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Technical Appendix: Descriptions of Cases and Modeling Approach

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UCS used the National Renewable Energy Laboratory's (NREL) Regional Energy Deployment System (ReEDS) model to analyze the technical and economic feasibility of Illinois achieving higher levels of energy efficiency and renewable energy spurred by the enactment of a stronger energy efficiency portfolio standard (EEPS) and renewable portfolio standard (RPS). This document describes the methodology and assumptions that were used for that analysis.

ReEDS is a computer-based, long-term capacity-expansion model for the deployment of electric power generation technologies in the United States. ReEDS is designed to analyze the impacts of state and federal energy policies, such as clean energy and renewable energy standards or policies for reducing carbon emissions, in the U.S. electricity sector. ReEDS provides a detailed representation of electricity generation and transmission systems and specifically addresses issues related to renewable energy technologies, such as transmission constraints, regional resource quality, variability, and reliability. UCS used the 2014 version of ReEDS for our analysis. However, we do make some changes to NREL's assumptions for renewable and conventional energy technologies based on project-specific data and mid-range estimates from recent studies and regulatory filings, as described in more detail below.

Summary description of three cases

To analyze the impacts of potential revisions to clean energy policies in Illinois, we developed three future cases, as described below. We compare the results of the cases to each other to estimate the impacts driven by the different policies and the interaction between the EEPS and RPS policies.

Other than the various iterations of Illinois's EEPS and RPS reflected in the future cases, we assume that all other state and federal policies enacted as of the end of 2014 remain in effect as enacted. In all cases, both the RPS and EEPS apply only to large investor owned utilities (IOUs) consistent with the currently-enacted RPS. Since Commonweatlth Edison and Ameren Illinois (the state's two IOUs) account for 89% of Illinois electricity sales on average from 2011 to 2013, we assume that large IOUs would continue to supply 89% of electricity sales in the future.

NO POLICIES CASE

The No Policies case refers to a future where Illinois does not require the state's utilities to meet renewable energy or energy efficiency targets beyond 2014. Both efficiency and renewable energy are included in this case, but these choices are not driven by a state regulatory policy.

The projected electricity sales in this case are derived from the Energy Information Administration's Annual Energy Outlook (AEO) 2014 projections, following the approach used in default assumptions for ReEDS. ReEDS starts with the 2010 electricity sales for each state, then projects future electricity sales using the growth rate for the appropriate census region from the AEO 2014 reference case. For states other than Illinois, we adjusted these projections to account for reductions in electricity sales resulting from currently-enacted state EEPS policies that are not included in the AEO 2014. Our adjustments follow the approach used by the Environmental Protection Agency in Projected Impacts of State Energy Efficiency and Renewable Energy Policies (EPA 2014) with minor updates (for example, we change sales projections to reflect AEO2014 and adjust targets in states that reduced their energy efficiency goals in 2014). We assume full compliance with EEPS policies for states other than Illinois.

EXISTING EEPS + FIXED RPS CASE

The Existing EEPS + Fixed RPS case considers an energy future where Illinois continues to implement its EEPS as currently designed and enacts policy to "fix" the RPS so that the state's utilities fully achieve the currently enacted target of 25 percent renewable energy by 2025 (as fraction of Illinois electricity sales). The EEPS target aims for 2 percent reductions in each year, relative to electricity sales in the previous year, subject to a cost cap in which the "estimated average net increase due to the cost of efficiency measures shall be no more than 2.015 percent of the amount paid per kWh by customers in EY 2007" (220 ILCS 5/8-103). As a simplification for the model, we assume that the cost cap would continue to limit the extent that energy efficiency programs are implemented by utilities, based on energy efficiency program implementation experience in recent years. In particular, the Illinois Power Authority recently accepted submissions from the two IOUs with electricity efficiency programs having savings that account for 1.35 percent of their previous year sales, rather than the full 2 percent savings. We therefore assume that the existing EEPS policy would continue to achieve electricity savings of 1.35 percent of previous year sales through 2030.

The RPS also includes a solar requirement stating that 6 percent of the RPS target must be met by solar resources starting in 2016. However, based on the limited progress to date towards meeting the solar requirement, we assume that achievement of this target would be delayed until 2025 with a linear increase in solar to meet that target. Due to constraints within the model, we do not explicitly include the RPS's resource-specific requirements for wind or distributed generation as input to the model. Eligible resources in ReEDs that were included in the RPS are existing hydro power and waste heat, plus new and existing solar, wind, landfill gas and biomass. See Table 1 below for the annual RPS targets.

Although the Illinois RPS allows renewable energy credit (REC) trading with a preference for in-state resources or procurement from adjoining states, ReEDS cannot model these exact specifications. ReEDS is designed to allow only REC trading where the REC is bundled with power to the state. To reflect the geographic preference in the Illinois RPS, we further restrict REC trading to only allow RECs from states in the PJM or MISO service territories.

STRENGTHENED EEPS + RPS CASE

Our third case assumes implementation of the Clean Energy Bill proposed in the Illinois legislature during the 2015 spring session, The proposed legislation would strengthen Illinois's RPS to 35 percent by 2030 for large utilities and enact an EEPS that achieves "a cumulative annual persisting reduction in electric energy demand from efficiency measures implemented as a result of utility programs from 2012 through 2025 of 20 percent, relative to average annual electricity sales from 2014 through 2016, by the year ending December 31 2025". We assume energy efficiency programs will be added or expanded after 2025 such that the total electricity sales in 2025 are not exceeded in subsequent years. The solar requirement for this bill calls for 5 percent of the RPS target to be from solar in 2020, 6 percent by 2025 and 7 percent by 2030. See Table 1 below for the annual RPS targets for the RPS cases.

We assume that the strengthened RPS maintains the same policy design elements as the fixed RPS, including the legislative fixes to provide stable markets. Resources eligible for compliance, any geographic limitations on eligible resources, and other policy design elements are assumed to be consistent with the current RPS.

TABLE 1. **EEPS and RPS Schedule as assumed for ReEDS cases**

	Existing EEPS and Fixed RPS case		Strengthened EEPS and RPS case	
	Overall RPS Standard (percent of Retail Electric Sales)	Solar Requirement (percent of the Standard)	Overall RPS Standard (percent of Retail Electric Sales)	Solar Requirement (percent of the Standard)
2016	10%	1%	11.5%	1.25%
2017	11.5%	1.8%	13%	2.2%
2018	13%	2.3%	14.5%	3.1%
2019	14.5%	2.8%	16%	4.1%
2020	16%	3.4%	17.5%	5%
2021	17.5%	3.9%	19%	5.2%
2022	19%	4.4%	20.5%	5.4%
2023	20.5%	4.9%	22%	5.6%
2024	22%	5.5%	23.5%	5.8%
2025	23.5%	6%	25%	6%
2026	25%	6%	27%	6.2%
2027	25%	6%	29%	6.4%
2028	25%	6%	31%	6.6%
2029	25%	6%	33%	6.8%
2030	25%	6%	35%	7%

* Applies to large Investor-Owned utilities and eligible resources are wind, solar photovoltaic, concentrated solar power, distributed solar, landfill gas and biomass. Energy efficiency savings account for natural, underlying growth rates from AEO2014 for the East North Central Census division.

UCS Assumptions for NREL ReEDS Model

COST AND PERFORMANCE FOR ELECTRIC GENERATING TECHNOLOGIES

The cost and performance assumptions for electric generating technologies that UCS uses in the 2014 version of NREL's ReEDS model are shown in Tables 1-3 below, compared to EIA's AEO 2014 assumptions (EIA 2014). For conventional technologies, NREL uses EIA's AEO 2014 cost and performance assumptions. We do not make any changes to EIA's assumptions for natural gas and coal prices, fixed and variable O&M costs, and heat rates, with a few exceptions noted below (EIA 2014). However, we do make several changes to EIA's capital cost assumptions and wind and solar capacity factors based on project specific data for recently installed and proposed projects, supplemented with mid-range estimates from recent studies when project data was limited or unavailable. The cost and performance assumptions for renewable energy technologies are mostly consistent with the assumptions that were developed for the DOE Wind Vision report (DOE 2014). We also describe our assumptions for energy efficiency investments under the current and the strengthened EEPS.

The key assumptions we made include:

- **Learning.** We do not use EIA's learning assumptions that lower the capital costs of different technologies over time as the penetration of these technologies increase in the U.S. (EIA 2014). EIA's approach does not adequately capture growth in international markets and potential technology improvements from research and development (R&D) that are important drivers for cost reductions. Instead, we assume costs for mature technologies stay fixed over time and costs for emerging technologies decline over time at the same levels for all scenarios.

- **Natural gas and coal.** For plants without carbon capture and storage (CCS), we use EIA's initial capital costs, but do not include EIA's projected cost reductions due to learning because we assume they are mature technologies. For new IGCC and supercritical pulverized coal plants, we use EIA's higher costs for a single unit plant (600-650 MW) instead of dual unit plants (1200-1300 MW), which is more consistent with data from proposed and recently built projects (SNL 2013). For plants with CCS, we assume: 1) higher initial capital costs than EIA based on mid-range estimates from recent studies (Black & Veatch 2012, Lazard 2013, NREL 2012, EIA 2014), 2) no cost reductions through 2020 as very few plants will be operating by then, and 3) EIA's projected cost reductions by 2040 will be achieved by 2050 (on a percentage basis).

- **Nuclear.** We assume higher initial capital costs than EIA for new nuclear plants based on mid-range estimates from recent studies and announced cost increases at projects in the U.S. that are proposed or under construction (Black & Veatch 2012, Henry 2013, Lazard 2013, Penn 2012, SNL 2013, Vukmanovic 2012, Wald 2012). We do not include EIA's projected capital cost reductions, given the historical and recent experience of cost increases in the U.S. We also assume existing plants will receive a 20-year license extension, allowing them to operate for 60 years and will then be retired due to safety and economic issues. To date, no existing plant has received or applied for an operating license extension beyond 60 years. Consistent with theNREL assumptions in ReEDS, we include 4.7 gigawatts (GW) of retirements at five existing plants (Vermont Yankee, Kewaunee, Crystal River, San Onofre, Oyster Creek) based on recent announcements and closures, and 5.5 GW of planned additions (Vogtle, V.C. Summer, and Watts Bar).

- **Onshore Wind.** We assume lower initial capital costs than EIA based on data from a large sample of recent projects from DOE's 2013 Wind Technologies Market Report (Wiser and Bolinger 2014). This report shows that capacity-weighted installed capital costs for U.S. projects declined 13 percent from $2,262/kW (in 2013$) in 2009 to $1,960/kW in 2012. While costs dropped again to $1,630/kW in 2013 and are expected to average $1,750/kW in 2014. These projects are heavily weighted toward lower cost projects in the interior region of the U.S. Thus, we conservatively assume that average U.S. installed costs will stay fixed at 2012 levels over time.

  However, we also assume the wind industry invests in technology improvements that result in increases in capacity factors. Current capacity factors are based on data from recent projects and studies that reflect recent technology advances (Wiser 2014). We assume capacity factors will increase over time to achieve a reduction in the overall cost of electricity based on mid-range projections from 13 independent studies and 18 scenarios (Lantz 2013). We also assume higher fixed O&M costs than EIA based on mid-range estimates (EIA 2014, Wiser 2012, Black & Veatch 2012, NREL 2012).

- **Offshore wind.** Initial capital costs are based on data from recent and proposed projects in Europe and the U.S. from NREL's offshore wind database (Schwartz 2010). We assume capital costs decline and capacity factors increase over time based on mid-range projections from several studies (Lantz 2013, EIA 2014, NREL 2012, Black & Veatch 2012, BVG 2012, Prognos 2013). We also assume higher fixed O&M costs than EIA based on mid-range estimates (EIA 2014, Wiser 2012, Black & Veatch 2012, NREL 2012).

- **Solar photovoltaics (PV).** We assume lower initial capital costs than EIA based on data from a large sample of recent utility scale and rooftop PV projects installed in the U.S. through the second quarter of 2014 (SEIA 2014). We assume future solar PV costs for utility scale, residential, and commercial systems will decline over time based on mid-range projections from the DOE Sunshot Vision Study's 62.5 percent by 2020 and 75 percent by 2040 cost reduction (relative to 2010 levels) scenarios. In addition, we use slightly lower capacity factors for solar PV than EIA based on NREL data (NREL 2012).

- **Solar CSP.** We assume concentrating solar plants will include six hours of storage and use the capital and O&M cost projections from the DOE Sunshot Vision Study's 62.5 percent by 2020 and 75 percent by 2040 cost reduction scenarios.

- **Biomass.** We use EIA's initial capital costs for new fluidized bed combustion plants, but do not include EIA's projected cost reductions due to learning because we assume it is a mature technology. For biomass co-firing in coal plants, we assume higher capital costs based on data from Black & Veatch (2012). We also use a different biomass supply curve than EIA and NREL based on a UCS analysis of data from DOE's Updated Billion Ton study that includes additional sustainability criteria, resulting in a potential biomass supply of 680 million tons per year by 2030 (UCS 2012, ORNL 2011).

- **Geothermal and hydro.** We restrict the construction of large hydroelectric dams until after 2019 to reflect the long lead times for planning, permitting and building such facilities. We do not make any other changes to NREL's assumptions for geothermal and hydro, which are site specific.

- **Recent or planned changes to generating resource or transmission availability.** To ensure the ReEDS model has an accurate accounting of the current and near-term electricity system, we undertook a thorough review of the model's depiction of the electricity system (across the contiguous United States) in 2012 and 2014 and compared that with our understanding, based on SNL data and industry reports/projections, of real-world conditions. Our updates to ReEDS included:
    - Accounting for prescribed builds within the model to accurately reflect newly constructed or under-construction generating resources (including natural gas, nuclear, coal, wind and utility-scale solar facilities);
    - Accounting for recent or recently-announced coal-plant retirements to ensure these resources are not available to the model; and
    - Updating assumptions for transmission projects that are under-construction, based on the Multi-Value Portfolio Analysis of MISO energy and the Minnesota Renewable Energy Integration and Transmission Study (MISO n.d.; MDOC 2014).

CALCULATION OF ENERGY EFFICIENCY COSTS AND SAVINGS

ReEDS does not include energy efficiency as an electricity generation resource and does not include cost assumptions for energy efficiency programs. UCS includes the differing targets for the EEPS programs through exogenous changes to future electricity sales in Illinois in each scenario.

We estimate energy efficiency investments using cost data from implementing energy efficiency programs in Illinois based on recent regulatory filings from ComEd and Ameren, supplemented with data collected by the American Council for an Energy Efficiency Economy (ACEEE) (Molina 2014). The utilities' reported first-year cost of energy efficiency that is expected for the years 2015 to 2017 is $0.204/kWh (in 2013$). We estimate an additional cost of $0.234/kWh (in 2013$) as participants costs, representing the cost of equipment and installation paid by customers when participating in utility energy efficiency programs. This estimate is based on the ratio of utility to participant costs on average across utility programs in the United States (Molina 2014). We further assume that utility programs are not financed (full cost is recovered through rates in the year of implementation) while 50 percent of participant costs are financed at a 5 percent interest rate.

TABLE 2. **Comparison of Assumed Overnight Capital Costs for Electricity Generation Technologies (2011$/kW)**

	UCS 2013					EIA AEO2014			
Technology*	**2010**	**2020**	**2030**	**2040**	**2050**	**2010**	**2020**	**2030**	**2040**
Natural Gas CC	1,036	1,036	1,036	1,036	1,036	1,043	1,036	914	826
Natural Gas-CC-CCS	n/a	3,005	2,724	2,513	2,407	n/a	2,052	1,777	1,559
Natural Gas CT	689	689	689	689	689	688	670	575	515
Coal-Supercritical PC	3,306	3,306	3,306	3,306	3,306	2,988	3,051	2,802	2,562
Coal-IGCC	n/a	4,482	4,482	4,482	4,482	n/a	3,828	3,412	3,067
Coal-PC-CCS	n/a	6,166	5,807	5,548	5,373	n/a	5,272	4,736	4,231
Nuclear	n/a	6,529	6,529	6,529	6,529	n/a	4,905	4,376	3,831
Biomass	4,187	4,187	4,187	4,187	4,187	4,188	3,862	3,492	3,112
Solar PV-Utility	5,215	1,925	1,604	1,283	1,283	3,943	3,334	2,963	2,625
Solar PV-Residential	7,700	2,888	2,406	1,925	1,925	7,636	3,850	2,823	2,823
Solar PV-Commercial	6,417	2,413	2,008	1,604	1,604	6,545	2,951	2,567	2,567
Solar CSP-With Storage	5,493	3,299	2,897	2,496	2,496	n/a	n/a	n/a	n/a
Wind-Onshore	2,280	1,969	1,969	1,969	1,969	2,254	2,301	2,113	1,932
Wind-Offshore	5,309	4,112	3,228	2,968	2,734	6,343	6,330	5,608	4,932

*Abbreviations are as follows: combined cycle (CC), combustion turbine (CT), carbon capture and storage (CCS), pulverized coal (PC), integrated gasification and combined cycle (IGCC), and photovoltaic (PV).

TABLE 3. **Operation and Maintenance (O&M) and Heat Rate Assumptions**

Technology*	Fixed O&M ($/kW-yr)	Variable O&M ($/MWh)	Heat Rate	
			2010	2050
Natural Gas-CC	14.53	3.5	6740	6567
Natural Gas-CC-CCS	32.36	3.3	7525	7493
Natural Gas CT	7.32	13.15	10,300	9500
Coal-Supercritical PC	31.75	4.55	8800	8740
Coal-IGCC	52.32	7.35	8700	7450
Coal-IGCC-CCS	67.68	4.53	12000	9316
Nuclear	94.98	2.18	10452	10452
Biomass	107.56	5.36	13500	13500
Solar PV-Utility	7.61	0.00	n/a	n/a
Solar PV-Residential	10.62	0.00	n/a	n/a
Solar PV-Commercial	8.02	0.00	n/a	n/a
Solar CSP-With Storage	41.30	2.64	n/a	n/a
Wind-Onshore	50.75	0.00	n/a	n/a
Wind-Offshore	132.00	0.00	n/a	n/a

* Abbreviations are as follows: combined cycle (CC), carbon capture and storage (CCS), combustion turbine (CT), pulverized coal (PC), integrated gasification and combined cycle (IGCC), photovoltaic (PV), and concentrating solar plants (CSP).

TABLE 4. **Comparison of Assumed Solar Capacity Factors**

Technology*	UCS 2014	EIA AEO 2014
Solar PV-Utility	17–28%	21–32%
Solar CSP-With Storage	40–65%	n/a

*Abbreviations are as follows: photovoltaic (PV) and concentrating solar plant (CSP).

TABLE 5. **Comparison of Assumed Wind Capacity Factors**

	UCS 2014					EIA AEO2014			
Technology*	**2014**	**2020**	**2030**	**2040**	**2050**	**2010**	**2020**	**2030**	**2040**
Onshore Wind									
Class 3	32%	35%	37%	38%	40%	28%	29%	29%	29%
Class 4	38%	41%	44%	45%	47%	32%	33%	33%	33%
Class 5	44%	47%	49%	51%	53%	39%	39%	39%	39%
Class 6	46%	49%	52%	53%	55%	45%	46%	46%	46%

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