APPENDIX F
Residential and Commercial Sector Work Plans

Summary of Work Plan Recommendations

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)			CCAC Voting Results (Yes / No / Abstained)
		GHG Reduc-tions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)	
1-4	High-Performance Buildings (Total for RC-1 Through RC-4)	31.9	-$256.3	-$8.0	139.7	-$1,653	-$11.8	21 / 0 / 0
1	High-Performance State and Local Government Buildings	2.7			11.3			
2	High-Performance School Buildings	1.9			7.8			
3	High-Performance Commercial (Private) Buildings	9.0			37.4			
4	High-Performance Homes (Residential)	18.3			83.1			
5	Commissioning and Retrocommissioning PA Buildings	1.5	-$17	-$11.2	9.6	-$71	-$7.4	21 / 0 / 0
6	Re-Light Pennsylvania	12.9	-$823	-$64	103.2	-$4,020	-$39	20 / 0 / 1
	Residential	3.5	-$328	-$95	30.0	-$1,887	-$63	
	Commercial—lighting power density	5.3	-$367	-$69	30.7	-$806	-$26	
	Commercial—fixture performance	4.0	-$136	-$34	33.9	-$1,039	-$31	
	Commercial—daylighting	0.8	-$64	-$82	5.0	-$204	-$41	
	Commercial—controls	2.1	$108	$52	14.3	$511	$36	
	Commercial—parking lot lighting	1.1	-$117	-$103	10.5	-$613	-$58	
	Commercial—exit signs	0.0	-$1	-$64	0.1	-$6	-$44	
7	Re-Roof Pennsylvania	1.4	$472	$327	4.3	$1,064	$247	14 / 7 / 0
	Light-colored, insulated roofs	0.2	-$4	-$18	0.8	$13	$17	
	Green roofs	0.1	$77	$614	0.3	$147	$462	
	PV roof	1.1	$399	$359	3.2	$903	$282	
8	PA buys EE appliances	1.9	-$68	-$36	12.4	-$291	-$24	13 / 8 / 0
9	Geothermal Heating and Cooling	1.4	$224	$158	8.0	$879	$109	21 / 0 / 0
10	DSM - Natural Gas	7.3	-$51	-$7	40.5	-$357	-$9	21 / 0 / 0
11	Conservation and Fuel switching for Heating Oil	5.7	-$21	-$4	35.8	$140	$4	21 / 0 / 0
13	DSM - Water	0.1	-$255	-$1,944	0.8	-$1,011	-$1,285	21 / 0 / 0
14	Renew PA buildings PA Values Embodied Energy in Building Materials, Including Historic Structures	Not quantified						17 / 1 / 2
15	Sustainability Education Programs	Not quantified						17 / 1 / 2
16	Adaptive Building Reuse	Not quantified						17 / 1 / 2
Sector Total After Adjusting for Overlaps		32.25	-$538	-$17	214.5	-$3,668	-$17	

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)			CCAC Voting Results (Yes / No / Abstained)
		GHG Reduc-tions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)	
Reductions From Recent Federal		5.07	-$145	-$28	29.9	-$567	-$19.0	
Federal Appliance Standards - Electricity		4.77			28.7			
Federal Appliance Standards - Natural Gas		0.3			1.2			
Sector Total Plus Recent Actions		37.4	-$683	-$18	244.4	-$4,235	-$17	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; NPV = net present value.

Negative values in the Cost and the Cost-Effectiveness columns represent net cost savings.

The numbering used to denote the above work plans is for reference purposes only; it does not reflect prioritization among these important work plans.

RC-1 – RC-4. High-Performance Buildings

Buildings are a major source of demand for energy and materials that produce by-product greenhouse gases. It will require immediate and significant action in the building sector to slow the growth rate of greenhouse gas emissions in Pennsylvania.

Recently, Architecture 2030 has issued **The 2030 Challenge** asking the global architecture and building community to adopt the following targets:

- All new buildings, developments and major renovations shall be designed to meet a fossil fuel, greenhouse gas (GHG)-emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type.

- At a minimum, an equal amount of existing building area shall be renovated annually to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type.

- Architecture 2030 established the following fossil fuel reduction standard for all new buildings and major renovations:

  60% for buildings in 2010
  70% for buildings in 2015
  80% for buildings in 2020
  90% for buildings in 2025
  100%* for buildings in 2030
  *(using no fossil fuel greenhouse gas emitting energy to operate).

Architecture 2030 envisioned that these targets would be accomplished by implementing innovative sustainable design strategies, generating on-site renewable power and/or purchasing (20% maximum) renewable energy and/or certified renewable energy credits.

The main goals for this work plan generally come from the Architecture 2030 Challenge building goals, with some revisions from the subcommittee. These goals are summarized in the following tables. Following the tables are proposed vehicles to meeting these goals.

The GHG emission reductions for Pennsylvania through 2020 were estimated assuming that these goals are met. The key assumptions and results of that analysis are shown below.

The quantification analysis helps provide an overall indication of potential GHG emission reductions. However, to better understand the changes to Pennsylvania's building sector equipment and practices, analysis of individual work plans is also needed. The other work plans for quantification will help indicate the ability for the state to meet the goals listed here, and will also provide estimates of the costs for meeting these goals.

The CCAC endorses these goals and recommends RC-1 for new and existing Commonwealth buildings and RC-2 for new schools as mandatory. The Committee recommends evaluating the viability of remaining goals by identifying funding sources to address implementation costs. CCAC further recommends a subcommittee be convened by DEP to provide this evaluation.

Goals:

New Buildings Goals and standards

		2015	2020	2030
New Commercial (Commonwealth owned or operated) RC-1	Overall goal (relative to 2005 building)	60% fossil fuel and electricity reduction	80% fossil fuel and electricity reduction	100% fossil fuel and electricity reduction
	Performance standard	LEED Silver ENERGY STAR 85	LEED Silver ENERGY STAR 85	Not specified
	Fraction of buildings that meet standard	100% of new buildings	100% of new buildings	100% of new buildings
	Deployment of renewable energy	Not specified	Not specified	Not specified
New Commercial (Schools) RC-2	Overall goal (relative to 2005 building)	50% fossil fuel and electricity reduction	70% fossil fuel and electricity reduction	80% fossil fuel and electricity reduction
	Performance standard	LEED Silver ENERGY STAR 85	LEED Silver ENERGY STAR 85	Not specified
	Fraction of buildings that meet standard	100% of new buildings	100% of new buildings	100% of new buildings
	Deployment of renewable energy	Not specified	Not specified	Not specified
New Commercial (private)	Overall goal (relative to 2005 building)	50% fossil fuel and electricity reduction	70% fossil fuel and electricity reduction	80% fossil fuel and electricity reduction

		2015	2020	2030
RC-3	Performance standard	LEED Silver ENERGY STAR 75	LEED Silver ENERGY STAR 85	Not specified
	Fraction of buildings that meet standard	100% of new buildings	100% of new buildings	100% of new buildings
	Deployment of renewable energy	Not specified	Not specified	Not specified
New Residential RC-4	Overall goal (relative to 2005 building)	50% fossil fuel and electricity reduction	70% fossil fuel and electricity reduction	80% fossil fuel and electricity reduction
	Performance standard	HERS 50	HERS 40	HERS 30
	Fraction of buildings that meet standard	100% of new buildings	100% of new buildings	100% of new buildings
	Deployment of renewable energy	Not specified	Not specified	Not specified

Existing Buildings Goals and standards

		2015	2020	2030
Existing Commercial (Commonwealth owned or operated) RC-1	Overall goal (relative to 2005 building)	40% fossil fuel and electricity reduction	50% fossil fuel and electricity reduction	70% fossil fuel and electricity reduction
	Performance standard	ENERGY STAR 75	LEED EB Silver ENERGY STAR 80	LEED EB Silver ENERGY STAR 85
	Fraction of buildings that meet standard	20% of existing buildings	50% of existing buildings	100% of existing buildings
	Deployment of renewable energy	Not specified	Not specified	Not specified
Existing Commercial (Schools) RC-2	Overall goal (relative to 2005 building)	30% fossil fuel and electricity reduction	50% fossil fuel and electricity reduction	70% fossil fuel and electricity reduction
	Performance standard	ENERGY STAR 75	LEED EB Silver ENERGY STAR 80	LEED EB Silver ENERGY STAR 85
	Fraction of buildings that meet standard	20% of existing buildings	50% of existing buildings	100% of existing buildings
	Deployment of renewable energy	Not specified	Not specified	Not specified
Existing Commercial (private) RC-3	Overall goal (relative to 2005 building)	30% fossil fuel and electricity reduction	40% fossil fuel and electricity reduction	50% fossil fuel and electricity reduction
	Performance	ENERGY STAR	LEED EB Silver	LEED EB Silver

		2015	2020	2030
	standard	75	ENERGY STAR 80	ENERGY STAR 85
	Fraction of buildings that meet standard	20% of existing buildings	50% of existing buildings	100% of existing buildings
	Deployment of renewable energy	Not specified	Not specified	Not specified
Existing Residential RC-4	Overall goal (relative to 2005 building)	30% fossil fuel and electricity reduction	40% fossil fuel and electricity reduction	50% fossil fuel and electricity reduction
	Performance standard	HERS 50	HERS 40	HERS 40
	Fraction of buildings that meet standard	20% of existing buildings	50% of existing buildings	100% of existing buildings
	Deployment of renewable energy	Not specified	Not specified	Not specified

Notes: Energy reductions refer to on-site energy consumption.

Possible Vehicles to Support Work Plan Goals

RC-1: High-Performance State and Local Government Buildings

In addition to work plans RC-5 through RC-13, which are technology and action-based work plans that will contribute to meeting the High-Performance Building goals, the following vehicles are presented for consideration:

- "High-Performance PA Buildings"—All Commonwealth of Pennsylvania-owned or -funded construction projects must meet a performance level equivalent to a minimum of LEED Silver plus an Energy Star rating of 85.

- The Department of General Services (DGS) is building a benchmarking database and will be utilizing existing contract capacity with the Penn State Facilities Engineering Institute to begin the auditing/benchmarking process for Commonwealth-owned facilities. Other implementation steps could include:

    - Revise facility manager job descriptions and train staff to incorporate benchmarking into their standard operating procedures.
    - Revise Guaranteed Energy Savings Act (GESA)/energy service company (ESCO) language to incorporate Energy Star performance-based requirements.
    - Mandate all FY 2009–2010 and future GESA/ SCO projects adopt the Energy Star performance-based requirements.
    - Continue working with EPA to streamline the work process and minimize the costs associated with implementing Energy Star performance requirements into building operational procedures.
    - Ask the (PUC) to develop and mandate that all PA utilities conform to a uniform billing structure and format to allow automated billing data entry into the Energy Star Portfolio Manager database.

- Hire and train in-house staff to run program, or educate existing qualified ESCOs on new requirements.

- "Green Strings"—All Commonwealth funding programs, whether grants, loans, tax credits, tax incentives, etc., will have at least a minimal expectation of energy/resource conservation results.
  - The intent of this initiative is to educate involved parties, inform the Commonwealth, and potentially reduce the GHG impacts of building projects. If projects with similar costs and benefits are proposed, the project with the lowest GHG impact will be given preference.
  - Commonwealth agencies to include in their decision-making processes appropriate and careful consideration of GHG emission effects from proposed actions, and their alternatives. This will be done to understand, minimize, and/or avoid potential adverse effects from GHG emissions from the proposed actions, as much as possible. Commonwealth agencies will integrate the GHG emission impacts as early in their planning processes as possible.
  - Commonwealth agencies to require analysis of GHG impacts in all award and approval (permits, grants, procurements, etc) decisions. Entities submitting applications for consideration will be required to include a comprehensive analysis of the GHG impacts of the proposed project. The Commonwealth agencies are only requiring an analysis be performed.

- Require U.S. Environmental Protection Agency (EPA) Energy Star Portfolio Manager benchmarking for all Commonwealth-owned and -leased facilities by 2009.

- Establish a goal of minimum Energy Star rating of 75 for all Commonwealth buildings by 2020.

- Implement the equivalent of LEED for Existing Buildings (LEED-EB), Green Globes, or other certification for ongoing operation and maintenance (O&M) and Energy Star ratings for all Commonwealth buildings. Meet at least the equivalent of LEED-EB Silver certification and an Energy Star score of 75 for all existing buildings by 2020.

- Establish a Pennsylvania Community and Local Government Climate Change Collaborative Clearinghouse to overcome barriers to progress on climate change actions. The project would do the following:
  - Assist communities to develop comprehensive plans that include buildings, transportation, agriculture, land-use planning, and commercial and industrial operations.
  - Provide grants and incentives for communities to conduct inventories and develop plans to monitor their progress.
  - Compile data and offer awards to communities that exceed their goals or demonstrate other significant progress.

RC-2: High-Performance School Buildings

In addition to work plans RC-5 through RC-13, which are technology and action-based work plans that will contribute to meeting the High-Performance Building goals, the following vehicles are presented for consideration:

- Require EPA Energy Star Portfolio Manager benchmarking for all Commonwealth-owned and -leased educational facilities by 2010.
- Establish a goal of minimum Energy Star rating of 75 for all public school buildings by 2020.
- Continue implementation of *Illuminating Education* program—Current Governor's Green Government Council/Office of Energy and Technology Development (GGGC/OETD) program to distribute compact fluorescent lamps (CFLs) to middle school students in PA as part of an overall energy curriculum program.
- Continue efforts of *Pennsylvania State System of Higher Education (PASSHE*) *Energy Consumption Reduction*—Continue emphasis on existing efforts to reduce energy consumption at Pennsylvania state universities through full implementation and seek new energy saving initiatives to meet or exceed the 1.5% annual energy use intensity (EUI) reduction goal. The following are some of the tools available to achieve this goal (Projected GHG reduction from PASSCHE EUI goal as estimated by the Department of Environmental Protection are included; these projected reductions are not included in the quantitative analysis):

    - Guaranteed Energy Saving Program (GESA) (0.04 million metric tons of carbon dioxide equivalent ($MMtCO_2e$))
    - Energy manager staffing (0.005 $MMtCO_2e$)
    - Aggressive building operating system control (0.005 $MMtCO_2e$)
    - Behavioral changes (0.02 $MMtCO_2e$)
    - LEED and Energy Star efforts (0.01 $MMtCO_2e$)
    - Total Reduction: 0.08 $MMtCO_2e$

- Increase utilization of campus energy managers.
    - About half of the PASSHE universities have established positions for energy managers. These positions are typically funded out of energy consumption and unit cost savings achieved through the work of the energy manager.
    - Energy managers utilize the building control systems to aggressively manage the heating, ventilation, and air conditioning systems (and sometimes lighting) to minimize energy consumption while maintaining an environment conducive to the university's mission.
    - Energy managers are also instrumental in managing and successfully implementing university GESA projects.
- Implement a *Green Campus Initiative* for all Pennsylvania colleges, universities, private schools, and secondary schools to minimize environmental impacts and create "learning labs" for sustainability.
    - Develop and support an effective process to promote energy and sustainability concepts.
    - Provide leadership and resources to schools for a comprehensive approach to lower energy use and energy costs, reduce GHG emissions from buildings and transportation, improve water and wastewater management, increase recycling, reduce disposal of hazardous waste, and promote procurement of environmentally friendly products.
    - Use a team-based approach that engages administrative staff, students, faculty and technical experts.

RC-3: High-Performance Commercial Buildings (Private) Buildings

In addition to work plans RC-5 through RC-13, which are technology and action-based work plans that will contribute to meeting the High-Performance Building goals, the following vehicles are presented for consideration:

- Incorporate green building requirements in the statewide building code (Uniform Construction Code [UCC]).
  - This could be a phased-in approach that begins in the first years with Energy Star standards, and expands to cover high-performance standards for energy, water, stormwater, materials, etc. The ultimate goal will be zero-carbon buildings[1] throughout the Commonwealth – a goal that is aligned with the 2030 Challenge.
  - UCC improvements will need to include a much higher level of administration and enforcement than what currently exists. Statewide emphasis on training must occur.
- *High-Performance Tax Credits*—Tax credits for private-sector construction projects that meet a performance level equivalent to a minimum of LEED Silver plus an Energy Star rating of 85.
- Require energy information to be included in a "seller's disclosure" for commercial real estate transfers. Alternatively, require an Energy Star portfolio manager energy use index. The "seller's disclosure" consists of a property disclosure statement; the seller is currently not obligated by the statute to make any specific investigation. A third-party-verified energy audit should be an additional document and not part of "seller's disclosure."
- Implement an *Airport Efficiency Initiative* - Under this initiative, the Governor of Pennsylvania would issue an Executive Order requesting all Federal Aviation Regulation (FAR) Part 139 airports to improve their energy efficiency by 10%. The individual airports (which include all facilities leased or owned by the airport) will be given flexibility to achieve the efficiency goal. This will allow each facility to find the most cost-effective options to meet the target. Under the Executive Order, applicable airports would be encouraged to coordinate with Pennsylvania Department of Transportation's (PennDOT's) Air Services Committee to develop plans to achieve the energy efficiency goal. An example of a similar initiative includes Washington State Governor Gary Locke's 10% energy efficiency goal for airports. The Seattle Tacoma International Airport (SEA-TAC) achieved this goal by installing 60 motor controllers on escalators, replacing inefficient lighting with energy-efficient fixtures, and retrofitting older heating and cooling systems with more efficient equipment.

[1] A zero-carbon house is a building where net carbon dioxide emissions resulting from all energy used in the dwelling are zero or better. This includes the energy consumed in the operation of the space heating/cooling and hot-water systems, ventilation, all internal lighting, cooking and all electrical appliances.

RC-4: High-Performance Homes (Residential)

In addition to work plans RC-5 through RC-13, which are technology and action-based work plans that will contribute to meeting the High-Performance Building goals, the following vehicles are presented for consideration:

- Incorporate green building requirements in the statewide building code (UCC).
  - Require all new residential construction in Pennsylvania to achieve a minimum of LEED certification.
  - This could be a phased-in approach that begins in the first years with Energy Star standards, and expands to cover high-performance standards for energy, water, stormwater, materials, etc. The ultimate goal will be zero-carbon residential buildings[2] throughout the Commonwealth.
  - UCC improvements will need to include a much higher level of administration and enforcement than what currently exists. Statewide emphasis on training must occur.
- Provide tax credits for private-sector construction projects that meet a performance level equivalent to a minimum of LEED Silver plus an Energy Star rating of 85. Several current legislative proposals based on this objective are being considered (See HB 46, SB 673.)
- *Energy Audits at Real Estate Transfer*—Energy audit required as part of "seller's disclosure" information in a residential sales transaction.
- *Keystone Home Performance*—Retooling of the Keystone HELP program to offer a greater degree of assistance (much lower loan rates) to homeowners implementing energy-saving measures based on a whole-house energy audit. (See also the Pennsylvania Housing Finance Agency's (PHFA's) Keystone Renovate and Repair program and Maine Home Performance Program)
- *LEED for Homes*—Require that all new homes have an Energy Star rating (15% more energy efficient than code-compliant construction). Increase the efficiency requirement every 5 years until all new homes are carbon-neutral.
- Implement a *Pennsylvania Home Climate Champion Collaborative* to provide vision, clarity, and access to human and physical resources so that 100,000 homes will achieve substantial (greater than 60%) energy reductions, while maintaining or improving indoor air quality, resilience to storms and power outages, adaptability, comfort, and affordability between now and 2025. Five percent of these demonstration projects should achieve the German PassivHaus energy independence goals of 90% energy reduction, with 10% met by renewable energy.
- Require energy information to be included in a "seller's disclosure" for residential real estate transfers.
- Require building performance labels that reflect actual utility use.

[2] A zero-carbon house is a building where net carbon dioxide emissions resulting from all energy used in the dwelling are zero or better. This includes the energy consumed in the operation of the space heating/cooling and hot-water systems, ventilation, all internal lighting, cooking and all electrical appliances.

- Develop energy improvement mortgages or energy-efficient mortgages and promote these products in PA.
- Offer the Commonwealth residential sector an incentive for implementing whole-house performance, provide consumer and contractor education, create jobs, spur marketplace development, and significantly improve PA's existing housing stock while reducing energy consumption and associated GHG emissions. Propose blending all existing programs and efforts, applying for federal loan guarantees and special project funding, and seeking partnerships with utilities and others (manufacturers, contractors, nonprofit organizations, etc.).

Supporting Steps to Meet Targeted Goals:

- Support the integrity of UCC as it gets negotiated in the General Assembly.
- Develop an accreditation system for energy auditors.
    - Companies with the appropriate expertise should conduct energy audits. While the requirements for determining expertise exist as guidelines for reputable companies, third-party-verified requirements are ill defined and span a broad spectrum of energy efficiency.
- Educate the mortgage industry on the benefits of recognizing a standardized home rating system and adjust the current mortgage profile to include value realized as a result of increased energy efficiency.
    - Energy audits coupled with energy mortgages could increase the number of families qualified for mortgages. Energy mortgages credit a home's efficiency rating into the loan by proportionately increasing the value of the home. To have a Pennsylvania policy of requiring lenders to provide energy mortgages, it is necessary to adopt a standardized home rating system, like the one adopted by the Residential Energy Services Network (RESNET). Home energy ratings provide a standard measurement of a home's energy efficiency. Ratings can be used for both new and existing homes. An effective rating system will include all information necessary for a lender to judge the worthiness of a home to meet the criteria for an energy mortgage. The program is already established through the mortgage industry and the National Association of State Energy Officials; however, it is not that widespread, with only 19 accredited providers in Pennsylvania.
    - Basing a mortgage on the home efficiency rating allows the buyer to borrow more on the basis that the monthly utility bills will be proportionally less. In cases where the home is in need of energy-efficient upgrades, an Energy Improvement Mortgage could help finance the upgrades in an existing home by allowing the owner to use a portion of the mortgage payment to pay for the cost of the upgrades.
- Revise GESA/ESCO language to incorporate the equivalent of LEED-EB and Energy Star performance-based requirements. (Could move this to RC-1)
- Require all FY 2009–2010 and future GESA/ESCO projects to adopt the equivalent of LEED-EB and Energy Star performance-based requirements. (Could move this to RC-1)
- Continue working with the U.S. Green Building Council (USGBC) and EPA to streamline work processes and minimize the costs associated with implementing LEED and Energy Star principles and performance requirements into building operational procedures.

- Modify the DGS Architect/Engineer Request for Proposal (RFP)/contract to require a higher standard of competency for design professionals performing state-funded design work.
- Secure an agreement with a developer of rating systems (e.g., USGBC) for acceptance of portfolio standards for the state, reducing costs to register, certify, and commission the projects.
- Require all FY 2009 and future GESA/ESCO projects to adopt the Energy Star performance-based requirements. (Could move this to RC-1)
    - Continue working with EPA to streamline work processes and minimize the costs associated with implementing Energy Star performance requirements into building operational procedures.
    - Ask the PUC to develop and mandate that all PA utilities conform to a uniform billing structure and format to allow automated billing data entry into the Energy Star Portfolio Manager database (based upon California Assembly Bill 1103).
    - Advocate and increase participation in the Build Green Schools initiative and the Green Schools Pledge.

Existing Measures:

- No LEED or high-performance requirements exist in PA. Energy Policy Act (EPAct) 2005 tax credits at the moment; Energy Star measures do exist.
- The Keystone HELP Program offers reduced-interest unsecured loans for Pennsylvania residents to purchase energy-efficient equipment, such as HVAC, windows, hot water heaters, etc.
- *PHFA*—Keystone Renovate & Repair Loan Program can be used to pay for repairs and improvements that increase the basic livability of the home, including additions and construction, that makes the home safer, more energy efficient, or more accessible to people with disabilities or people who are elderly.
- *EPA and DOE*—The model Home Performance with ENERGY STAR program uses a comprehensive, whole-house approach to improving energy efficiency and comfort at home, while helping to protect the environment.
- *PUC*—As part of the AEPS, PA utilities are required to explore energy efficiency measures prior to applying for capacity increases.
- *DCED*—The Department currently runs PA's Weatherization Assistance Program (WAP), and has contractors, auditors, and program administration in place.
- *PA Home Energy*—A nonprofit organization-sponsored residential energy audit and performance evaluation program serving WPP utility customers.
- *ECA (unnamed program)*—This start-up program is similar to PA Home Energy, serving the Philadelphia and Pittsburgh metro areas.
- *Alternative Energy Investment Act*— This Act provides $92.5 million for residential and commercial energy efficiency activities and other initiatives. A portion of this money will be integrated into the Keystone HELP Program and the PHFA.

Key Assumptions:

RC-1 High Performance State and Local Buildings

Other Data, Assumptions, Calculations	2012	2020/all	Units
Total Commercial Floorspace in Pennsylvania (million square feet)	857	928	
Estimated (see "PA_BLDG_Activities" worksheet in this workbook) based on USDOE EIA CBECS (comercial survey) data for the Mid-Atlantic region, extrapolated using DEP approach.			
Annual demolition of commercial floorspace		0.58%	
Taken from analysis by DEP, see PA_Bldg_activities sheet in this workbook. Based on analysis by AIA research corporation for Architecture 2030, national values.			
Est. area of new commercial space per year in PA (million square fee	13.7	14.4	
Calculated based on annual floorspace estimates above. Note high growth in 2006 and 2007 based on article from American Institute of Architects (see PA_Bldg_Activities page).			
Implied Average Electricity Consumption per Square Foot Commercial Space in Pennsylvania as of 2005		10.60	kWh/yr
Implied Average Natural Gas Consumption per Square Foot Commercial Space in Pennsylvania as of 2005		34.57	kBtu/yr
Estimate based on Reference case forecast, using average intensity of all commercial buildings in PA - REVIEW OF ASSUMPTION NEEDED			
Implied Average Petroleum Consumption per Square Foot Commercial Space in Pennsylvania as of 2005		11.03	kBtu/yr
Estimate based on Reference case forecast, using average intensity of all commercial buildings in PA - REVIEW OF ASSUMPTION NEEDED			

CALCULATION OF SAVINGS

	2012	2020/all	Units
New construction floorspace covered by program, annual	7	14	million sq ft
Existing building floorspace covered by program, annual	27	44	million sq ft
Energy consumption, Reference case			
Energy consumption in new commercial buildings			
Electricity	611	664	billion BTU
Natural gas	320	328	billion BTU
Total	931	991	billion BTU
Estimate based on Reference case forecast			
Energy consumption in new commercial buildings, per sq foot			
Electricity	45	46	thousand BTU
Natural gas	23	23	thousand BTU
Total	68	69	thousand BTU
Estimate based on Reference case forecast, using average intensity of all commercial buildings in PA - REVIEW OF ASSUMPTION NEEDED			

RC-2 High Performance Schools

Other Data, Assumptions, Calculations	2012	2020/all	Units
Total School Building Floorspace in Pennsylvania (million square feet)	720	780	
Estimated (see "PA_BLDG_Activities" worksheet in this workbook) based on USDOE EIA CBECS (comercial survey) data for the Mid-Atlantic region, extrapolated using DEP approach.			
Annual demolition of commercial floorspace		0.58%	
Taken from analysis by DEP, see PA_Bldg_activities sheet in this workbook. Based on analysis by AIA research corporation for Architecture 2030, national values.			
Est. area of new school building space per year in PA (million square	11.5	12.1	
Calculated based on annual floorspace estimates above. Note high growth in 2006 and 2007 based on article from American Institute of Architects (see PA_Bldg_Activities page).			
Implied Average Electricity Consumption per Square Foot school building Space in Pennsylvania as of 2005		10.60	kWh/yr
Implied Average Natural Gas Consumption per Square Foot school building Space in Pennsylvania as of 2005		34.57	kBtu/yr
Estimate based on Reference case forecast, using average intensity of all commercial buildings in PA - REVIEW OF ASSUMPTION NEEDED			
Implied Average Petroleum Consumption per Square Foot Commercial Space in Pennsylvania as of 2005		11.03	kBtu/yr
Estimate based on Reference case forecast, using average intensity of all commercial buildings in PA - REVIEW OF ASSUMPTION NEEDED			

CALCULATION OF SAVINGS

	2012	2020/all	Units
New construction floorspace covered by program, annual	6	12	million sq ft
Existing building floorspace covered by program, annual	23	37	million sq ft
Energy consumption, Reference case			
Energy consumption in new school building buildings			
Electricity	514	558	billion BTU
Natural gas	269	275	billion BTU
Total	783	834	billion BTU
Estimate based on Reference case forecast			
Energy consumption in new school building buildings, per sq foot			
Electricity	45	46	thousand BTU
Natural gas	23	23	thousand BTU
Total	68	69	thousand BTU
Estimate based on Reference case forecast, using average intensity of all commercial buildings in PA - REVIEW OF ASSUMPTION NEEDED			

RC-3 High Performance Commercial Buildings (private)

Other Data, Assumptions, Calculations	2012	2020/all	Units
Total Commercial (Private) Floorspace in Pennsylvania (million square feet)	3,597	3,895	
Estimated (see "PA_BLDG_Activities" worksheet in this workbook) based on USDOE EIA CBECS (comercial survey) data for the Mid-Atlantic region, extrapolated using DEP approach.			
Annual demolition of commercial floorspace		0.58%	
Taken from analysis by DEP, see PA_Bldg_activities sheet in this workbook. Based on analysis by AIA research corporation for Architecture 2030, national values.			
Est. area of new commercial (private) space per year in PA (million square feet)	57.5	60.3	
Calculated based on annual floorspace estimates above. Note high growth in 2006 and 2007 based on article from American Institute of Architects (see PA_Bldg_Activities page).			
Total Residential Housing Units in Pennsylvania	5,513,044	5,570,337	
Assumes 2007 number of homes to increase following population through 2020. Based on 2007 PA housing units as provided in U.S Census Bureau annual data, http://www.census.gov/popest/housing/HU-EST2005.html.			
Implied persons per housing units in Pennsylvania (for reference only)	2.26	2.26	
Annual demolition of residential floorspace		1.43%	
Based on average lifespan of home of 70 years, placeholder estimate			
Estimated number of new residential units per year	85,901	85,701	
Calculated based on estimates above.			
Implied Average Electricity Consumption per Square Foot Commercial Space in Pennsylvania as of 2005 (see Note 2)		10.60	kWh/yr
Implied Average Natural Gas Consumption per Square Foot Commercial Space in Pennsylvania as of 2005 (see Note 2)		34.57	kBtu/yr
Implied Average Petroleum Consumption per Square Foot Commercial Space in Pennsylvania as of 2005		11.03	kBtu/yr

New construction floorspace covered by program, annual	29	60	million sq ft
Existing building floorspace covered by program, annual	113	185	million sq ft
Energy consumption, Reference case			
Energy consumption in new commercial buildings			
Electricity	3,690	4,008	billion BTU
Natural gas	1,932	1,979	billion BTU
Total	5,622	5,987	billion BTU
Estimate based on Reference case forecast			
Energy consumption in new commercial buildings, per sq foot			
Electricity	45	46	thousand B
Natural gas	23	23	thousand B
Total	68	69	thousand B
Estimate based on Reference case forecast			
Energy consumption in existing commercial buildings, per sq foot		2005	
Electricity		36.17	thousand B
Natural gas		34.57	thousand B
Petroleum		11.03	thousand B
Total		82	
Estimate based on Reference case forecast			

RC-4. High-Performance Homes

Other Data, Assumptions, Calculations	2012	2020/all	Units
Total Residential Housing Units in Pennsylvania	5,513,044	5,570,337	
Assumes 2007 number of homes to increase following population through 2020. Based on 2007 PA housing units as provided in U.S Census Bureau annual data, http://www.census.gov/popest/housing/HU-EST2005.html.			
Implied persons per housing units in Pennsylvania (for reference only)	2.26	2.26	
Annual demolition of residential floorspace		1.43%	
Based on average lifespan of home of 70 years, placeholder estimate			
Estimated number of new residential units per year	85,901	85,701	
Calculated based on estimates above.			
Implied Average Electricity Consumption per Housing Unit in Pennsylvania as of 2005 (see Note 2)		9.90	MWh/yr
Implied Average Natural Gas Consumption per Housing Unit in Pennsylvania as of 2005 (see Note 2)		46.56	MMBtu/yr
Implied Average Petroleum Consumption per Housing Unit in Pennsylvania as of 2005 (see Note 2)		27.88	MMBtu/yr

CALCULATION OF SAVINGS

	2012	2020/all	Units
New construction housig units covered by program, annual	42,951	85,701	housing ur
Existing building housing units covered by program, annual	169,954	242,325	housing ur
Energy consumption, Reference case			
Energy consumption in new residential buildings			
Electricity	5,060	4,783	billion BTU
Natural gas	2,776	2,677	billion BTU
Total	7,836	7,460	billion BTU
Estimate based on Reference case forecast			
Energy consumption in new residential buildings, per housing unit			
Electricity	58.9	55.8	MMBTU/h
Natural gas	32.3	31.2	MMBTU/h
Total	91.2	87.0	MMBTU/h
Estimate based on Reference case forecast			

Energy consumption in existing residential buildings, per housing unit	2005	
Electricity	33.77	MMBTU/h
Natural gas	46.56	MMBTU/h
Petroleum	27.88	MMBTU/h
Total	108	
Estimate based on Reference case forecast		

GHG Reductions:

Table 4-1. Estimated GHG Reductions and Cost-effectiveness

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)		
		GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)
	High-Performance Buildings						
RC-1	High-Performance State and Local Government Buildings	2.7			11.3		
RC-2	High-Performance School Buildings	1.9			7.8		
RC-3	High-Performance Commercial (Private) Buildings	9.0			37.4		
RC-4	High Performance Homes (Residential)	18.3			83.1		
	Sub-total High Performance Buildings	31.9	-$275.7	-$8.7	139.7	-$1,170	-$8.4

Economic Costs:

See Table 4.1, above.

Potential Overlap:

Overlaps with RC-5 through RC-13.

Other Involved Agencies:

DGS, Labor & Industry, DCED, Department of State's State Real Estate Commission, Public Utility Commission, PA Housing and Finance Authority, Fannie Mae, PA Treasury, EPA and DOE, PDE, All Commonwealth Agencies.

Subcommittee Comments:

Setting high performance goals for new and existing buildings is the most cost effective GHG actions for the State of PA. The subcommittee recommends combining LEED Silver goals with Energy Star goals for non-residential buildings and LEED Silver goals with HERS goals for residential buildings to ensure the highest energy savings in both building systems and in land-use and transportation. The subcommittee further recommends the incorporation of EPA WaterSense goals for all buildings. These savings will be ongoing with outstanding payback especially for public buildings and schools that intend to be in business for the next ten years as well as strengthening home equity for homeowners and yield substantial GHG savings.

While the market may realize the benefits of energy conservation on its own, this is a policy driven action. The technologies to achieve these goals are available now. The first 30-50% savings are easily doable and cost effective with a five year payback. The next 30% will be tough unless the market growth ensures manufacturing growth and cost savings, especially for renewables that would be key to the achieving the highest 80% reductions.

For non-residential buildings cost effective available technology can achieve the first five year goals. Changes in the market will be important to the next five years, but all signs are that these changes are occurring. The accuracy of cost and savings are somewhat accurate, given the track record in LEED and Energy Star, but savings are also dependent on occupant behavior, and costs are often subject to the market and design expertise.

The real challenge in residential standards for new construction is the separation of investor from the benefit, while standards for existing homes will have investment and gain in the same hands. For both of these communities it will be imperative to have a change in financing to reflect mortgage plus energy, and to have clear labels of energy performance at point of sale. Cost effective available technology can achieve the first five year goals. Changes in the market will be important to the next five years, but all signs are that these changes are occurring. The accuracy of cost and savings are somewhat accurate, given the track record of HERS, but savings are also dependent on occupant behavior, and costs are often subject to the market and design expertise.

Building renovations are labor intensive activities, with in-state economic benefits. The reduction of energy loads and mechanical conditioning operation have definite environmental benefits as well as health benefits through the upgrading of systems that are long overdue for improvements.

The subcommittee puts performance goals as the highest priorities. The first three actions RC1-3 are prioritized based on ease of implementation, with state and local government buildings first, public schools second, and private commercial buildings third. However, both 1 and 2 will require the commitment of public funds, albeit with excellent payback, while 3 is a mandate for private investment. RC will not require the commitment of public funds except for residences of families below the poverty line, albeit with excellent payback.

RC-5. Commissioning and Retro-commissioning

Summary: Promote the common practice of performing commissioning and retro-commissioning processes on newly constructed, renovated, and existing buildings for the purpose of ensuring optimal performance of building systems.

Goals: Commission or retro-commission all non-commonwealth buildings greater than 25,000sq.ft. within 10 years and, commission or retro-commission all commonwealth buildings greater than 25,000 sq.ft. within 5 years.

Possible Vehicles: Promote the common practice of performing commissioning processes on newly constructed and/or renovated buildings for the purpose of ensuring optimal performance of building systems.
Building project teams are currently familiar with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards, which cite building commissioning as good practice (Guideline 0-2005).
Expand existing training for building operators to include energy management training. Building operators, such as maintenance technicians, lead custodians, and plant engineers, currently have little formal training in building efficiency.

Implementation Steps: This program may be implemented through stricter municipal/state building codes. Certain tax incentives and/or credits may also be assigned to assist in full implementation. Several mainstream certification standards also promote the practice of performing building commissioning, making the activity seem more attractive.

An example of such a program is the California Governor's Green Building Executive Order and AB 32, which calls for all California state buildings greater than 50,000 square Feet (sq.ft.) be retro-commissioned (RCx) by June 30, 2013, and re-commissioned every 5 years. Nearly 25 RCx buildings are at or near completion. The energy efficiency measures implemented through this program to date have a verified electricity savings of approximately 10%.

Key Assumptions:

Key Data and Assumptions		2012	2020	Units
First Year Results Accrue			2010	
Building size threshold			25,000	sq.ft.
Elegibility *See Note 1 below*	*% of all commercial buildings*		68.9%	
Deadline				
Commonwealth buildings			2015	
Non-commonwealth buildings			2020	
Avoided Costs				
Avoided Electricity Cost *See "Common Factors" worksheet in this workbook.*			$84	$/MWh
Avoided Natural Gas Cost *See "Common Factors" worksheet in this workbook.*			$8.4	$/MMBtu
Avoided Electricity Emissions Rate *See "Common Factors" worksheet in this workbook.*		0.46	0.46	tCO_2e / MWh
Avoided Natural Gas Emissions Rate *See "Common Factors" worksheet in this workbook.*		0.05	0.05	tCO_2e / MMBtu

Other Data and Assumptions	2012	2020	Units
Eligible non-Commonwealth, commercial floorspace	3,566	3,862	million sq.ft.
Eligible Commonwealth floorspace	131	141	million sq.ft.
Electricity savings	*In 2025*	300	GWh
ACEEE (2009) Potential for Energy Efficiency, Demand Response and Onsite Solar in Pennsylvania - Table B-10		0.24	kWh / sq.ft.
Implied number of square feet recommissioned		1,250,000,000	sq.ft.
Commercial non-Commonwealth			
Number of years to full uptake		10	
Placeholder			
Annual rate of uptake	30%	100%	
Building area recommissioned	1,070	3,862	million sq.ft.
Electricity savings	256,762,489	926,945,655	kWh
Natural gas savings	*In 2025*	6,572,000	MMBtu
ACEEE (2009) Potential for Energy Efficiency, Demand Response and Onsite Solar in Pennsylvania - Table B-13		3.11	MBtu / sq.ft
Implied number of square feet recommissioned		2,113,183,280	sq.ft.
Number of years to full uptake		10	
Placeholder			
Annual rate of uptake	30%	100%	
Building area recommissioned	1,070	3,862	sq.ft.
Natural gas savings	3,327,214	12,011,671	MMBtu
Commonwealth			
Number of years to full uptake		5	
Placeholder			
Annual rate of uptake	60%	100%	
Building area recommissioned	78	141	sq.ft.
Electricity savings	18,801,161	33,937,307	kWh
Natural gas savings	*In 2025*	6,572,000	MMBtu
ACEEE (2009) Potential for Energy Efficiency, Demand Response and Onsite Solar in Pennsylvania - Table B-13		3.11	MBtu / sq.ft
Implied number of square feet recommissioned		2,113,183,280	sq.ft.
Number of years to full uptake		5	
Placeholder			
Annual rate of uptake	60%	100%	
Building area recommissioned	78	141	million sq.ft.
Natural gas savings	243,632	439,771	MMBtu
Levelized cost of recommissioning (electricity)			
Calculated from ACEEE (2009) Table B-10		$0.07	$ / kWh
Levelized cost of recommissioning (natural gas)			
Calculated from ACEEE (2009) Table B-13		$8.34	$ / MMBtu
Gross annual cost	$50	$173	$ million
Annual savings	$54	$190	$ million
Net annual cost	-$5	-$17	$ million

Potential GHG Reduction:

Table 5-1. Estimated GHG Reductions and Cost-effectiveness

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)		
		GHG Reduc-tions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)
RC-5	Commissioning and Retro-commissioning	1.5	-$17	-$11.2	9.6	-$71	-$7.4

Economic Cost: See Table 5-1, above.

Potential Overlap:
Overlaps with RC-1 through RC-4

Other Involved Agencies: ASHRAE; LEED Certification, Building Owners and Manufacturers Association, International Facility Management Association, EPA.

Subcommittee Comments:
Commissioning Existing and New Buildings should be state law, for both the health and comfort of building occupants and for the guaranteed energy savings. HVAC retro-commissioning efforts in existing buildings consistently reveal over 10% energy savings with 1-2 year paybacks, given the age and poor maintenance of systems due to consistent maintenance under-funding.

The technologies to achieve these goals are available now, however the commissioning workforce is not. This will be a significant job growth opportunity with excellent payback for both the public and private sector.

The real challenge for commissioning is the trained workforce, especially given the diversity of installed HVAC, lighting and electrical systems. The accuracy of cost and savings are accurate given the track record.

Building commissioning is labor intensive, with in-state job benefits. The reduction of energy loads and mechanical conditioning operation have definite environmental benefits as well as health benefits through the upgrading of systems that are long overdue for improvements.

This Action Plan may be considered redundant with High Performance Building Standards Action Plans, in which commissioning would very likely be undertaken to meet the annual goal increases. However, National energy reduction mandates have not often been met since the building community was unclear on critical steps to undertake in the near term. RC5 is a critical step in achieving timely building energy reductions.

RC-6. Re-Light Pennsylvania

Summary: This initiative is a critical building technology that accelerates replacement of less efficient outdoor and indoor lighting systems, including maximizing use of daylighting in indoor settings. It applies to residential and commercial buildings, as well as parks, streetlights, and parking facilities.

Actively invest in PA manufacturing, sales, green collar jobs, and green building infrastructure by relamping, re-fixturing, and upgrading lighting systems, windows, and control systems. This would also measurably improve the pastoral and remarkable qualities of the state, the quality of light delivered, and the health and safety of residents.

Goals: The following implementation steps could be considered:

Lighting Performance goals

- Lighting power density (LPD) 0.9 watt/sq.ft. connected load as maximum for all workplaces.
- New construction effective immediately; existing construction by 2020, with a linear percentage increase in performance each year.

Fixture Performance

- LOR (lighting output ratio, an index of fixture effectiveness) 70% minimum for all new construction, all building types, and all fixture replacements.

Lamp Performance (for all new lamp purchases, for all points of sale by 2015)

- 90 mean lumens/watt lamps.
- Mercury not to exceed 80 picograms per lumen-hour, 5 milligrams of mercury per lamp.
- CRI (color rendering index) of 85 minimum.
- 92% luminance maintenance (lamp depreciation) over rated life.

Controls and System Performance (new and existing construction by 2015)

- Individual lighting controls for 90% of occupants.
- Occupancy sensors in single-occupancy rooms or short time-of-use rooms.
- Commissioning of installed lighting system, including controls.

Daylight (all non-residential buildings)

- 25 foot candle (fc) of daylight to 90% of occupied spaces (new construction and historic buildings).
- Seated daylight access for 90% of occupants (new construction and historic buildings).
- Glazing with visible transmission over 50%, solar heat gain coefficient (SHGC) under 50% or 1.5 ratio of visible light divided by SHGC in summer (whenever replacements are made).
- Window blinds/shades to ensure daylighting and view without glare and overheating (all buildings 2015).
- Daylight-responsive controls for all fixtures within 15 feet of window (all buildings 2012).

Exit Lighting (all new construction, 2012 existing)

- Maximum 5 watts per fixture or "face."

Site Lighting (all new construction, 2012 existing)

- LPD 0.15 watt/sq.ft. max
- No night sky pollution (0% above 90° cutoff)
- Zone-occupancy controls in large parking lots.
- Light-emitting diode (LED) traffic lights.
- No LED billboard faces.

No- or Low-Cost Education Campaign

- Wash reflectors, lenses to maximize light output.
- Install occupancy and daylight sensors.
- Promote the Turn It Off campaign.
- Delamp where light levels are not needed.
- Raise or tilt the blinds and use daylight.

Key Assumptions:

Assumptions and Calculations	2012	2020	Units
Residential			
Number of housing units	5,513,044	5,570,337	
Single-family	4,222,992	4,266,878	
http://pasdc.hbg.psu.edu/pasdc/whats_new/2008factsfortheweb.pdf			
Multi-family	1,290,052	1,303,459	
Fraction of Residential Electricity Consumption as Lighting		8.8%	
National average based on Residential Energy Consumption Survey data from 2001 survey (http://www.eia.doe.gov/emeu/recs/recs2001/enduse2001/enduse2001.html).			
Residential electricity consumption as lighting	5,075	5,762	GWh
Power demand of existing lamps		60.0	W
Power demand of new lamps		15.0	W
Difference between old lamp and new lamp		45.0	W
Daily hours of operation		6.0	h
Rate of uptake of high-efficiency lamps	60%	100%	
Assumed			
Lifetime		5.0	yr

Existing power intensity of lighting		14.5	lm/W
Assume incadescent bulbs http://www.ccri.edu/physics/keefe/light.htm		0.069	W/lm
New power intensity of lighting		90.0	lm/W
From workplan goals		0.011	W/lm
Energy savings	2,234	4,002	GWh
Number of high-efficiency lamps in use	22,670,292	40,607,603	lamps
Number of lamps replaced annually	10,408,587	8,485,363	lamps
Cost premium		$3.44	one-time
Placeholder from www.homedepot.com		$0.79	$ / lamp / year
Gross annual cost	$36	$29	$ million

Commercial

Lighting Performance Goals

Existing lighting power density		2.0	W / sq.ft.
Based on conversation with Vivian Loftness			
Proposed lighting power density		0.9	W / sq.ft.
Proposed From workplan goals			
Rate of update in existing buildings	20%	100%	
Cost premium		$0.36	$/sq ft
US DOE Energy efficiency and renewable energy website, The Business Case for Sustainable Design in Federal Facilities http://www1.eere.energy.gov/femp/sustainable/sustainable_federalfacilities.html www1.eere.energy.gov/femp/pdfs/buscase_appendixb.pdf			

Fixture Performance Goals

Existing power intensity of lighting		60.0	lm/W
Assume incadescent bulbs http://www.ccri.edu/physics/keefe/light.htm		0.017	W/lm
New power intensity of lighting		90.0	lm/W
From workplan goals		0.011	W/lm
Rate of uptake of high-efficiency lamps in existing buildings	60%	100%	
Assumed			
Cost premium (4-ft. 32 W T8)	*one-time*	$2.99	$ / lamp
From www.homedepot.com		$0.69	$ / lamp / year
Lifetime		5.0	yr
Difference between old lamp and new lamp		19	W
Daily hours of operation		10	h / d
Number of days in use annually		261	d / yr
Existing power per lamp	*Assumed*	44	W / lamp
Existing lighting power density	*Assumed*	1.1	W / sq.ft.
Estimate of lamps in PA	125,363,629	125,363,629	lamps
Number of lamps replaced annually	25,072,726	25,072,726	lamps

Daylighting

Reduction in lighting energy consumption		44%	
Attachment in email from Vivian Loftness - e-BIDS Guidelines for High Performance Buidlings 2005			
Percentage of existing buildings that are historic		0.5%	by floorspace
Placeholder, pending input from PA Bureau for Historic Preservation			
Applicable floorspace (new construction and historic)	77.0	76.4	million sq.ft. / yr
Cost premium - levelized		$0.22	$ / sq.ft.
Attachment in email from Vivian Loftness - e-BIDS Guidelines for High Performance Buidlings 2005			

Controls and System Performance				
Reduction in lighting energy consumption			19%	
Attachment in email from Vivian Loftness - Architects of the Capital Interior Lighting				
Rate of uptake in existing buildings		20%	100%	
Cost premium for new construction			$0.25	$ / sq.ft.
e-BIDS Guidelines for High Performance Buildings 2005				
Estimate in document includes ballasts, lamps, etc. Assume 25% of cost is for controls.				
Life of measure (life of building)			50	yrs
Levelized incremental cost			$0.01	$ / sq.ft. / yr.
Cost of retrofit			$0.90	$ / sq.ft.
e-BIDS Guidelines for High Performance Buildings 2005				
Estimate in document includes ballasts, lamps, etc. Assume 25% of cost is for controls.				
Life of measure (remaining life of building)			25	yrs
Levelized cost of retrofit			$0.06	$ / sq.ft. / yr.

Site Lighting				
Number of vehicles in Pennsylvania		9,598,142	9,697,888	vehicles
Bureau of Transportation Statistics http://www.bts.gov/publications/state_transportation_statistics/pennsylvania/html/table_05_01.html				
Ratio of parking spaces to vehicles			9	spaces / vehicle
Subcommittee input				
Area of parking lots			150	sq.ft. / space
Existing lighting intensity in parking lots	*See Note 3*		0.29	W / sq.ft.
Proposed lighting intensity in parking lots			0.15	W / sq.ft.
Annual hours in operation	*Assumed*		2,920	h / yr
Rate of participation		100%	100%	
Area of parking lot with efficient lighting		12,957	13,092	million sq.ft.
Area of parking lot with efficient lighting (new)		11,016	14	million sq.ft.
Energy savings		5,220	5,275	GWh / yr
Cost premium - levelized			$0.05	$ / sq.ft.
Email from Vivian Loftness				
Gross cost		$550.82	$0.72	$ million

Exit sign - 5 W / face				
Annual savings per sign			114	kWh / sign / yr
http://www.cmhc-schl.gc.ca/en/inpr/bude/himu/waensati/waensati_039.cfm				
Density of signs			0.00013	signs / sq.ft.
Attachment in email from Vivian Loftness - Architect of the Capital - Emergency Lighting and http://www.aoc.gov/cc/cobs/rhob.cfm				
Rate of uptake in existing buildings		100%	100%	
Number of signs		155,072	155,121	signs
Cost of unit retrofit	*Annualized*		$4	$ / sign / yr
http://www.cmhc-schl.gc.ca/en/inpr/bude/himu/waensati/waensati_039.cfm				
Total cost of retrofit		$0.61	$0.61	$ million

GHG Reductions:

Table 6-1. Estimated GHG Reductions and Cost-effectiveness

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)		
		GHG Reduc-tions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)
RC-6	Re-Light Pennsylvania	12.9	-$823	-$64	103.2	-$4,020	-$39

Economic Cost: See Table 6.1, above.

Potential Overlap: Overlaps with RC-1 through RC-4.

Subcommittee Recommendations

This Action Plan has 7 key assumptions and each action has outstanding GHG reduction potential and economic potential. Lighting energy is 10% of all national and state electricity use, and conservation often with improved lighting quality is technically straightforward and economically viable.

The technologies to achieve these goals are available now; however replacing lighting in commercial buildings often suggests ceiling replacement as well, and the effective use of daylight must be accomplished without glare or overheating.

The State of PA has a manufacturing community that will benefit from this action (fixtures, blinds, controllers, ceilings) and the potential for industrial growth; building engineering and unions will also benefit from this action plan. The payback is typically 3-5 years for the building owner, with immediate energy benefits to the State.

Existing lighting is often too bright for computer work, too dim in areas of safety, and old enough to still contain magnetic ballasts that buzz and contain PCBs, both health concerns. Relighting PA will measurably improve these conditions for productivity, safety and health benefits.

This Action Plan may be considered redundant with High Performance Building Standards Action Plans, in which lighting retrofits would very likely be undertaken to meet the annual goal increases. However, National energy reduction mandates have not often been met since the building community was unclear on critical steps to undertake in the near term. RC6 is a critical step in achieving timely building energy reductions.

RC-7. Re-Roof Pennsylvania

Summary: This initiative mandates improved standards for solar reflectance and thermal resistance for all new roofing projects, and recommends the consideration of daylighting, green roofs and renewable energy roofs.

Goals: Replace commercial building roofs with more energy-efficient roofing at the time of regular replacement. (See Table 7.1 for roof types.)

Table 7.1. Portfolio of Roof Replacements for Commercial Buildings

Types of Roofs	2012	2020
Light colored, super insulated	90%	50%
Green roofs with super insulation	0%	20%
Solar PV roofs with super insulation	10%	30%

Possible Vehicles:

- High reflectivity should be mandatory for all commercial buildings to minimize cooling loads.
- Thermal resistance standards (R/U factors) should be raised to minimize both cooling and heating loads.
- Green roofs should be promoted with incentives for benefits to cooling, carbon sequestration, and stormwater management.
- Skylights for daylighting should be mandatory for roof replacements in buildings lower than four stories, with deep sections that result in windowless spaces for occupants.
- Shading or insulation from renewable energy systems as secondary goals should be explored.

Assumptions:

- Only commercial buildings.
- All public and private.
- 75% are less than 4 stories; roof is 25% of floor space.
- 20–25-year roof replacement cycles are common for commercial buildings but many roofs in PA have not been replaced so there is pent-up need for replacement; assume 5% roof replacement a year until 2030.
- Replace with light-colored or highly reflective roof colors (75% dark now, 15% cooling energy savings with light colored roofs, with no cost delta).
- Replace with highly reflective and super-insulated R40 certainly in buildings lower than four floors (10% heating energy savings and 20% cooling energy savings).
- Promote green roofs for carbon and storm water management benefits, with super insulation for heating and cooling energy savings.
- Promote solar photovoltaic (PV) roofs with super insulation (10% heating and cooling energy savings, as well as distributed power generation PA GHG savings)

Incremental Cost of roof replacement (relative to regular roof replacement)

Upgrade from R-11 to R-30 roof insulation	**$0.07**	$/sq ft roof
ACEEE (2009) Table B-10		
Light coloured, super insulated	**$0.96**	$/sq ft roof
e-BIDS Guidelines for High Performance Buildings 2005 cites $0.89/sq.ft. for light-coloured membrane; no reference to super insulation		
Green roofs with super insulation	**$10.07**	$/sq ft roof
Dirksen (email from Vivian Loftness) and ACEEE (2009)		
Solar PV roofs with super insulation	**$38**	$/sq ft roof
Implied from ACEEE (2009) p. 227		

Energy savings from roof replacement

Light coloured, super insulated		
Heating	**10.00%**	
Placeholder - no basis		
Cooling	**11.30%**	
e-BIDS Guidelines for High Performance Buildings 2005; not PA-specific		
Green roofs with super insulation		
Heating	**10.00%**	
Placeholder - consistent with e-BIDS Guidelines for High Performance Buildings		
Cooling	**48.00%**	
e-BIDS Guidelines for High Performance Buildings 2005; not PA-specific		
Solar PV roofs with super insulation		
Heating	**10.00%**	
Placeholder - no basis		
Cooling	**11.30%**	
Assume same as light coloured		
Electricity capacity	**12.00**	W/sq.ft. roof
Email from solar design firm - reference Vivian Loftness		
Capacity factor	25%	
Assumed		
Electricity generation	**26.28**	kWh/sq.ft. roof
Email from solar design firm - reference Vivian Loftness		

Avoided Electricity Cost	**$89**	$/MWh
See "Common Factors" worksheet in this workbook.		
Avoided Natural Gas Cost	**$8.4**	$/MMBtu
See "NG prices aeo2006" and "Common Factors" worksheets in this workbook.		

Potential GHG Reduction:

Table 7-2. Estimated GHG Reductions and Cost-effectiveness

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)		
		GHG Reduc-tions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)
RC-7	Re-Roof Pennsylvania	1.4	$633	$438	4.3	$1,412	$327
	Light-colored materials	0.2	-$4	-$18	0.8	$13	$17
	Green roofs	0.1	$77	$614	0.3	$147	$462
	PV roof	1.1	$399	$359	3.2	$903	$282

Economic Cost: See table above

Potential Overlap: Overlaps with RC-1 to RC-4

Subcommittee Recommendations

This action plan has three alternative considerations – highly reflective or light colored highly insulated roofs with excellent payback and very manageable costs; green roofs with high costs but measurable benefits in reducing heat island effect and offering carbon sequestration as well as major aesthetic advantages; and photovoltaic roofs with the highest cost but obvious benefits as a distributed energy source. All three should be considered, in addition to solar hot water systems, to advance the States competitiveness.

Buildings have a natural cycle for re-roofing in the order of 20-25 years, meaning that 4-5% of PA roofs are in the process of selecting new roof materials. This Action Plan has three alternative considerations - light colored highly insulated roofs with excellent payback and very manageable costs; green roofs with high costs but measurable benefits in reducing heat island effect and offering carbon sequestration as well as major aesthetic advantages; and photovoltaic roofs with the highest cost but obvious benefits as a distributed energy source. The differences in these three alternatives make the selection of a single score difficult.

Roofs have a natural cycle of replacement and hence are excellent opportunities for innovation that achieves GHG gains or new energy sources.

The opportunity to replace roofs with integral solar photovoltaic and solar domestic hot water systems is a growth area for both manufacturing and installers. PA should take a lead in this area. At a very minimum, well-insulated, highly reflective roofs (need not be light colored) should be mandated.

RC-8. PA buys Energy Efficient (EE) Appliances

Summary: This initiative promotes accelerated adoption of energy-efficient appliances that meet current and proposed federal standards. It also proposes that Pennsylvania, in collaboration with other leading states, adopt its own efficiency standards for products that are not sufficiently covered in the joint DOE and EPA ENERGY STAR specifications.

In developing this initiative, PA should consider the following criteria proposed by the American Council of Energy Efficiency Engineers (ACEEE)[3]:

- The standard would achieve significant energy savings.
- The standard would be cost-effective for the purchaser.
- Products that meet the standard are readily available.
- The state can implement the standard at low cost.
- Federal preemptions do not apply.

Another resource for identifying which appliance standards to adopt is the Appliance Standards Awareness Project, which summarizes what other states have developed: www.standardsasap.org/state/index.htm. Pennsylvania also should consider joining the Multistate Appliance Standards Collaborative: http://appliancestandards.org/.

Goals (Actions)

- Pennsylvania should support all federal efforts to develop and adopt high-efficiency and ENERGY STAR standards for appliances and to accelerate the rulemaking for additional products.
- Pennsylvania should adopt existing ENERGY STAR and federal appliance standards for all state-owned buildings, and projects receiving state funding.
- Through incentives and financing, the state should encourage local government and municipalities to adopt similar standards for their own buildings and for public housing in their jurisdiction by 2015 (possibly require this by 2020).
- Pennsylvania should monitor and encourage or require public utilities to include ENERGY STAR qualified appliances in their Act 129 implementation, and in all low-income programs they administer.
- The state should require that all appliances sold in the state meet the existing federal standards by 2015, or adopt federal requirements as they are promulgated, unless market forces achieve earlier adoption of efficient appliances.

Per ACEEE (2009),[4] Pennsylvania should set standards for the following appliances:

- furnace fans,
- fluorescent lighting fixtures,
- DVD players,

[3] ACEEE (2006) Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards www.aceee.org/pubs/a062.htm

[4] ACEEE (2009.04) Potential for Energy Efficient, Demand Response, and Onsite Solar Energy in Pennsylvania http://www.aceee.org/pubs/e093.htm

- compact audio equipment,
- portable electric spas,
- water dispensers,
- hot food holding cabinets,
- TVs, and
- portable lighting fixtures.

The Multi-State Collaborative has outlined the following products, which have similar state standards, primarily based on the California State Appliance Energy Efficiency Standards, Title 2. Pennsylvania should review and consider adopting its own standards for these products.

- commercial ice makers,
- compact audio players,
- distribution transformers,
- DVD players and recorders,
- hot food holding cabinets,
- metal halide lamp fixtures,
- pool heaters,
- portable electrics spas,
- refrigerators and freezers,
- unit heaters and duct furnaces, and
- water dispensers.

Information Sources:

- ACEEE (2009) is the primary information source for this quantification.
- Also check the data on the Multi-State Appliance Standards Collaborative.
- DOE Appliance Standards :www1.eere.energy.gov/buildings/appliance_standards/
- EPA ENERGY STAR for Appliances: www.energystar.gov/index.cfm?c=appliances.pr_appliances

Key Assumptions:

Other Data and Assumptions	2012	2020	Units
Average annual cost for state appliance efficiency standards *ACEEE (2009) Table 18*		$92.54	$ million
Number of years before full penetration		**10**	yr
Percent penetration by year	30%	100%	
Percent replacement	100%	10%	
Annual gross cost	$39	$129	$ million
Annual cost savings	$55	$184	$ million
Net cost of program	-$17	-$55	$ million
Energy savings			
Electricity	660	2,200	GWh / yr
Average annual electricity savings for state appliance efficiency standards *ACEEE (2009) Table 16*		1,581	GWh / yr

GHG Reductions:

Table 8-1. Estimated GHG Reductions and Cost-effectiveness

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)		
		GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)
RC-8	Appliance Standards	1.9	-$68	-$36	12.4	-$291	-$24

Economic Cost: See above.

Possible Overlap:

RC-1 through RC-4 High Performance Building Standards.

Additional information:

One of the authors of the ACEEE report states the following regarding federal preemption, "Federal standards now cover about 45 products. Nearly all of these 45 products, including all major home appliances, also have an Energy Star specification. States are preempted from setting standards on these products. A waiver process exists, but the hurdle to gain waivers is very high, and the process is very drawn out. Plus, the Obama administration is working on updating most of the key standards.

Similarly, the author of the ACEEE report states the following with regards to ENERGY STAR: "Energy Star is a voluntary program meant to help consumers distinguish efficient choices; it is not designed to be mandatory. Every time a given Energy Star spec is considered for a mandatory standard, we need to think through whether it is appropriate. For example, we need to be careful not to ban products that meet a specific need, but can't or don't meet the spec. We carefully consider ENERGY STAR specs when updating our model standards, but it would be a mistake to adopt it across the board for all products as a mandatory level."

Subcommittee Recommendations

This Action Plan fills the gap between appliances and equipment that is covered under Energy Star and other appliances that consume substantial amounts of electricity for which quality differences matter. Appliance Standards are cost effective ways to achieve GHG and energy savings for consumers. Often first cost is not affected for the consumer, while long term running costs are reduced. .

This has some impact on retail choices, especially at the low cost end, but national commitments are emerging and PA should be in the forefront of demand for these appliances and equipment.

Appliances have a natural cycle of replacement and hence are excellent opportunities for innovation that achieves GHG gains and consumer energy savings.

Appliance replacement with energy efficient and long life choices will reduce waste.

Appliance and Equipment Standards are cost effective ways to achieve GHG and energy savings for consumers. PA should adopt all CA appliance standards that are issued above and beyond Energy Star. In addition, the State should consider further incentives to urge consumers to buy the most energy efficient appliances and equipment (there is a significant variation in energy efficiency even within energy star rated appliances).

RC-9. Geothermal Heating and Cooling

Summary: This strategy capitalizes on the energy-effectiveness of geothermal or ground source heat pumps (GSHPs) in Pennsylvania's climate, and the accompanying reductions in carbon emissions and in demand for peak generation and transmission. Pennsylvania is already ranked as one of the top-tier states for experienced and competitive installation of GSHPs in its urban centers. This strategy would build on that strength, expanding the network of trained drillers and installers throughout the state. This strategy advocates GSHP installations for individual buildings and in district systems. Warren, PA, hosts one of the few district GSHP systems in the United States, and this strategy supports further development of such systems for their energy and environmental benefits and for economic revitalization.

Additional benefits of GSHPs include:

- Levels seasonal electrical demand and 42%-48% reduced demand for new capacity.[5] (DOE/ORNL, 12/08).
- Widely applicable.
- Elimination of bulky and noisy exterior equipment, such as cooling towers or condensing units and heating plants.
- Atmosphere not used as a heat sink.
- Economical operating costs due to high coefficient of performance (metered Department of Defense installations in Pennsylvania achieve mean Coefficient of Performance of 4.0 and energy efficiency ratio of 20.83)
- Water heating integrated at low cost (can be scavenged whenever compressors are running).
- The fossil fuel used is burned at a large, industrial generating facility where air scrubbers and other anti-pollution equipment can be installed due to the economy of scale.
- Excellent part-load performance.
- Maintenance simpler and less costly than conventional fossil fuel and cooling tower systems.
- Frees peak transmission and generation capacity for other purposes.
- Reduces the use of natural gas as a heating fuel.
- Reduces water consumption by power plants

The calculations here are based on GSHP installations for individual buildings. District systems can offer economies of scale in the exterior infrastructure, but data on this are limited.

[5] Hughes, Patrick (2008). Geothermal (Ground-Source) Heat Pumps: Market Status, Barriers to Adoption, and Actions to Overcome Barriers. Oak Ridge National Laboratory. www1.eere.energy.gov/geothermal/pdfs/ornl_ghp_study.pdf

Goals:

Residential

Each year, 20% of new dwellings and 2% of existing dwellings will install GSHPs for heating and cooling, either on a building-by-building basis, or in district systems, serving multiple dwellings.

[Optional: 10% of new installations and 1% of replacement systems will be metered to support system maintenance and improvement.]

Commercial

By 2020, 40% of existing commercial buildings and 12.5% of new commercial buildings will be heated and cooled with GSHPs serving individual buildings or serving multiple buildings in district systems.

[Optional: 100% of new installations and 50% of replacement systems will be metered to support system maintenance and improvement.]

Possible Vehicles:

1. Require the DGS to do comprehensive life-cycle cost analysis for new buildings and building upgrades and advocate/support use of life-cycle cost analysis for all new and retrofit projects in the public and private sectors.

2. Educate designers/contractors/consumers about geothermal heat pump efficiency ratings (COP/EER), different from conventional gas furnace and air conditioner ratings, and highlight currently achievable efficiencies in PA climate, which are significantly higher than the ENERGY STAR standard.

3. Encourage the use of ESCOs to address first-cost hurdles.

4. To address the potential environmental impacts of ground loop, establish a mechanism for verifying the competence of drillers and external loop/well installers, and require that only state-approved drillers/installers are used (Oregon has such a policy).

5. Establish policies that will give utilities an incentive to install the external loop infrastructure and lease them on per-ton basis:
   a. Allow utilities to count the energy savings from GSHPs toward a renewable portfolio standard (RPS) target.
   b. Allow aggregated savings from GSHPs to be proxy for carbon-trading contracts.

   With these strategies, utilities will lose energy sales revenue, but will recoup some of it on loop leases and rate-based infrastructure. They'll also lose money on demand charges, but can get RPS credit and look good for doing so. Consumers get some efficiency benefits. Reduction in peak demand reduces the need for new power plants and carbon emissions are reduced.

Other Involved Agencies:

DCED.

Implementation Steps: see *Vehicles* above

Potential Overlap:

DCED Renewable Energy Program: Geothermal and Wind Projects (January 2009); RC-1 through RC-4

Potential Complementarity: Potential integration with DOE/Oak Ridge National Laboratory's (ORNL's) interest in extending/funding infrastructure for geothermal heating and cooling. December 2008 report available at www1.eere.energy.gov/geothermal/pdfs/ornl_ghp_study.pdf

Key Assumptions:

Incremental Cost of Geothermal system			
Resdiential, household without central cooling		**$3,000**	$/housing unit
Residential, household with heating and central cooling		**$0**	$/housing unit
Input from V. Loftness & N.Baird. Because the ground infrastructure is warrantied for 50 years, assumption here is that the cost of installing ground source heat pumps is no greater than cost of conventional equipment. Cost here reflects 2-ton exterior heat exchange per unit.			
Cost of Geothermal system			
Commercial, existing buildings		**$14.4**	$/sq ft
G. Mattern, P.E., Adjunct Professor & geothermal specialist, Carnegie Mellon Univ., estimates $19.60/sf f			
Commercial, new buildings		**$12.5**	$/sq ft
G. Mattern, P.E., Adjunct Professor & geothermal specialist, Carnegie Mellon Univ., estimates $17.00/sf for new installation, bu ground infrastructure is warrantied for 50 years, assumption here is that the cost of installing ground source heat pumps is no g cost of conventional equipment. May be less.			
Cost of NG+AC VAV system (base case system)			
Commercial, existing buildings		**$14.4**	$/sq ft
Commercial, new buildings		**$12.5**	$/sq ft
Input from G, Mattern, P.E., Adjunct Professor, Carnegie Mellon Univ.			
Avoided Electricity Cost		**$89**	$/MWh
See "Common Factors" worksheet in this workbook.			
Avoided Natural Gas Cost		**$8.4**	$ / million Btu
See "NG prices aeo2006" and "Common Factors" worksheets in this workbook.			
Avoided Fuel Oil Cost	**$15.8**	**$13.6**	$ / million Btu
See "Common Factors" worksheets in this workbook.			
Emissions from additional Electricity Use		**0**	tCO_2/MWh
Assume that all new electricity for geothermal heatpump use is supplied by green electricity			
Green Electricity Premium		**12**	$/MWh
Based on BeGreen cost of $288 for 24 MWh of renewable energy, http://www.begreennow.com/ accessed on June 22, 2009			

Note: analysis assumes that electricity for heatpumps will be provided by "green electricity" with zero GHG emissions/MWh.

Energy savings due to ground source heatpumps	
Residential	45%
Commercial	30%

P Hughes, ORNL, 12/ 2008, p. 26

Residential

- 50% of existing homes have HVAC systems that will need to be replaced before 2020.
- 30% of existing homes will decide to add air conditioning when this replacement is necessary.
- For the 20% replacement without air conditioning, the first cost differential of geothermal over conventional will be $3,000. Without cooling, the use of geothermal may not be as strategic as high-performance boilers and furnaces, especially integrated with domestic hot water (DHW) which would be a technology identified in the RC-8 Appliance Standards and RC-10 demand-side management (DSM)-Gas workplans.
- For the 30% with both heating replacement and air conditioning addition, the differential cost for geothermal over conventional will be $0. Energy savings will be substantial with two-season use.
- 45% savings relative to new heating and cooling equipment (Hughes, 2008).

Potential GHG Reductions:

Table 9-1. Estimated GHG Reductions and Cost-effectiveness

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)		
		GHG Reduc-tions ($MMtCO_2e$)	Costs (Million $)	Cost-Effective-ness ($/$tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/$tCO_2e$)
RC-9	Geothermal Heating and Cooling	1.4	$224	$158	8.0	$879	$109

Economic Cost: See Table 9-1, above.

Subcommittee Recommendations

This Action Plan addresses two approaches to geothermal heating and cooling: ground source heat pumps that would provide adequate conditioned water for heating and cooling individual residential and commercial buildings; and geothermal loops that would provide infrastructures for entire communities of heating and cooling requirements including load balancing benefits. Both of these offer significant commercial potential for the State of PA.

PA is a prime state for using geothermal energies for heating and cooling both with GSHP and with geothermal loops; however industry and labor growth is needed.

First cost intensive compared to the alternative, however GSHPs provide good alternatives to the addition of new AC in homes, changing the economics.

New industry growth area for PA. Economic benefit for building owners in reduced energy costs if first cost incentives exist, or reductions in installer costs.

RC-10. Demand Side Management (DSM)—Natural Gas

Summary: This initiative replaces or upgrades inefficient household appliances that utilize natural gas with more energy-efficient models.

Goals:
Residential sector: Achieve 36% reductions from reference case natural gas demand in 2025.
Commercial sector: Achieve 28% reductions from reference case natural gas demand in 2025.

Value from Pennsylvania: *Potential for Energy Efficiency, Demand Response, and Onsite Solar Energy in Pennsylvania* (ACEEE, 2009). See page 19 for residential and page 26 for commercial. This represents the cost-effective potential. Note that these savings are greater than the amount identified by ACEEE analysis as achievable by the set of policies analyzed. The policy analysis led to savings of 15% natural gas in 2025, for residential and commercial combined (see page 46). This work plan's assumptions imply stronger policies than those identified by ACEEE (mostly standards and utility programs)

Possible Vehicles:

1. Air Sealing and Insulation (10%–40% annual energy savings)
   - Nationwide and in PA, about 50% of homes use natural gas for heating, on average 600 therms per household.
   - By air sealing & insulation, consumers could easily save 25%.
2. Increased furnace and boiler efficiency to >95 AFUE .
   - The minimum allowed annual fuel utilization efficiency (AFUE) rating for a non-condensing, fossil-fueled, warm-air furnace is 78%; the minimum rating for a fossil-fueled boiler is 80%; and the minimum rating for a gas-fueled steam boiler is 75%.
   - Although older furnace and boiler systems had efficiencies in the range of 56%–70%, modern conventional heating systems can achieve efficiencies as high as 97%, converting nearly all the fuel to useful heat for the home. Energy efficiency upgrades and a new high-efficiency heating system can often cut fuel bills and a furnace's pollution output in half. Upgrading a furnace or boiler from 56% to 90% efficiency in an average cold-climate house will save 1.5 tCO_2 emissions each year if heated with gas, or 2.5 tCO_2 if heated with oil (DOE, Energy Savers).
   - Therefore consumers could expect to see a 15%–50% range in energy savings from "heating season" improvements (depending on age and efficiency of equipment being replaced).
3. Solar domestic hot water heaters
   - Heating water accounts for 14%–25% of total household energy consumption. Solar water heaters can provide 85% of DHW needs.
4. Instantaneous hot water heaters with an energy factor >0.80
   - For homes that use 41 gallons or less of hot water daily, instantaneous hot water heaters can be 24%–34% more energy efficient than conventional storage tank water heaters.
   - for homes that use a lot of hot water—around 86 gallons per day, instantaneous hot water heaters can be 8%–14% more energy efficient. You can achieve even greater energy savings of 27%—50% if you install an instantaneous hot water heater at each hot water outlet.

5. ENERGY STAR front-loading washing machines.
    - Most ENERGY STAR-qualified clothes washers extract more water from clothes during the spin cycle. This reduces the drying time and saves energy and wear and tear on your clothes.
    - ENERGY STAR-qualified clothes washers clean clothes using 50% less energy than standard washers (including energy used in the washing process, including machine energy, water heating energy, and dryer energy).

6. Pilot lights.
    - Standing pilot lights may use over 7 therms (700,000 British thermal units) of gas per appliance, if left on year round.
    - Replacing old appliances that have pilot lights on full time with appliances that have electronic (intermittent) ignitions could create savings.
    - Some people feel that standing pilot lights on appliances are gradually becoming the exception, instead of the rule, with new appliances on the market using electronic ignitions. However, even though electronic ignition pilot lights are becoming increasingly common, without legislation, standing pilots may not disappear by 2025 because they are cheaper to manufacturer, and the appliance is sometimes viewed as solution to emergency heat when the electricity fails, because they do not need electric power to start.
    - This initiative would institute public benefit funds for investment in residential, commercial, and industrial energy efficiency and renewable energy programs through third-party administrators.

Implementation Steps:

- Market driven.
- Encourage natural gas utilities to engage in consumer education initiatives regarding these efficient technologies.
- Potential opportunity for appliance efficiency legislation.

Key Assumptions:

Key Data and Assumptions	2012	2020	Units
Savings Targets			
Natural Gas			
Achievable cost-effective savings in natural gas use as a fraction of total gas demand:			
Residential		36.00%	
Commercial		28.00%	
Value from Pennsylvania: Energy Efficiency, Demand Response and On-Site Solar Potenial. ACEEE 2009. See page 19 for residential and page 26 for commercial. This represents the cost-effective potential. Note that these savings are greater than the amount identified as ACEEE analysis as achievable by the set of policies analysed. The policy analysis led to savings of 15% natural gas in 2025, for residential and commercial combined (see page 46). This workplan assumptions imply stronger policies than those identified by ACEEE (mostly standards and utility programs)			
Fraction of achievable savings reached under program		100%	Option Goal
Year in which target fraction reached		2025	Option Goal
Year in which programs fully "ramped in"		2012	Assumption
Fraction of full program savings by year	100%	100%	
Implied fractional annual gas demand savings, residential	3.6%	3.6%	
Implied fractional annual gas demand savings, commercial	2.8%	2.8%	
Analysis			
RCI Gas Sales Covered *(from inventory)*	414,382	415,519	Billion Btu
Residential	254,778	247,865	Billion Btu
Commercial	159,604	167,655	Billion Btu
Industrial	0	0	Billion Btu
Conversion Factor: Million Btu per Thousand Cubic feet		1.03	MMBtu/Mcf

Additional Results	2012	2020	Units
Investments to Meet RC-7 Savings Target--Natural Gas			
Reduction in Gas Use (Cumulative)	4,549	136,308	Billion Btu
as % of overall projected sales in that year	1.10%	32.80%	

Cost of Saved Energy:
Residential Sector: $5.29/MMBtu
Commercial Sector: $3.28/MMBtu
Source: ACEEE 2009 report, see above

Table 10-1. Residential Natural Gas Efficiency Potential and Costs by End-Use (2025)

End-Use	Savings (MMBtu)	Savings relative to Reference Case (%)	% of Total Efficiency Potential	Levelized Cost of Saved Energy ($/MMBtu)
Single Family Gas	**74,070**	**35%**	**100%**	**$5.01**
Space Heating	47,540	22%	64%	$3.70
Water Heating	16,840	8%	23%	$7.90
Cooking	920	0.4%	1%	$9.34
Existing	65,300	30%	88%	$4.86
New Homes	8,770	4%	12%	$4.82
Multifamily Gas	**9,620**	**46%**	**100%**	**$7.47**
Space Heating	4,350	20%	45%	$6.86
Water Heating	3,360	16%	35%	$3.04
Cooking	100	0.5%	1%	$11.71
Existing	7,810	37%	81%	$5.28
New Homes	1,810	9%	19%	$9.40
All Residential Gas	**83,690**	**36%**	**100%**	**$5.29**
Space Heating	51,890	22%	62%	$3.96
Water Heating	20,200	9%	24%	$7.09
Cooking	1,010	0.4%	1%	$9.57
Existing	73,10	31%	87%	$4.91
New Homes	10,590	5%	13%	$5.61

Table 10-2. Commercial Natural Gas Efficiency Potential and Costs by End-Use (2025)

End-Use	Savings (MMBtu)	Savings over Reference Case (%)	% of Efficiency Potential	Weighted Levelized Cost of Saved Energy ($/MMBtu)
HVAC equipment & controls	26,200,000	15%	54%	$ 2.39
Building shell	2,000,000	1%	4%	$ 0.30
Water Heating	5,400,000	3%	11%	$ 6.27
Cooking	4,000,000	2%	8%	$ 1.11
Other	7,200,000	4%	15%	$ 8.43
Existing Buildings	44,700,000	26%	93%	$ 3.19
New Buildings	3,500,000	2%	7%	$ 2.45
Total Gas	48,200,000	28%	100%	$ 3.28

Source: ACEEE 2009

Avoided Cost of Natural Gas:

All sectors: $8.40/MMBtu

GHG Reductions and Economic Costs:

Table 10-3. Estimated GHG Reductions and Cost-effectiveness

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)		
		GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)
10	DSM - Natural Gas	7.3	-$51	-$7	40.5	-$357	-$9

Economic Cost: See table 10-3 above.

Potential Overlap:

- Reduced Load Growth Work Plan
- HB 2200 Work Plan
- Appliance Standards Work Plan
- Alternative Energy Investment Act Work Plan
- RC-1 through RC-4

Other Involved Agencies: PUC.

Subcommittee Recommendations

Demand side management of natural gas appliances and equipment in residential and commercial buildings offer excellent GHG reduction potential and excellent cost savings. This is especially important since aging equipment may be subject to replacement by electric alternatives which would increase PA electricity use and commensurate GHGs.

The technologies to achieve these goals are available now.

The real challenge for demand-side management (DSM) of gas equipment is upfront cost to the building owners. Federal and state incentives may significantly reduce this challenge, although many home owners do not have the ready cash. It may be imperative for utility sponsored retrofits with pre-certified installers and constant fuel bills until the DSM is paid for.

Replacement of gas appliances and equipment have health benefits as well, since older equipment is more subject to fumes and leakage in occupied spaces. Homes may also benefit from appropriately matched equipment sizing to the load, ensuring adequate temperatures are met, but with reducing 'cycling'.

The GHG and energy cost savings benefits are excellent, but the upfront cost implications must be addressed through utility programs.

RC-11. Oil Conservation and Fuel Switching for Heating Oil

Summary:

Oil conservation
This initiative replaces or upgrades inefficient household appliances that utilize fuel oil with more energy-efficient models.

Biofuel
This initiative aims to blend all heating oil sold in PA with a 5% blend of biodiesel. Bioheat is the industry term for heating oil that is blended with biodiesel. Heating oil is essentially the same as diesel, with some difference in sulfur content and a colorant added to deter tax evasion through its potential use as a transportation fuel. The use of bioheat has been proven to reduce maintenance concerns and burns cleaner than conventional heating oil. Significant, positive experience utilizing bioheat exists. Numerous customers throughout south central and southeastern PA have been using bioheat in their furnaces and boilers for the past few years. The DGS also has bioheat on contract for state agencies.

Goal:

Oil conservation
Residential sector: Achieve 37% reductions from reference case oil consumption in 2025.
Commercial sector: Achieve 26% reductions from reference case oil consumption in 2025.

Biofuel
Replace 5% of heating oil with biodiesel.

Implementation Steps: Representatives from the Northeast Regional Biomass Program, including PA, have been working in association with oil heat industry representatives to promote greater awareness and acceptance of bioheat among both customers and distributors. Further discussions should occur between the Departments of Public Welfare, the Office of Consumer Advocate, and the DEP so that all are aware of potential economic considerations in implementing such an initiative. Implementation would require legislative action. Adequate injection-blending facilities would need to be in place around the state to support this measure.

Assumptions: Values from Pennsylvania: Potential for Energy Efficiency, Demand Response, and Onsite Solar Energy (ACEEE 2009). See page 21 for residential and page 27 for commercial. This represents the cost-effective potential. Note that these savings are greater than the amount identified by ACEEE analysis as achievable by the set of policies analyzed. The policy analysis led to savings of 11% fuel oil in 2025, for residential and commercial combined (see page 46). The assumptions in this work plan imply stronger policies than those identified by ACEEE (mostly standards and utility programs).

Heating Oil

Achievable cost-effective savings in heating oil use as a fraction of total gas demand:

Residential		37%	
Commercial		26%	

Value from Pennsylvania: Energy Efficiency, Demand Response and On-Site Solar Potenial. ACEEE 2009. See page 21 for residential and page 27 for commercial. This represents the cost-effective potential. Note that these savings are greater than the amount identified as ACEEE analysis as achievable by the set of policies analysed. The policy analysis led to savings of 11% fuel oil in 2025, for residential and commercial combined (see page 46). This workplan assumptions imply stronger policies than those identified by ACEEE (mostly standards and utility programs)

Fraction of achievable savings reached under program		100%	Option Goal
Year in which target fraction reached		2025	Option Goal
Year in which programs fully "ramped in"		2012	Assumption
Fraction of full program savings by year	100%	100%	
Implied fractional new annual oil demand savings, residential	3.7%	3.7%	
Implied fractional new annual oil demand savings, commercial	2.6%	2.6%	

Biofuel for heating		5%	
Lifecycle emissions factor for biofuel	*Y/N*	Y	*1*

Weighted Levelized Cost of Saved Energy

Residential		$0.63	$/gal
Commercial		$0.98	$/gal

Value from Pennsylvania: Energy Efficiency, Demand Response and On-Site Solar Potenial. ACEEE 2009. See page 21 for residential and page 27 for commercial.

Assumed average measure lifetime		8	years
Avoided Delivered Heating Oil Cost		$14.0	$/MMBtu
See common assumptions		$1.9	$/gal
Cost of biofuel for heat	$28.73	$24.75	$ / MMBtu
See "Common Factors" worksheet in this workbook			
Avoided Heating Oil Emissions Rate		0.07	tCO_2e / MMBtu
See "Common Factors" worksheet in this workbook.			

Analysis

RCI Oil Sales Covered	*(from inventory)*	208,860	209,113	Billion Btu
Residential		155,241	150,678	Billion Btu
Commercial		53,619	58,434	Billion Btu
Industrial		0	0	Billion Btu
Conversion Factor: Million Btu per Thousand Cubic feet			1.03	MMBtu/Mcf

Potential GHG Reduction:

Table 11-1. Estimated GHG Reductions and Cost-effectiveness

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)		
		GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)
RC-11	Oil conservation and Fuel Switching for Fuel Oil	5.7	-$21	-$4	35.8	$140	$4

Economic Cost: See Table 11-1 above.

Potential Overlap:

- Biofuels Investment and In-State Production Act
- RC-1 through RC-4

Other Involved Agencies: Department of Welfare.

Subcommittee Recommendations

Demand side management of heating oil appliances and equipment in residential and commercial buildings offer excellent GHG reduction potential and excellent cost savings. This is especially important since aging equipment may be subject to replacement by electric alternatives which would increase PA electricity use and commensurate GHGs.

The technologies to achieve these goals are available now.

The real challenge for demand-side management (DSM) of heating oil equipment is upfront cost to the building owners. Federal and state incentives may significantly reduce this challenge, although many home owners do not have the ready cash. It may be imperative for utility sponsored retrofits with pre-certified installers and constant fuel bills until the DSM is paid for.

Replacement of heating oil appliances and equipment have health benefits as well since older equipment is more subject to fumes and leakage in occupied spaces. Homes may also benefit from appropriately matched equipment sizing to the load, ensuring adequate temperatures are met, and reducing 'cycling'.

The GHG and energy cost savings benefits are excellent, but the upfront cost implications must be addressed through utility programs.

Information sources:

Table 11.2. Projected Heating Oil Consumption and Associated B5 Bioheat Requirements

Projected Heating Oil Consumption and Associated B5 Bioheat Requirements							
Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
#2 Heating Oil	929,363,000	909,673,787	890,401,704	871,537,914	853,073,766	835,000,795	
Biodiesel for B5 Bioheat	46,468,150	45,483,689	44,520,085	43,576,896	42,653,688	41,750,040	
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
#2 Heating Oil	817,310,712	799,995,406	783,046,937	766,457,534	750,219,588	734,325,655	
Biodiesel for B5 Bioheat	40,865,536	39,999,770	39,152,347	38,322,877	37,510,979	36,716,283	
Year	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
#2 Heating Oil	718,768,446	703,540,828	688,635,818	674,046,581	659,766,427	645,788,808	632,107,315
Biodiesel for B5 Bioheat	35,938,422	35,177,041	34,431,791	33,702,329	32,988,321	32,289,440	31,605,366

Baseline consumption data for PA is from EIA's Petroleum Navigator (http://tonto.eia.doe.gov/dnav/pet/pet_cons_prim_dcu_SPA_a.htm).

Table 11.3. Diesel Production GHG Lifecycle Assessment

Diesel* Production GHG Lifecycle Assessment (LCA) (Includes Production-Related GHGs & Finished Fuel Carbon Content, Expressed as CO_2e/Gallon)						
	CO_2	CH_4	N_2O	Total CO_2e	Carbon Content (Lbs CO_2/Gal.)	Total LCA (Lbs. CO_2e/Gal.)
G/MMBtu	20,142	109.1	0.343			
MMBtu per Gallon	0.1284	0.1284	0.1284			
GWP	1	23	296			
CO_2e	2586.23	322.19	13.04	6.44	22.38	28.82

"Biomass-based diesel" means renewable fuel that is biodiesel as defined in section 312(f) of the Energy Policy Act of 1992 (42 U.S.C. 13220(f)) and that has life-cycle greenhouse gas emissions, as determined by the Administrator, after notice and opportunity for comment, that are at least 50% less than the baseline life-cycle emissions. Notwithstanding the preceding sentence, renewable fuel derived from co-processing biomass with a petroleum feedstock shall be advanced biofuel if it meets the requirements of subparagraph (B), but is not biomass-based diesel.

RC-12. Demand-Side Management (DSM)—Electricity

Summary: Electric energy conservation in buildings is the most affordable strategy for achieving major GHG reductions as well as providing substantial energy cost savings for consumers. This work plan is focused on delivering a diverse portfolio of cost-effective energy-conserving retrofits to existing residential and commercial buildings through the creation of utility ESCOs (UESCOs) or independently led ESCOs that ensure expertise, installed performance and warranty, as well as finance. It is anticipated the funds needed for these efforts will be secured through a systems benefit charge.

Other Involved Agencies: PUC, PA Department of Commerce.

Work Plan: This strategy builds upon the energy efficiency and conservation program of Act 129, HB 2200, which mandates the introduction of utility demand-side management (DSM) programs. While an Energy Subcommittee work plan addresses both performance incentives as well as rate decoupling (see Appendix A of Energy Subcommittee Work Plan), this work plan is focused on the need for education, adding expertise with trained labor, and financing opportunities to the building sector.

Education

The first level of electric energy savings can be achieved through consumer education. Consumers determine both peak and annual energy use through product selection and use, such that a dedicated education program in concert with state commitments to the energy quality of products for purchase can reduce energy use in PA. All appliances, light fixtures, desktop technology, and entertainment technology have measurable energy differences in operation and

in standby modes. In addition to product selection and standby power demands, a "Turn it off PA" program is described at the end of this work plan.

Trained Workforce

The second level of electric energy savings must be achieved through a trained "green collar" workforce ensuring the installed performance of more significant building components: replacement furnaces, boilers and air conditioners, roof and window replacements, building insulation, shade trees, and green roofs (for cooling load reductions). In other states, these retrofits—with sustained energy savings—have been delivered by ESCOs and UESCOs. A critical factor for the building owner will be one-stop-shopping with finance, trained labor, and performance guarantees.

Finance

The third element in this work plan is funding. While ESCOs have a track record of shared economic benefits supporting ongoing investments, the lack of widespread action for either commercial or residential buildings in PA suggests that other funding must be secured. One alternative to financing electricity DSM is to mandate utility electricity load reductions of 5% by 2015 and 10% by 2010, and allow utilities to negotiate costs and savings with the customer base. A second alternative is to establish system benefit charges ranging from $.001 to $.004 per kWh linked to statewide energy savings. As demonstrated in California—the leading state for electricity DSM—system benefit charges alongside mandated electricity savings by utilities will ensure measurable GHG savings and measurable citizen benefits.

Possible Vehicles:

Turn it Off PA! Campaign
Consumer Education and Feedback

Goal:. A campaign to eliminate unnecessary equipment operating hours and appliance loads can reduce residential and commercial energy consumption by 5% to 15% (without any loss in quality of life).[6] The limitations are awareness and easy hardware for controlling equipment and appliances, which can be overcome with a concerted state work plan.

Possible New Measure(s):

The *Turn it off PA! Campaign 1* will address unnecessary heating, cooling, and lighting conditioning energy use during periods when no one is in the building, or when natural conditioning would be equally effective.

User-friendly setback thermostats to replace manual thermostats in homes and commercial buildings without building automation systems would reduce heating and cooling during unoccupied periods by an average of 20% (for homes daytime for dual working parents for example). To further address heating loads in homes and small commercial buildings, education and policy would emphasize the value of increasing south-facing windows and living spaces, maintaining high solar transmission glass on the south, so passive solar heat can meet an

[6] Darby, Sarah. 2006. *The Effectiveness of Feedback on Energy Consumption: A Review for DEFRA of the literature on metering, billing and direct displays.* Environmental Change Institute, University of Oxford. http://www.defra.gov.uk/environment/climatechange/uk/energy/research/pdf/energyconsump-feedback.pdf

additional 20% of the heating load. To further address cooling loads, the promotion of internal and external shading devices for windows in all building types, alongside a shade tree program will reduce air conditioning by at least 20%.

Education and policy would promote the use of natural ventilation as a cooling and ventilation system for a majority of the year whenever outside conditions are not too hot, humid, or polluted. A statewide policy to mandate operable windows for all long-term occupancy spaces would ensure that natural ventilation (and daylighting) remains viable if not central solutions to reducing conditioning energy loads.

Finally, policy and education would guarantee the maximum use of daylighting for both task and ambient lighting in commercial buildings. Policies would include: mandates for high-visible transmission glass (independent of shading or heat gain coefficients) in all new and retrofit projects, the design and/or specification of light-redirection devices (light shelves and horizontal blinds) that maintain views while improving daylight distribution, the renovation of historic academic and municipal buildings to re-activate their effective daylighting systems, and the introduction of daylight or time-of-day responsive controls.

The *Turn it off PA! Campaign 2* will address unnecessary appliance loads caused by equipment left on in unoccupied spaces and by parasitic or vampire loads caused by transformers and stand-by modes of equipment that is turned off.

Simple household energy software introduced in elementary schools can help families recognize the unnecessary energy being used by everyday appliances in on, standby, sleep, and off positions. Education should be supported by mandated or subsidized meters that give residents feedback for turning equipment off in daily, monthly, and annual benefits. All legislation that limits low-energy living would be modified, from clothes line ordinances to mandated air conditioning.

In a mini campaign focused on *PA kills vampire loads!,* standards would be set for all Pennsylvania transformers and set-top boxes; subsidies could be considered for switchable power strips that enable residents to turn off banks of equipment when leaving, with timers or occupancy sensors; and electricity counters could be integrated into power strips. The Prius effect, by which drivers continuously learn which actions improve the mile-per-gallon performance of their car, would be brought to residential and commercial appliances.

Assumptions:

Cost of measure | 3% | premium

Geller (2002) Utility Energy Efficiency Programs and Systems Benefit Charges in the Southwest p.4
http://www.swenergy.org/pubs/system_benefit_charges.pdf

	2017	2027
Electricity savings	6.7%	10.2%

Darby, Sarah. 2006. *The Effectiveness of Feedback on Energy Consumption: A Review for DEFRA of the literature on metering, billing and direct displays.* Environmental Change Institute, University of Oxford. http://www.defra.gov.uk/environment/climatechange/uk/energy/research/pdf/energyconsump-feedback.pdf

The analysis indicates that "The norm is for savings from direct feedback (immediate, from the meter or an associated display monitor) to range from 5-15%." We assume this could be achieved over time for the majority of homes and businesses, approaching an average of 10% by 2027.

Potential GHG Reduction:

Table 12-1. Estimated GHG Reductions and Cost-effectiveness

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)		
		GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)
RC-12	DSM—Electricity	10.1	$31	$3	66.2	$136	$2

Economic Cost: The literature indicates a range of costs for the education programs from net savings to low net costs. The costs here reflect the costs reported for electricity savings programs in south western states. Costs will depend on the decisions for programs, education and financing.

Potential Overlap:

This Action Plan was not adopted by the subcommittee because it was considered redundant with Electricity work plans. However, the vehicles described should be considered under those work plans.

Subcommittee Recommendations

Demand side management of electric appliances and equipment in residential and commercial buildings offer excellent GHG reduction potential and excellent cost savings.

The technologies to achieve these goals are available now.

In addition to behavioral changes and technology to reduce standby loads with only educational costs, aging equipment due for replacement ensures the economic viability of DSM efforts.

There may not be significant externalities for electric DSM.

DSM of electric appliances and equipment, behavioral changes and technology improvements to reduce stand by and parasitic loads makes excellent economic and environmental sense.

RC-13. Demand-Side Management (DSM) – Water

Summary: This initiative supports water conservation that achieves both water and energy savings. To achieve 25% potable water conservation, it is critical to enact new utility incentives, conservation credits, smart metering, and education programs. The energy impact of water use is estimated at 4% of all electricity consumption nationwide.

Most homeowners in PA have water bills that exceed electric bills, with little awareness of where those costs are generated. Landscaping, showers, toilet flushing, dish and clothes washing are the most significant contributors to building water loads. These water costs have measurable GHG implications (4% of all energy use) because of the energy costs of water processing and the pumping energy costs. Showers, dish and clothes washing also have hot water loads, gas or electric, with GHG implications.

As a result, water conserving alternatives benefit building owners both in water cost savings and in DHW energy cost savings.

Conservation can be achieved through State efforts to promote rain capture for landscaping, dual flush toilets, low flow faucets and shower heads, and water efficient/ front loading washing machines. This can be achieved by: point of sale education and Watersense product performance standards; elimination of code barriers; and utility managed programs that combine certified installers with equitable utility rate financing.

Goals:

- Reduce per-capita water use by 20% statewide by 2015.
- Achieve a 10% overall water savings by 2025.
- Install WaterSense fixtures for all new construction.

Possible Vehicles:

- Low-water landscaping:
  - Irrigation (low-water landscaping, rain capture).
- Low-water plumbing:
  - Toilets (WaterSense uses 1.28–1.6 gallons per flush).
  - Faucets and Showerheads.
  - Dishwashers and Washing machines.

Assumptions:

Other Data, Assumptions, Calculations	2012	2020	Units
Population	12,439,741	12,569,017	persons
Population (2005)		12,328,348	persons
Baseline (2005) per capita water use *Assumes no change in per capita use from 1995 to 2005*		30,081	gal/person/yr
Baseline (2005) total water use *Assumes no change in per capita use from 1995 to 2005*		370,847	million gal / yr
Energy Intensity (excluding heating) *Griffiths-Satenspiel and Wilson (2009.04) The Carbon Footprint of Water, provided by Mary Ann Dickinson, Alliance for Water Efficiency* *Savings from water heating included under RC-8 Appliances*		4	MWh / million gal
Goals			
Water use avoided (per capita)	10.0% 37,420	20.0% 75,617	 million gal
Water use avoided (absolute)	1.9% 6,953	6.9% 25,496	 million gal
Water use avoided (greater of per capita and absolute)	37,420	75,617	million gal
Costs			
Levelized cost of measure - landscaping *See Note 2 on this sheet*		$4.84	$ / thousand gal
Levelized cost of measure - fixtures *See Note 2 on this sheet*		$0.34	$ / thousand gal
Levelized cost of measure - washing machine *See Note 2 on this sheet*		$0.01	$ / thousand gal
Levelized cost of measure - toilet *See Note 2 on this sheet*		$1.74	$ / thousand gal
Avoided cost of water *Pittsburgh water and sewer authority http://www.pgh2o.com/fees.htm*	*Residential* *Commercial* *Weighted average*	$7.50 $7.19 $7.42	$ / thousand gal $ / thousand gal $ / thousand gal
Buildings undergoing irrigation retrofits annually		10,000	buildings
Washing machines replaced annually		50,000	machines
Homes retrofitting fixtures annually		250,000	housing units
Toilets replaced annually		250,000	toilets

Additional Results	2012	2020	Units
Overall			
Avoided water use	10,679	39,156	million gal

Note: the measures assumed are not sufficient to meet the overall goals of the workplan

Potential GHG Reduction:

Table 13-1. Estimated GHG Reductions and Cost-effectiveness

Work Plan No.	Work Plan Name	Annual Results (2020)			Cumulative Results (2009-2020)		
		GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (NPV, Million $)	Cost-Effectiveness ($/tCO_2e$)
13	Demand Side Management (DSM) – Water	0.1	-$255	-$1,944	0.8	-$1,011	-$1,285
	Irrigation at commercial buildings	0.0	-$4	-$804	0.0	-$18	-$558
	Replace fixtures	0.0	-$89	-$2,242	0.2	-$372	-$1,556
	Replace clothes washing machines	0.0	-$22	-$2,340	0.1	-$91	-$1,624
	Replace toilets	0.1	-$140	-$1,822	0.5	-$582	-$1,264

Economic Cost: See Table 13-1, above.

Potential Overlap: None

Other Involved Agencies: None identified

Subcommittee Recommendations

Water use contributes 4% of all electric demand, for processing and pumping energy. Water conservation in the areas of greatest use - landscape irrigation, toilets, faucets and washing machines, offers measurable GHG benefits at low costs especially given the natural cycles of replacement.

Between 1950 and 2000, the U.S. population nearly doubled. However, in that same period, public demand for water more than tripled. American public water supply and treatment consume approximately 56 billion kilowatt-hours per year. If one out of every 100 American homes was retrofitted with water-efficient fixtures, 100 million kilowatt-hours of electricity would be saved each year. (Source: EPA WaterSense Program - website accessed 06/10/09)

The technologies to achieve these goals are available now. Water conservation and water reuse technologies have infiltrated the market, public perspective, and government policy. While the products marketed to the public are recognizable, technologies are strongly supported by policy across all levels of government.

The major barrier to water conservation is the upfront cost of replacing fixtures. While low-flow faucets have very low costs, low water consumption toilets and washers, as well as rain barrels have first costs and installation costs that are often prohibitive for building owners and renters. Utility-based programs are needed to ensure certified installers, carefully specified fixtures, and financing, with water cost savings to pay for the program. Dry states such as California offer excellent precedent.

The average household spends as much as $500 per year on its water and sewer bill. If all U.S. households installed water-efficient appliances, the U. S. could save more than 3 trillion gallons of water and more than $18 billion dollars per year. (Source: EPA WaterSense Program - website accessed 06/10/09) While a significant portion of water conservation and reuse technologies are affordable to most, legislation could provide financial assistance and incentives.

While water is not scarce in PA, there are periods of drought and significant processing costs to providing potable water. Water conservation will ensure that water is available for the highest and best use. Water conservation and water reuse encourages economic development and benefits the environment. Water conservation reduces water costs for building owners and renters and associated energy costs for DHW - benefits that can pay for the retrofit actions. The cost savings borne out of water conservation and reuse will reduce infrastructure loading for the utilities and provide a higher quality of life for Pennsylvania citizens.

WORKPLANS THAT ARE NOT QUANTIFIED IN THIS ANALYSIS

RC-14. PA Values Embodied Energy in Building Materials, Including Historic Structures

Summary: This work plan promotes the use of regionally sourced and manufactured building products, as well as the adaptive reuse of historic and other quality existing structures.

Other Involved Agencies: DCED, U.S. Small Business Administration, local/regional economic development companies, Pennsylvania Technical Assistance Program, Industrial Resource Centers, DGS COSTAR, PA Historic and Museum Commission, county historic societies, PA Historic Landmark Foundation, Young Preservationists of Pittsburgh/PA.

Possible Vehicles: Promotion of the use of regionally sourced and manufactured building products as well as the adaptive reuse of historic/existing structures.

The notion of supporting regional communities and economies is becoming widespread in "buy-local" campaigns. Included in that notion is the procurement of building product materials within one's own region. This practice supports local businesses and manufacturers by strengthening demand for local industries instead of relying on shipping from other regions. The buy-local ideology can also reduce the amount of embodied energy in building materials by reducing the distance of travel for those materials. Many state and municipal governments are already promoting the practice of utilizing regional materials within public buildings through legislation. Locally sourced building materials are also a major component of the LEED Rating System.

Included with the concept of embodied energy is the practice of reusing existing structures, such as historic buildings. By repurposing buildings, builders are reducing GHGs and embodied energy by reducing new infrastructure, landfill waste, and the use of many new materials typically consumed in the new building construction.

Potential GHG Reduction: Locally sourced building materials reduces transportation energy costs and truck, train or shipping emissions. In addition, the reinvestment in existing buildings, infrastructures and neighborhoods reduces energy use in material manufacturing and transportation, and reduces the GHG consequences of daily commuters in sprawl communities.

Economic Cost: The economic cost of locally sources building materials might be less low cost competitive products, choices easily obtainable through past and present purchasing orders/shipping orders related to the building industry. This might necessitate tax credits to initiate the shift in purchasing until local industries increase production. A cost may also be associated with a PA preferred product label/database to be administered by staff. On the other hand, the economic benefits are greater revenues for Pennsylvania manufacturers.

The economic costs of reinvesting in existing buildings, infrastructures and neighborhoods are more significant in first costs due to the care needed to work within and around existing buildings, but life cycle costs and public utility and transportation costs will be lower. Subsidies for sprawl should be replaced by full public costs, and legislative or financial incentives should be developed.

Implementation Steps: Implementation of this program includes state and municipal legislation, such as that outlined above. Certain tax credits may also be structured and applied to building projects that strive to utilize regionally sourced materials and historic/existing structures.

Potential Overlap:

- Transportation and Land Use Work plan

RC-15. Sustainability Education Programs

Summary: This initiative supports sustainable education programs in primary and secondary schools and post-secondary, college, and university programs.

- Introduce or augment environmental/energy curricula in schools.
- Introduce energy efficiency at community colleges and trade schools.
- Provide training and certification for builders and contractors and building code officials working in energy code enforcement.
- Provide continuing education for design professionals, including architects, engineers, developers, contractors, urban planners and realtors.
- Educate consumers with information programs on efficiency and conservation targeted to reduction and wise use of energy.
- Ensure municipalities coordinate and share resources.

Possible Vehicles:

One example is the establishment of the Turn it off PA! campaign (see DSM Electricity) that eliminates unnecessary equipment operating hours and appliance loads. This can reduce residential and commercial energy consumption by 25% without loss in quality of life. The limitations are education and needed hardware for equipment. Heating, cooling, lighting, and appliance energy conservation and plug loads would be the focus of a multistage statewide campaign.