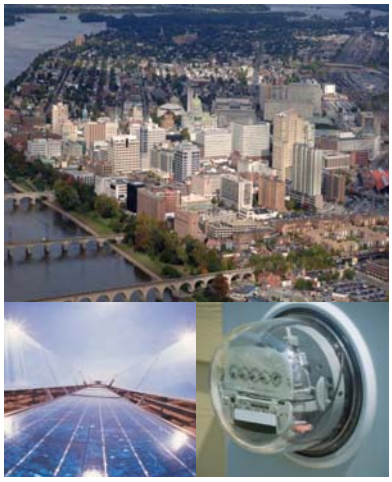


Energy BAU Draft Results, Energy Resource Potential Methods, and Other Work Status Update

February 6, 2018

Prepared for the Climate Change Advisory Committee Meeting

Anne Choate (ICF)
William Prindle (ICF)

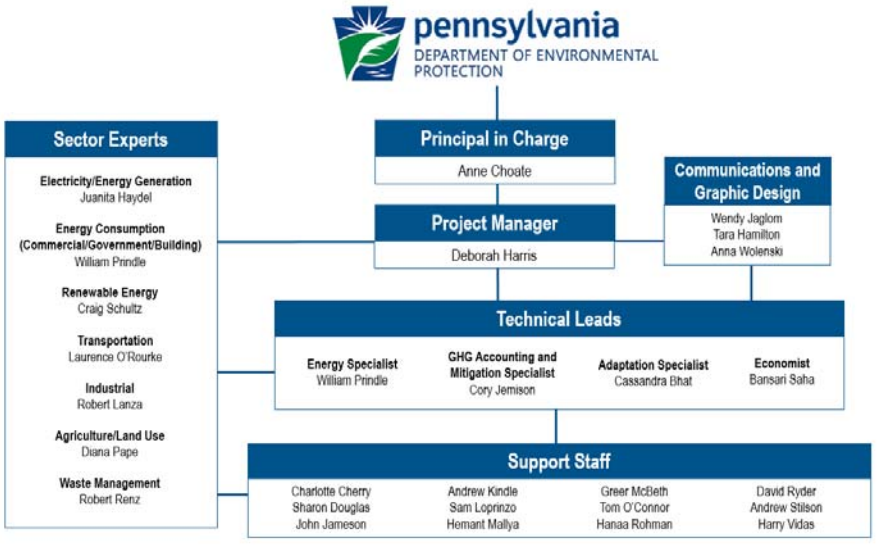
Agenda

- Introductions
- Reminder of Overall Project Approach
- Energy Business as Usual (BAU) Assessment Draft Results
- Energy Resource Potential Assessment Methods Review
- Other Work Status Update

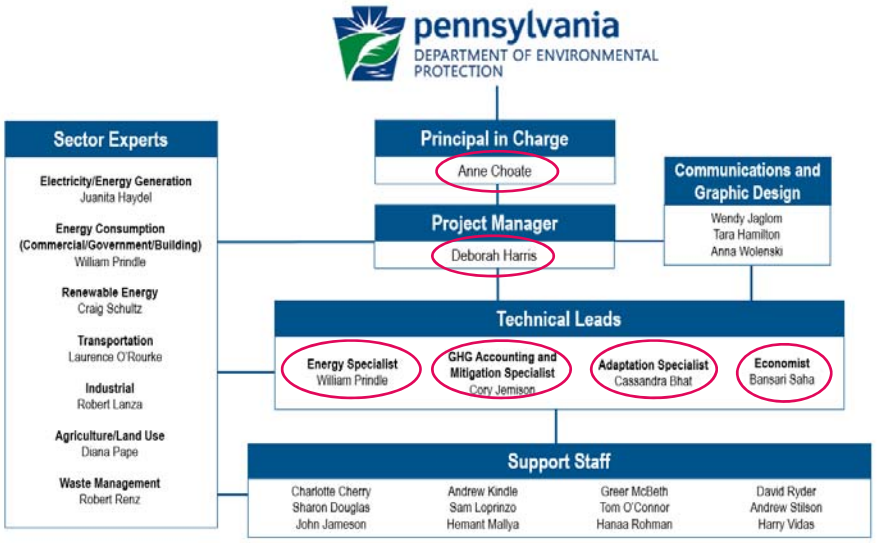
Note: All numbers included in this presentation are draft, and should not be cited or quoted.

ICF Introductions

Team Organization



Team Members Who Have Attended CCAC Meetings



ICF Principal in Charge and Energy Technical Lead

Anne Choate, Principal in Charge

- PA native
- 21 years experience energy and climate change
- Expert in climate adaptation and resilience
- Works with DVRPC, Philadelphia, Kleinman Center and numerous other states and localities, in addition to federal, corporate, and international clients
- Leads ICF's Sustainability & Management Services Division

Bill Prindle, Energy Specialist

- 40+ years of experience in the energy field
- M.S. in Energy Management and Policy from Penn
- Philadelphia EMP, Kleinman Center, and MWCOG technical lead
- Works with DVRPC and numerous other cities, municipalities, states, and fed. agencies

Reminder of Overall Project Approach

ICF's Integrated Project Approach

Energy Business as Usual (BAU) Assessment Draft Results

Energy Business as Usual (BAU) Assessment Draft Results

- Objectives and Approach
- Findings and Key Conclusions
- Questions and Input from CCAC
- Final Steps

Objectives and Approach

Objectives

- Summarize and present state-wide historical and projected (2000 through 2050) BAU energy production and consumption data by sector and fuel type
- Reflect existing policies and identify key trends and patterns in state energy production and consumption, including assessing Pennsylvania's gap between production and consumption

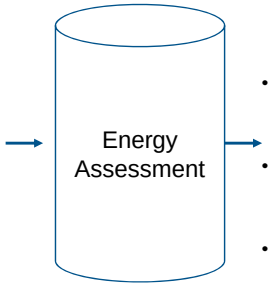
Relationship with CAP and PA Inventory

- Energy Assessment provides the foundation for the energy portion of the CAP inventory and projections
- Alignment with EPA State Inventory Tool estimates
- Allows for tracking progress towards CAP

Approach

Inputs

- **PA-specific data** (e.g., coal and oil production, State GHG Inventory, Solar Future Draft report, AEPS)
- **US Department of Energy data** (e.g, State Energy Data System and Annual Energy Outlook, Electric Power Monthly)
- **US Environmental Protection Agency data** (e.g., eGRID and other emission factors, LMOP, CMOP, AgStar)
- **ICF models and databases** (e.g., ICF Gas Markets Model and CHP databases)
- **ICF and DEP expert assumptions** (e.g., future growth based on historical trends, extrapolation)
- **Other data** (e.g., renewable fuels associations, CCAC members, ARIPPA)



Outputs

- **Commonwealth-level Energy Consumption and Expenditures, Total and by Sector** - details by fuel type also available
- **Commonwealth-level Energy Production Total and by Fuel Type**
- **Commonwealth-level Electricity Generation Total and by Fuel Type**
- **Commonwealth-level Imports and Exports for Electricity, and Select Fossil Fuels and Renewables/Alt. Fuels**
- **Criteria Air Pollutant and Price data available as data allows**

Findings and Key Conclusions

Energy Consumption: Electricity DRAFT

Sector (Units in GWH)	2000	2005	2015	2018	2020	2025	2030	2050	% Delta 2005-2050
Residential	45,008	53,661	54,419	51,878	50,348	49,216	48,949	45,981	-14%
Commercial	42,988	45,782	43,745	43,953	44,498	44,278	43,329	44,155	-4%
Industrial	45,449	47,950	47,404	46,215	47,814	51,417	50,298	52,096	9%
Transport	401	880	776	910	1,042	1,621	2,166	3,402	287%
Total	**133,846**	**148,273**	**146,344**	**142,956**	**143,702**	**146,532**	**144,742**	**145,634**	**-2%**

Data to the left of the red line are actual data, and data to the right are projected data.

Note: Percentages changes in tables may appear off due to rounding in some cases.

Energy Consumption: Fuels DRAFT

Fuel Type	2000	2005	2015	2018	2020	2025	2030	2050	Change from 2005 to 2050
Natural Gas	706,188	635,724	888,527	921,843	944,789	957,577	977,929	1,141,014	79%
Coal	297,454	265,925	209,585	184,657	180,379	168,032	149,404	74,567	-72%
Motor Gasoline	614,320	638,812	551,093	555,498	533,553	472,983	423,539	392,430	-39%
LPG	26,769	44,949	45,127	56,173	56,534	57,013	56,179	56,649	26%
Distillate Fuel Oil	380,548	406,428	367,862	369,847	365,143	360,556	341,835	332,793	-18%
Residual Fuel Oil	46,066	44,896	2,692	2,685	2,885	2,990	2,944	3,766	-92%
Jet Fuel	107,780	95,404	42,599	43,711	44,562	47,659	49,908	58,942	-38%
Kerosene	19,352	13,603	1,562	1,758	1,651	1,552	1,487	1,379	-90%
Other – Industrial	349,272	372,394	318,309	310,868	263,150	297,731	308,656	340,416	-9%
Other – Transportation	116,866	102,915	49,997	50,729	50,053	48,516	47,146	42,800	-58%
Total	**2,664,615**	**2,621,050**	**2,477,353**	**2,497,770**	**2,442,699**	**2,414,610**	**2,359,029**	**2,444,755**	**-7%**

Energy Production: Fossil Fuels DRAFT

Fuel Type	2000	2005	2015	2018	2020	2025	2030	2050	Change from 2005 to 2050
Bituminous Coal	1,682	1,539	1,015	702	896	895	802	715	-54%
Anthracite Coal	59	50	98	79	83	94	108	143	184%
Natural Gas	156	177	5,128	5,848	6,595	7,219	7,745	10,195	5,675%
Crude Oil	9	14	40	41	48	45	43	79	455%
Coal Mine Methane	0	1	1	1	1	1	1	1	50%
Waste Coal	86	114	78	78	78	78	78	78	-32%
Total	**1,993**	**1,895**	**6,362**	**6,750**	**7,701**	**8,333**	**8,778**	**11,212**	**492%**

Energy Production: Renewable/Alternative Fuels DRAFT

Fuel Type	2000	2005	2015	2018	2020	2025	2030	2050	Change from 2005 to 2050
Landfill Gas Methane	327	2,077	8,691	8,723	8,723	8,723	8,723	8,723	320%
Digesters – Wastewater	-	2	45	45	45	45	45	45	2,581%
Digesters – Ag Waste	7	7	32	35	36	41	45	62	749%
Biodiesel	-	1,287	3,070	3,349	3,349	3,349	3,349	3,349	160%
Solid Biomass	90,050	78,465	96,409	100,895	171,687	175,603	207,286	297,963	280%
Corn Ethanol	-	-	9,319	9,319	9,319	9,319	9,319	9,319	N/A
Cellulosic Ethanol	-	-	-	-	-	-	-	-	N/A
Total	**90,384**	**81,839**	**117,566**	**122,366**	**193,159**	**197,079**	**228,767**	**319,460**	**290%**

Electricity Generation: Fossil Fuels DRAFT

Fuel Type	2000	2005	2015	2018	2020	2025	2030	2050	Change from 2005 to 2050
Natural Gas	2,971	11,088	60,102	69,669	69,800	69,830	73,491	113,649	925%
Coal	116,403	121,124	64,828	68,541	77,317	79,687	80,390	77,396	-36%
Waste Coal	7,999	9,972	6,551	6,551	6,551	6,551	6,551	6,551	-34%
Residual Fuel Oil	2,514	4,031	34	34	34	34	34	34	-99%
Distillate Fuel Oil	1,255	667	729	278	305	306	304	304	-54%
Petroleum Coke	22	275	-	-	-	-	-	-	-100%
Coal Mine Methane	-	-	-	-	-	-	-	-	N/A
Other Fuel (CHP)	2,231	2,231	2,471	2,471	2,471	2,471	2,471	2,471	11%
Pumped Storage	(411)	(711)	(509)	(419)	(419)	(419)	(423)	(426)	-40%
Total	**132,985**	**148,678**	**134,205**	**147,124**	**156,058**	**158,459**	**162,817**	**199,978**	**35%**

Electricity Generation: Renewable and Alternative Fuels DRAFT

Fuel Type	2000	2005	2015	2018	2020	2025	2030	2050	Change from 2005 to 2050
Utility-Scale Solar PV	-	-	15	152	243	443	643	1,444	N/A
Building-Scale Solar PV	-	-	37	279	440	542	643	1,049	N/A
Hydroelectric	2,290	2,232	2,604	3,523	4,128	4,128	4,128	4,410	98%
Wind	10	284	3,353	4,075	4,139	4,140	4,161	4,621	1527%
Biomass Solids	2,852	2,176	2,582	3,298	9,932	10,115	13,238	21,681	896%
Landfill Gas Methane	304	396	1,621	1,648	1,648	1,648	1,648	1,648	316%
Digesters – Wastewater	-	2	40	40	40	40	40	40	2154%
Digesters – Ag Waste	7	7	32	34	36	40	44	60	749%
Total	5,462	5,097	10,283	13,047	20,605	21,095	24,545	34,953	586%

GHG Emissions: (MMtCO2e) DRAFT

Sector	2000	2005	2015	2018	2020	2025	2030	2050	% Delta 2005-2050
Residential	26	24	21	20	19	18	17	15	-38%
Commercial	13	13	12	12	12	12	12	14	11%
Industrial	43	40	48	49	49	49	47	45	14%
Transport	71	73	59	61	59	56	52	54	-26%
Electricity Generation	124	132	94	98	106	108	110	118	-11%
Total Emissions	278	282	234	238	245	243	239	246	-13%

Energy Expenditures and Intensity DRAFT

Sector ($ million)	2000	2005	2015	2018	2020	2025	2030	2050	% Delta 2005-2050
Residential	$5,096	$6,890	$4,864	$4,744	$4,853	$4,877	$4,814	$4,761	-31%
Commercial	$2,015	$3,096	$2,206	$2,212	$2,451	$2,579	$2,721	$3,660	18%
Industrial	$2,686	$4,455	$4,357	$5,326	$6,091	$6,591	$6,731	$8,814	98%
Transportation	$14,275	$20,436	$16,951	$15,301	$17,232	$18,106	$17,298	$19,483	-5%
Electricity Generation	$3,193	$5,352	$3,833	$3,731	$4,331	$4,612	$4,916	$6,590	23%
Total Expenditures	$27,265	$40,229	$32,210	$31,313	$34,958	$36,765	$36,479	$43,308	8%
Pennsylvania State GDP	$395,602	$482,200	$708,402	$710,022	$744,233	$829,762	$915,291	$1,268,552	163%
Btu per dollar of state GDP	9.60	7.99	5.00	5.10	4.99	4.48	4.07	3.20	-60%

Key Conclusions from the Energy BAU DRAFT

- Electricity demand growth is flat in the buildings sector, rising in industry and transport
- Fossil fuel consumption falling overall, though natural gas and propane use is rising
- Fossil fuel production booming, much of it exported
- Renewable fuel production rising, but still only projected to be 5% of fossil production in 2050 (does not include fuels or resources used for electricity generation)
- Renewable electricity generation is rising, and is projected to be ~30% of total generation in 2050
- GHG emissions in 2050 are 12% below 2005 levels, but up slightly from 2015
- Energy expenditures rise modestly, but energy intensity falls by more than half

Questions and Input from the CCAC on the Energy BAU

Final Steps

Final Steps for Energy BAU

- ICF has received a round of feedback from DEP
- Revised numbers and report will be delivered to DEP in early February
- CCAC to provide feedback on what ICF has presented today by February 19
- Final feedback from DEP will be addressed in the Comprehensive Energy Assessment Report, which will combine the Energy BAU and the Energy Resource Potential Assessment
- CCAC will have an opportunity to review and comment on this combined report in April 2018

Energy Resource Potential Assessment Methods Review

Energy Resource Assessment Methods Review

- **Objectives, Approach, and Data**
- **Questions and Input from CCAC**
- **Next Steps**

Objectives, Approach, and Data

Objectives

- **Develop technical and economic energy resource potential by sector for Pennsylvania's resources**
- **For purposes of this analysis a resource is defined as:**
  - Either a physical commodity or a technology that can be utilized to drive energy efficiency, fuel production, or power production

Approach

1. **Develop supplemental resource assessments**
   - Include energy efficiency, fossil fuels, electricity generation, transportation, and distributed energy resources
2. **Define sectoral energy resource opportunities**
   - Map the resource potential data into sectoral allocations where feasible
   - Produce estimates in the form of energy supply and/or efficiency potential
   - Sectors include fuel production, electricity generation, buildings (residential, commercial, and government), industrial, and transportation
3. **Develop environmental impact and economic benefit and cost estimates.**
   - Project environmental and economic benefits
4. **Produce task summary and spreadsheet(s)**

Data Sources - Energy Efficiency and Conservation

- **Energy Efficiency** - Technology Measures, including Geothermal Heat Pumps
  - Rely primarily on Act 129 potential studies
  - Augment with other studies, such as material from ACEEE and DOE
- **Energy Conservation –** Behavioral/Operational Measures
  - Rely primarily on Act 129 potential studies
  - Augment with selected sources, such as measured effects of benchmarking from EPA Energy Star, results of city benchmarking and disclosure regulations (Philadelphia, NYC), and selected utility program evaluation studies

Data Sources - Fossil Fuels and Nuclear

- **Natural Gas and Crude Oil (will be estimated separately)**
  - Rely on EIA AEO data and supporting documents, including high energy production case, data from the DOE Office of Fossil Energy; PA-specific studies to assess potential; and ICF Gas Markets Model (GMM)
  - Focus on upstream technology assumptions in the AEO forecast scenarios and the future upstream technology assumption underlying ICF GMM forecasts
  - Estimate propane as part of natural gas assessment as it is increasing as part of natural gas liquids
- **Coal**
  - Rely on EIA AEO data and supporting documents, including high energy production case; data from the DOE Office of Fossil Energy; and ICF coal models
- **Waste Coal**
  - Supplement previously noted DOE/EIA resources with data from ARIPPA
- **Coal Mine Methane**
  - Rely on EPA CMOP, PA coalbed methane potential study, and USGS resources
- **Nuclear**
  - Rely on EIA AEO, recent news of Three Mile Island closing, and FERC rulings

Data Sources - Renewables

- **Solar PV (Utility and Building Scale)**
  - Align with Solar Future project
  - Augment with national sources such as EIA and the Solar Energy Industries Association if needed
- **Wind**
  - Rely on of EIA studies, DOE/NREL, American Wind Energy Association (AWEA) sources, and PA Wind Working Group potential estimates
- **Hydroelectric**
  - Review potential studies as identified, but limit focus on this resource

Data Sources - Renewables

- **Biodiesel**
  - Take into account the state law requiring 2% biodiesel in motor fuels and suggest an alternative, realistic number based on research and input from DEP and CCAC
- **Ethanol**
  - Take into account state and federal mandates (10% ethanol in motor gas) and suggest an alternative, realistic number based on research and input from DEP and CCAC
- **Landfill Methane, Wastewater, Agricultural Waste**
  - Rely on a mix of sources, many used in the BAU Assessment, such as:
    - EPA databases (AgStar, LMOP, CHP Partnership)
    - ICF CHP database
    - NREL Biogas potential studies
    - Other sources provided by CCAC members

Data Sources - Enabling Technologies

- **CHP/Microgrids**
  - Rely on ICF CHP database and CHPower model
- **Energy Storage (Battery)**
  - Currently reviewing data sources that could be used for quantification, particularly in relation to renewable energy
- **Heat Pumps (Ground and Air Source)**
  - May augment EE analysis through illustrative examples, especially in relation to the electrification issue
- **Electrification**
  - Provide illustrative calculations of simple examples based on review of existing studies, such as shifting percentages of fuel loads to electric technologies, with accompanying assumptions of grid decarbonization
- **Internet of Things**
  - Discuss potential for grid interaction with a wide range of end-use devices, to support better monitoring and control, but will not quantify
- **Hydrogen Fuels Cells**
  - Residential/micro-CHP uses fuel cell technology; transport fuel cells giving way to EVs

Questions and Input from the CCAC on the Energy Resource Potential Assessment

Questions for CCAC on Energy Resource Potential Assessment

- **Does the CCAC have any recommendations for data or information sources that we should be considering?**
- **Are there any energy resources the CCAC thinks will be particularly important to focus in the assessment?**

Next Steps

Next Steps for Energy Resource Assessment

- ICF and DEP will work to finalize numbers and associated write up by the end of February 2018
- Results and write up will be integrated in the Comprehensive Energy Assessment Report, which will combine the BAU Assessment and the Energy Resource Assessment
- CCAC will have an opportunity to review and comment on this combined report in the April 2018 timeframe

Other Work Status Update

Update on Other Work ICF and DEP are Undertaking

Development of Clean Energy and GHG Reduction Strategies and Economic Analysis

- Established GHG goals through review of other plans, for example
  - ✓Long-term aspirational goal: 80 by 50 (80% reduction in GHGs by 2050, 2005 baseline)
  - ✓Short-term goal: Reduction 28% below 2005 levels by 2025 (aligns with Paris Agreement)
- Established analysis parameters and setting up model
- Beginning to think through potential strategies as Energy Resource assessment is being conducted
- Analysis will occur through winter, spring and summer 2018 and results will be shared via CCAC meetings

Update on Other Work ICF and DEP are Undertaking

Adaptation Strategy Assessment

- Received feedback from a number of Agencies and Departments
  - DEP, Department of Conservation and Natural Resources, the Public Utilities Commission, Department of Health, and the Department of Community & Economic Development, PennDOT
- Will align adaptation strategies with clean energy and GHG reduction strategies and sectors where feasible (e.g., energy efficiency) in winter/spring 2018
- Once this alignment occurs, will prepare summary write up in spring 2018
- Final results may be presented to CCAC in April 2018

Update on Other Work ICF and DEP are Undertaking

Climate Action Plan Report

- Working through an outline that addresses mitigation and adaptation in an integrated fashion where possible
- CAP organization will be presented to CCAC in April 2018
- Draft report anticipated to be shared with the CCAC in late summer 2018
- Report will be finalized in fall 2018

Thank You

Anne Choate, Senior Vice President
Anne.Choate@icf.com, (215) 381-0480

Bill Prindle, Vice President
William.Prindle@icf.com, (202) 862-1179