

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

February 6, 2018



Prepared for the  
Climate Change  
Advisory Committee  
Meeting

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## 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**

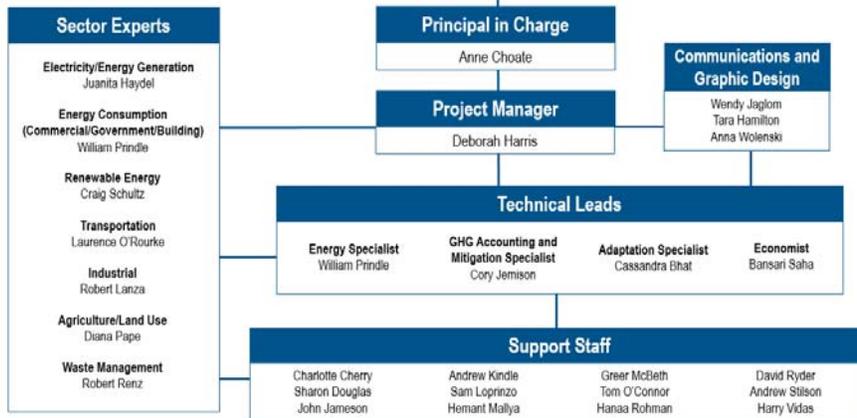
*Note: All numbers included in this presentation are draft, and should not be cited or quoted.*

# ICF Introductions

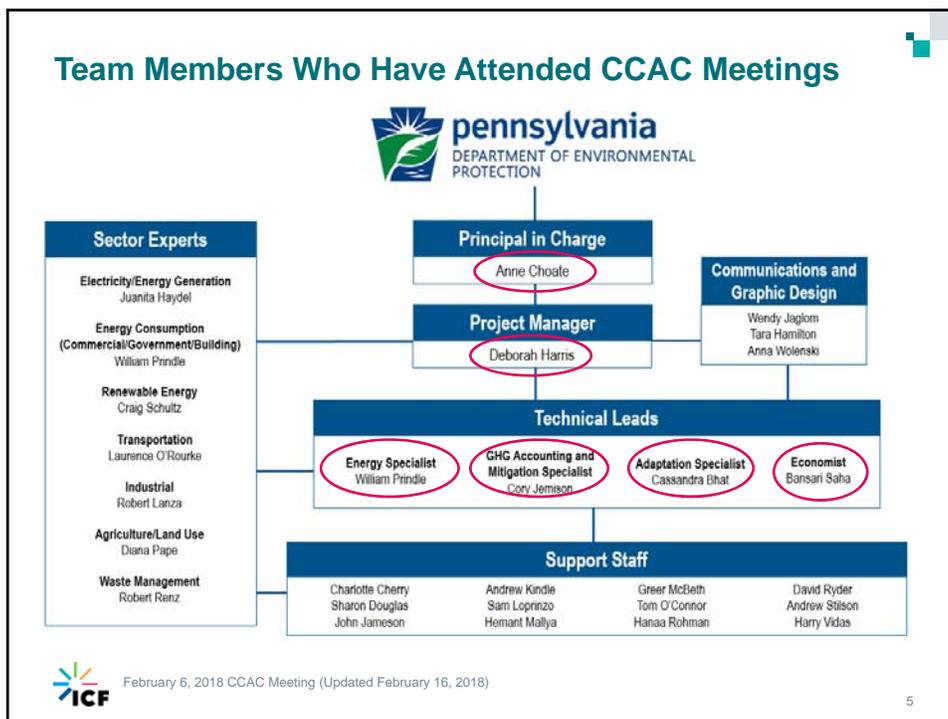


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# Team Organization



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### 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 MWCOC technical lead
- Works with DVRPC and numerous other cities, municipalities, states, and fed. agencies

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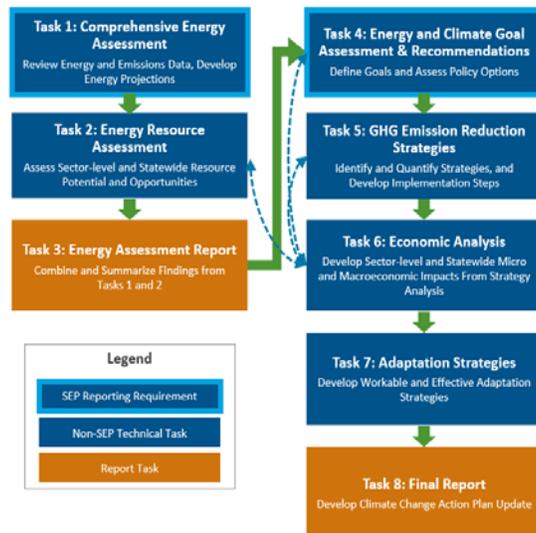
## Reminder of Overall Project Approach



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## ICF's Integrated Project Approach



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## Energy Business as Usual (BAU) Assessment Draft Results



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## Energy Business as Usual (BAU) Assessment Draft Results

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



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## Objectives and Approach



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## 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



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## 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



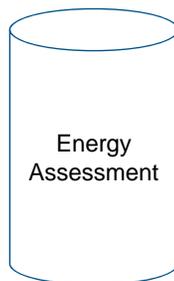
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## Approach

### 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**



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## Findings and Key Conclusions



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### 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%
<b>Total</b>	<b>133,846</b>	<b>148,273</b>	<b>146,344</b>	<b>142,956</b>	<b>143,702</b>	<b>146,532</b>	<b>144,742</b>	<b>145,634</b>	<b>-2%</b>

*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.*



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## 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%
<b>Total</b>	<b>2,664,615</b>	<b>2,621,050</b>	<b>2,477,353</b>	<b>2,497,770</b>	<b>2,442,699</b>	<b>2,414,610</b>	<b>2,359,029</b>	<b>2,444,755</b>	<b>-7%</b>



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## 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%
<b>Total</b>	<b>1,993</b>	<b>1,895</b>	<b>6,362</b>	<b>6,750</b>	<b>7,701</b>	<b>8,333</b>	<b>8,778</b>	<b>11,212</b>	<b>492%</b>



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## 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
<b>Total</b>	<b>90,384</b>	<b>81,839</b>	<b>117,566</b>	<b>122,366</b>	<b>193,159</b>	<b>197,079</b>	<b>228,767</b>	<b>319,460</b>	<b>290%</b>



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## 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%
<b>Total</b>	<b>132,985</b>	<b>148,678</b>	<b>134,205</b>	<b>147,124</b>	<b>156,058</b>	<b>158,459</b>	<b>162,817</b>	<b>199,978</b>	<b>35%</b>



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## 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%
<b>Total</b>	<b>5,462</b>	<b>5,097</b>	<b>10,283</b>	<b>13,047</b>	<b>20,605</b>	<b>21,095</b>	<b>24,545</b>	<b>34,953</b>	<b>586%</b>



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## GHG Emissions: (MMtCO<sub>2</sub>e) **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%
<b>Total Emissions</b>	<b>278</b>	<b>282</b>	<b>234</b>	<b>238</b>	<b>245</b>	<b>243</b>	<b>239</b>	<b>246</b>	<b>-13%</b>



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## 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%



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## 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



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## Questions and Input from the CCAC on the Energy BAU



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## Final Steps



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## 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



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## Energy Resource Potential Assessment Methods Review



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## Energy Resource Assessment Methods Review



**Objectives, Approach, and Data**



**Questions and Input from CCAC**



**Next Steps**



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**Objectives, Approach, and Data**



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## 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



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## 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)**



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## 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



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## 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



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## 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



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## 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



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## 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



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



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## 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



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## 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



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## 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



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## Thank You

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