577	406,062	29,234.00	6.85E+08	0.00E+00	0.00E+00	6.85E+08
		5 South Atlantic	Single Family	2003	15,543,991	437,870	30,274.00	6.76E+08	1.48E+07	0.00E+00	6.91E+08
		5 South Atlantic	Single Family	2004	15,970,878	473,519	31,419.00	6.81E+08	3.82E+07	0.00E+00	7.19E+08
		5 South Atlantic	Single Family	2005	16,428,849	505,884	32,676.00	6.88E+08	6.07E+07	0.00E+00	7.49E+08
		5 South Atlantic	Single Family	2006	16,832,538	452,976	33,803.00	6.94E+08	8.18E+07	0.00E+00	7.76E+08
		5 South Atlantic	Single Family	2007	17,195,510	413,468	34,833.00	7.05E+08	9.62E+07	0.00E+00	8.01E+08

Business as usual stock model

		census division	bldg type	year	MEDtotal purch	MEDI purch	MEDCFL purch	MEDLED purch	MEDtotal turnover	MEDI turnover	MEDcfl turnover	MEDled turnover	MEDtotal stock	MEDI stock	MEDCFL stock	MEDLED stock
5 South Atlantic	Single Family	5 South Atlantic	Single Family	2001	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.97E+08	3.97E+08	0.00E+00	0.00E+00	686388986	6.86E+08	0	0
		5 South Atlantic	Single Family	2002	4.20E+08	4.20E+08	0.00E+00	0.00E+00	3.96E+08	3.96E+08	0.00E+00	0.00E+00	685433327.8	6.85E+08	0	0
		5 South Atlantic	Single Family	2003	4.35E+08	4.09E+08	2.61E+07	0.00E+00	4.10E+08	4.10E+08	0.00E+00	0.00E+00	709628830.3	7.10E+08	0	0
		5 South Atlantic	Single Family	2004	5.36E+08	4.40E+07	0.00E+00	0.00E+00	4.12E+08	4.10E+08	2.23E+06	0.00E+00	735022277.2	7.09E+08	26129886.5	0
		5 South Atlantic	Single Family	2005	4.32E+08	3.76E+08	5.62E+07	0.00E+00	4.08E+08	4.02E+08	5.80E+06	0.00E+00	763037503.4	6.95E+08	67890624.9	0
		5 South Atlantic	Single Family	2006	4.20E+08	3.59E+08	6.04E+07	0.00E+00	3.97E+08	3.87E+08	1.00E+07	0.00E+00	787966008.1	6.70E+08	118311490.5	0
		5 South Atlantic	Single Family	2007	4.07E+08	3.43E+08	6.44E+07	0.00E+00	3.85E+08	3.71E+08	1.42E+07	0.00E+00	810807070.9	6.42E+08	168711869.9	0

Assessment of potential for new purchases and turnover

		census division	bldg type	year	MEDBAU kWh	MEDkWh	MEDSavings	MEDBAU op cost	MEDHigh Op Cost	MEDBAU Incan cap	MEDBAU CFL capital	MEDBAU LED capital
5 South Atlantic	Single Family	5 South Atlantic	Single Family	2001	2.95E+10	3.00E+10	-5.37E+08	1.92E+09	1.95E+09	\$902,036,516.61	\$0.00	\$0.00
		5 South Atlantic	Single Family	2002	2.97E+10	2.99E+10	-2.41E+08	1.94E+09	1.95E+09	\$900,780,612.69	\$0.00	\$0.00
		5 South Atlantic	Single Family	2003	2.97E+10	3.10E+10	-1.27E+09	1.94E+09	2.02E+09	\$888,830,458.93	\$18,136,380.63	\$0.00
		5 South Atlantic	Single Family	2004	3.02E+10	3.13E+10	-1.14E+09	1.97E+09	2.04E+09	\$894,342,759.90	\$46,758,590.18	\$0.00
		5 South Atlantic	Single Family	2005	3.08E+10	3.14E+10	-5.25E+08	2.01E+09	2.04E+09	\$904,481,699.57	\$74,308,077.89	\$0.00
		5 South Atlantic	Single Family	2006	3.14E+10	3.09E+10	4.51E+08	2.04E+09	2.01E+09	\$906,060,874.07	\$99,582,203.75	\$0.00

BAU consumption and costs

		census division	bldg type	year	MEDIncan Capital	MEDCFL Capital	MEDLED Capital	MEDNet Op	MEDNet Capital	med net cost	MEDNet Abatement
5 South Atlantic	Single Family	5 South Atlantic	Single Family	2001	\$0.00	\$0.00	\$0.00	\$34,989,145.84	(\$902,036,516.61)	(\$867,037,071.57)	-5.37E+08
		5 South Atlantic	Single Family	2002	\$0.00	\$0.00	\$0.00	\$34,989,145.84	(\$900,780,612.69)	(\$885,078,953.36)	-2.41E+08
		5 South Atlantic	Single Family	2003	\$0.00	\$0.00	\$0.00	\$34,989,145.84	(\$888,830,458.93)	(\$855,380,150.55)	-1.27E+09
		5 South Atlantic	Single Family	2004	\$34,339,423.40	\$0.00	\$0.00	\$34,989,145.84	(\$894,342,759.90)	(\$855,380,150.55)	-1.14E+09
		5 South Atlantic	Single Family	2005	\$89,220,287.68	\$0.00	\$0.00	\$34,989,145.84	(\$894,342,759.90)	(\$880,654,271.35)	-5.25E+08
		5 South Atlantic	Single Family	2006	\$154,394,191.04	\$0.00	\$0.00	\$34,989,145.84	(\$904,481,699.57)	(\$917,419,759.95)	4.51E+08
		5 South Atlantic	Single Family	2007	\$218,625,782.19	\$0.00	\$0.00	(\$106,344,811.01)	(\$811,074,948.93)	(\$964,811,735.03)	1.69E+09
		5 South Atlantic	Single Family	2008	\$281,637,480.24	\$0.00	\$0.00	(\$193,258,186.21)	(\$771,553,548.82)	(\$964,811,735.03)	2.97E+09

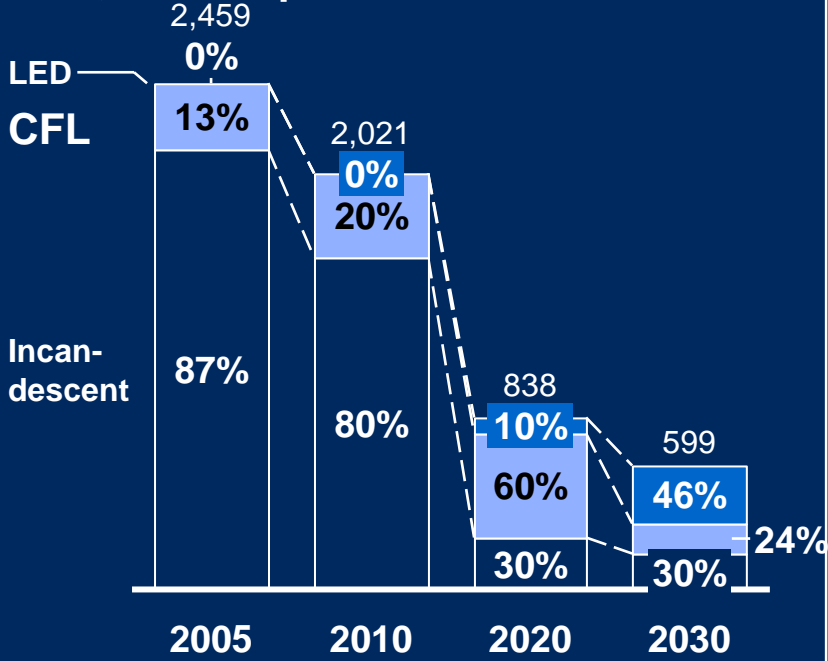
Abatement volume and costs module

2030 avoided energy demand – single-family homes, SA CDIV

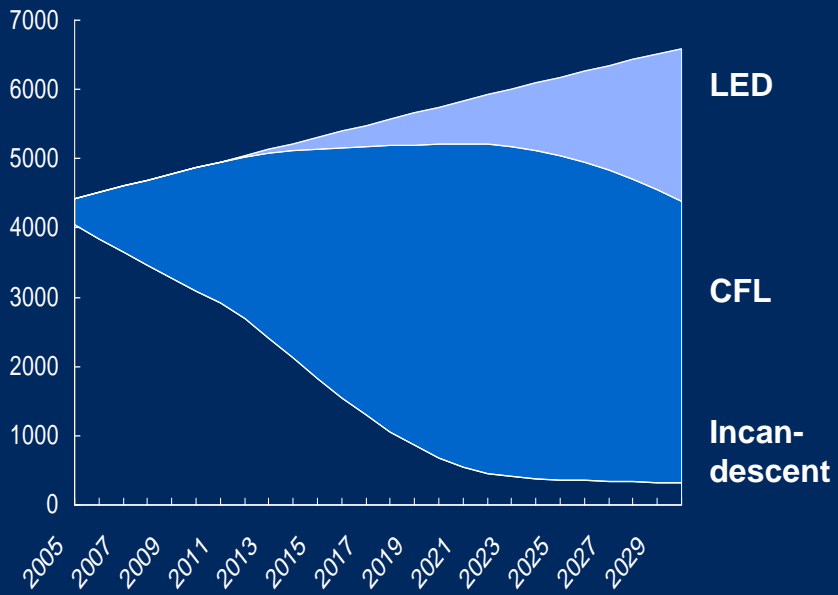
Residential general use lighting abatement results in changes in the U.S. lighting market

Million lamps sold (normalized for lumen output)

Sales penetration
Percent, MM lamps



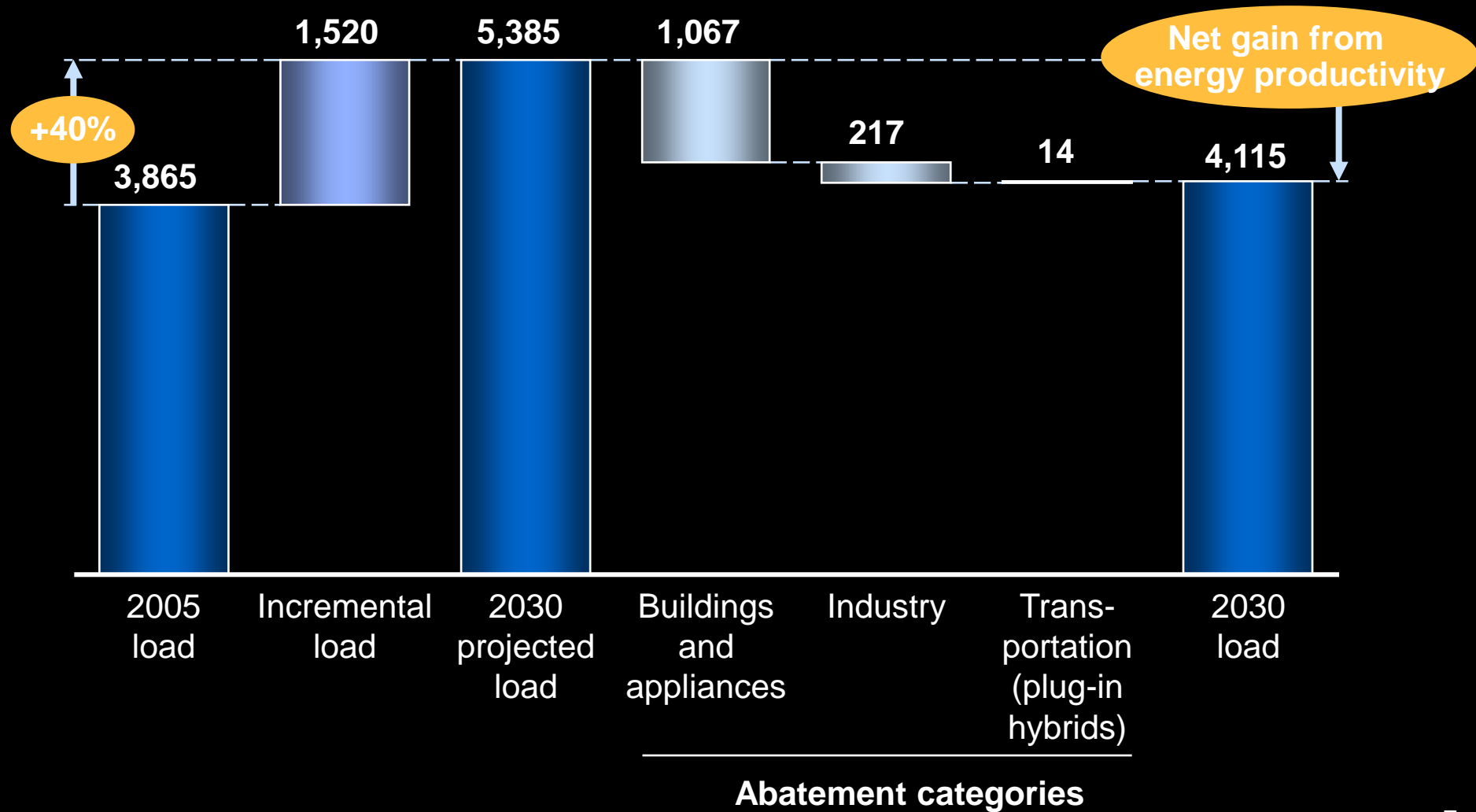
Stock of lights
MM lamps



Energy productivity has potential to offset majority of incremental electric growth through 2030

Terawatt-hours

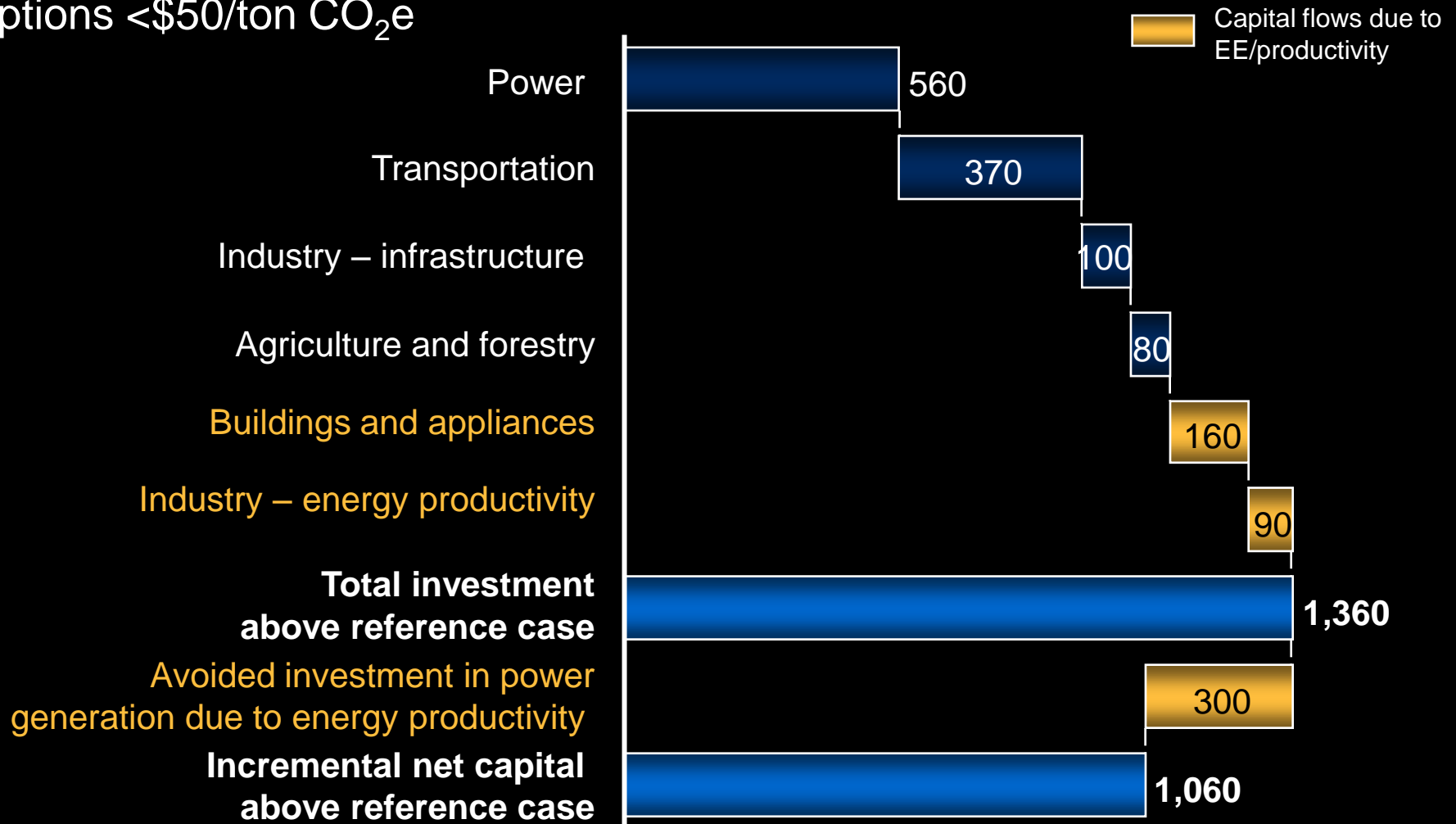
MID-RANGE CASE - 2030



Incremental capital investment in mid-range case

MID-RANGE
CASE – 2030

Real 2005 \$ billions, cumulative through 2030;
options <\$50/ton CO₂e

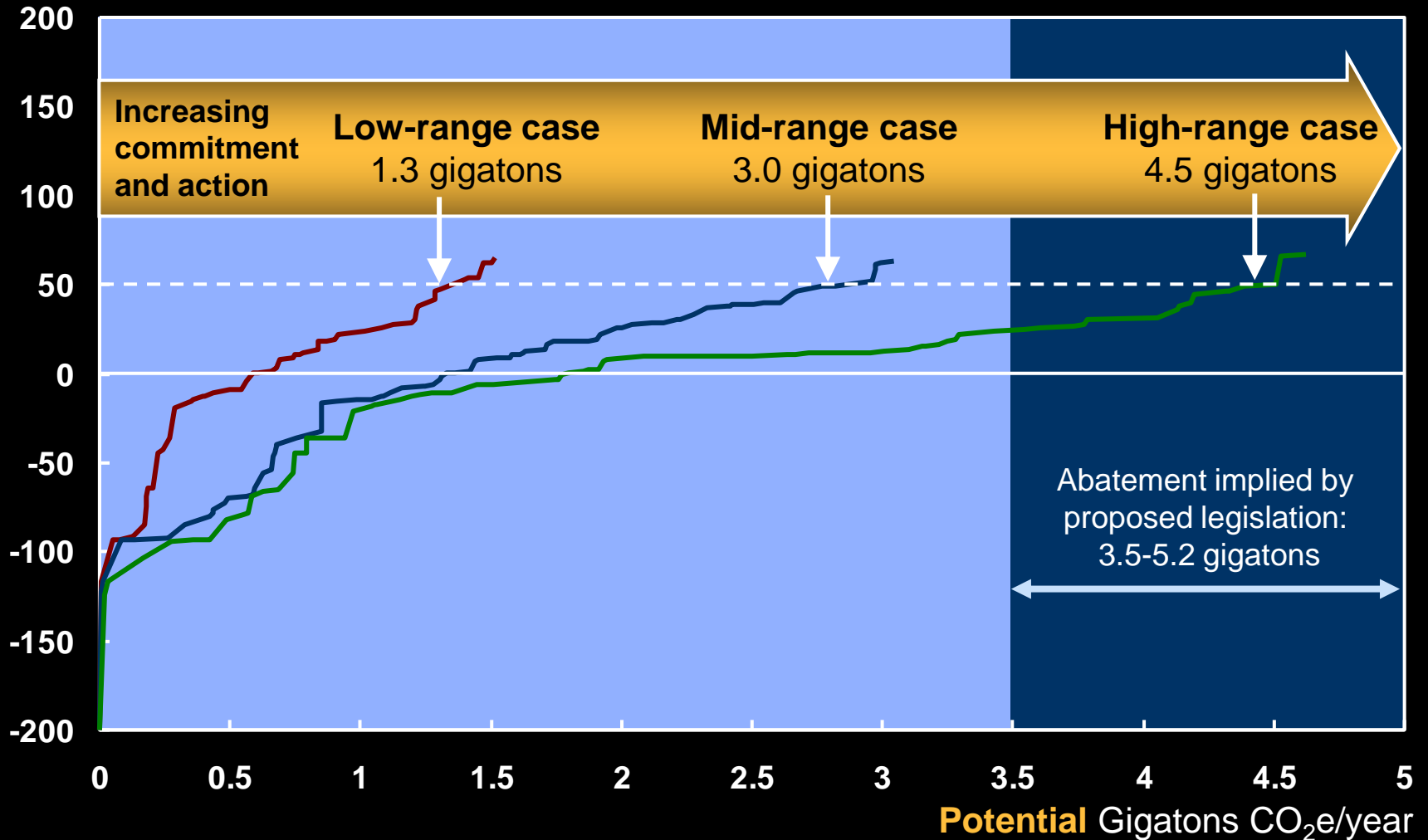


Energy Efficiency/Productivity: How “easy” to achieve???

- *“Without a forceful and coordinated set of actions, it is unlikely that even the most economically beneficial options would materialize at the magnitude and costs estimated here.”*
- **“Unlocking the negative cost options would require overcoming persistent barriers to market efficiency such as mismatches between who pays the cost of an option and who gains the benefit...”**
- **“Given consumers’ historically inelastic response to variations in energy prices, motivating end users to act based on price signals alone would likely require price stimuli well beyond what may be politically feasible.”**
- **“Further, simply imposing “carbon caps” on point-source emitters might provide the incentive – but not the means – to extract the energy efficiency potential that is distributed across millions of energy users.”**
- **“Put simply, the potential for energy efficiency is real and large, but without a change in policy or approach, this potential will remain out of reach.”**

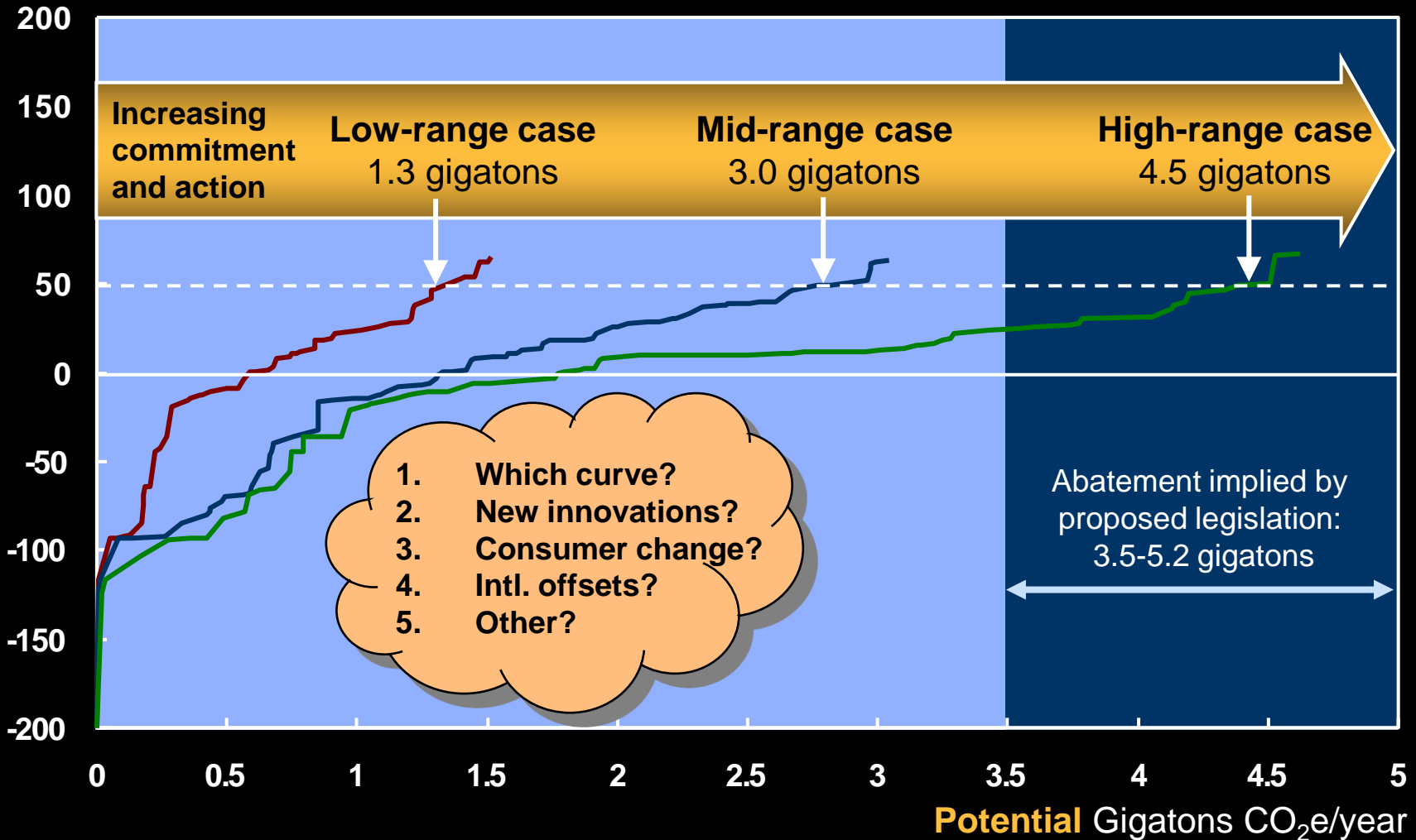
3.0 to 4.5 gigatons of reduction potential available with concerted economy-wide action

Cost \$(2005 real) ton CO₂e



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