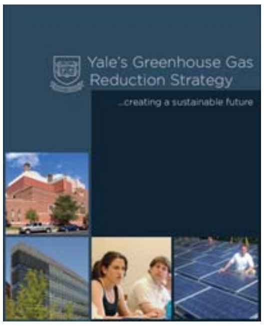
Yale's Greenhouse Gas Reduction Goals and Strategy

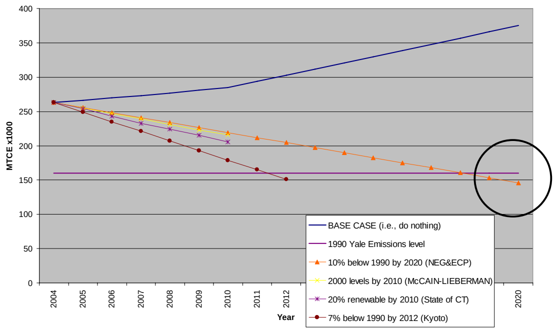
…reshaping the way we think and innovate

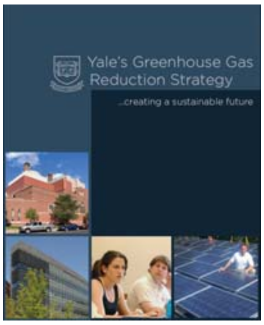


Julie Newman, Ph.D., Director, Yale Office of Sustainability

***Central Power Plant**, a cogeneration facility that can supply 18 megawatts of electricity, 340,000 pounds per hour of steam and 14,600 tons of chilled water to the Central and Science Campuses;*

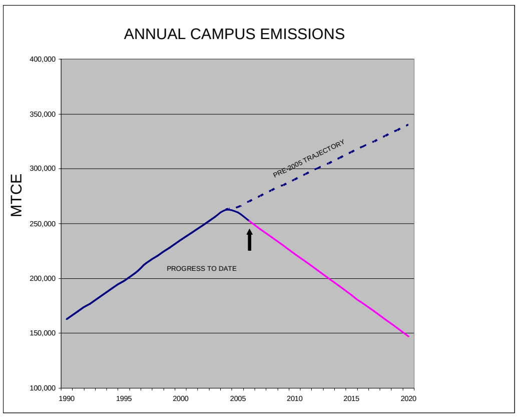
***Sterling Power Plant**, a thermal energy facility that can supply 350,000 pounds per hour of steam and 19,900 tons of chilled water to the Yale School of Medicine and the Yale-New Haven Hospital.*

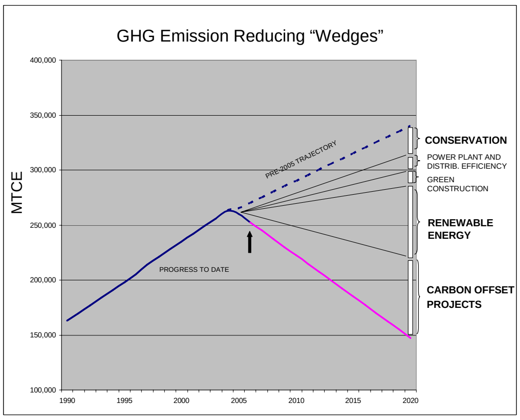




10% reduction from 1990 levels by 2020

43% reduction from 2005 levels





Means of Reducing GHG Emissions

1. Conservation
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   -
   -
   -
2. Renewable Energy
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   -

Higher Efficiency Systems

Relative to current status quo:
- First cost premium
- Lower annual operating cost
- "Payback" of premium prior to end of equipment's useful life

-
-
-

Lower Efficiency Systems

Relative to current status quo:
- First cost premium
- Higher annual operating cost
- No payback of premium

3. Offsets
   -
   -

Financial Support to Others

- Higher annual operating cost

Carbon Reduction Initiatives and Potentials

Assumptions: 140lb/mmbtu, $8/MCF, i=5.2%

Initiative	Capital $	MTCE Avoid. Pot'l	$Cap / MTCE	Total Potential (Campus% or GSF)	Annual: Energy Cost Savings	Annual: I & A Cost	Annual: I & A Cost per MTCE
Bldg temp. standardization in Metasys bldgs	$0	7,800	NA	60-70%	$1,000,000	na	$0
Buy National RECs @$0.0025/kwh	$0	1	0	PER MTCE	na	$5	$5
Prog. Thermostats non-Metasys / small bldgs	$100,000	300	333	All Small bldgs	$40,000	$13,080	$44
Ground Source Heat pump - OPEN loop	$3,000,000	3,200	938	1M GSF	$400,000	$244,800	$77
Continuous commissioning All Metasys Bldgs	$0	2,600	0	60-70%	$320,000	$250,000	$96
Ground Source Heat pump - Closed loop	$4,000,000	3,200	1,250	1M GSF	$400,000	$326,400	$102
Occ Sensors for lighting control	$1,500,000	1,800	833	3.9M GSF	$400,000	$196,200	$109
New Science Bldgs 50% below ASHRAE (90.1 1999) Energy Stds	$1,575	1	1,575	PER MTCE	$125	$114	$114
Heat Recovery	$6,000,000	4,100	1,463	Labs w/100% OA ~1M GSF	$520,000	$489,600	$119
Wind Farm at Yale Myers Forest NE CT	$9,000,000	5,400	1,667	three 1.5Mw wind turbines	TBD	$651,600	$121
Roof - Green	$5,000,000	2,500	2,000	Assume 500,000 sq ft	$320,000	$362,000	$145
Fume hood retrofit/replacement CV to VAV	$1,700,000	750	2,267	All CV Hoods - 150 total	$100,000	$138,720	$185
New Academic Bldgs 20% below ASHRAE (90.1 1999) Energy Stds	$2,835	1	2,835	PER MTCE	$125	$205	$205
High Efficiency filters	$0	1,500	0	All CEN/SCI/MED	$200,000	$400,000	$267
CPP Bldgs: Steam to HW retrofit	$6,000,000	1,300	4,615	1.65M GSF	$225,000	$489,600	$377
Cogen installation at Spp	$50,000,000	9,200	5,435	90% of Medical Area Elec	TBD	$3,620,000	$393
Roof - PV panels or integrated	$1,500,000	200	7,500	Assume Pot'l is 10 x Divinity	$40,000	$108,600	$543
Maint. Of Steam traps	$0	300	0	All Dist & Bldgs	$30,000	$250,000	$833
Insulation of Dist. Systems	$0	300	0	All Dist & Bldgs	$30,000	$500,000	$1,667

Renewable Energy Analysis

	Technology	Annual Carbon Offset (MTCE)	Evaluation Criteria – Efficacy of Technology: I&A / MTCE	Efficacy of Technology: Lbs. CE / $ I&A	Cost Premium vs. Efficacy: Incremental Capital Cost	Cost Premium vs. Efficacy: Incremental I&A Cost	Cost Premium vs. Efficacy: Simple Payback assuming 3% annual growth (Yrs)	Post "Payback" Attributes: Years "in the black" before system replacement	Post "Payback" Attributes: Percentage of system requiring replacement at end of useful life
	Geothermal - (Standing Column)								
	Near Term - Decision Needed Now								
1	Social Science 1 (150 ton)	453	$54	40.8	$300,000	$24,480	4.4	15.6	25%
2	Greenberg Conference Center	91	$68	32.6	$75,000	$6,120	5.5	14.5	25%
3	Health Services	302	$68	32.6	$250,000	$20,400	5.5	14.5	25%
4	Lanman Ctr	456	$63	35.2	$350,000	$28,560	5.1	14.9	25%
	Future							20.0	25%
5	Social Science 2	1,463	$42	52.6	$750,000	$61,200	2.0	18.0	25%
6	Divinity Area remainder	848	$58	38.1	$600,000	$48,960	2.1	17.9	25%
7	13 Res College Courtyards	2,559	$70	31.4	$2,200,000	$179,520	3.3	16.7	25%
8	H H / Trum / Prospect Zone	845	$106	20.7	$1,100,000	$89,760	5.0	15.0	25%
		7,017	**$65**	**33.6**			**5.3**	**14.7**	**25%**
	Bio-Diesel								
9	B20 in small buildings	66 (17)	$97	22.7	na	$6,400	na	never	na
10	B5 in Powerplants	300 (17)	$143	15.3	na	$43,000	na	never	na
		366	**87**	16.3	na	**49,400**	**na**	**never**	**na**
	Solar PV panels								
11	Cullman Tennis Courts - standard panels	76	$756	2.9	$700,000	$30,056	19.5	never	75%
12	Swing Dorm - "thin film" pv	18	$742	3.0	$160,000	$8,013	22.7	never	75%
		93	**$754**	**2.9**	**$860,000**	**$38,069**	**20.0**	**never**	**75%**
	Micro Wind (linear array)								
13	OML (48 turbines @ 1kw)	30	$1,088	2.0	$400,000	$17,175	19.5	never	100%
14	KBT Corridor (6 turbines @ 1kw)	4	$1,020	2.2	$50,000	$2,147	19.5	never	100%
		34	**$1,080**	**2.0**	**$450,000**	**$19,322**	**19.5**	**never**	**100%**
	Micro Wind (vertical axis)								
15	Swing Dorm	3	$1,768	1.2	$65,000	$3,623	26.0	never	100%
		3	**$1,768**	**1.2**	**$65,000**	**$3,623**	**26.0**	**never**	**100%**

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Status of GHG Reduction Efforts

Conservation

- Residential colleges likely to achieve a 5% reduction this year on top of 10% reduction previous year.

- Aggressively pursuing all conservation opportunities.

Renewable Energy

- Actively evaluating "higher efficiency solutions" such as geothermal for installation on campus.

- Seeking strategic visible locations for "lesser efficiency systems" such as solar pv and micro-wind.

Offsets

- Modeling portfolios of offsets that maximize impacts and "additionality".