

## Integrated Resource Planning (IRP) Annotated Bibliography

Prepared for USAID Integrated Resource and Resiliency Planning (IRRP) Workshop

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### General Integrated Resource Planning Resources

- a. Rachel Wilson and Bruce Biewald, “Best Practices in Electric Utility Integrated Resource Planning,” Regulatory Assistance Project (June 2013), <http://www.raponline.org/wp-content/uploads/2016/05/rapsynapse-wilsonbiewald-bestpracticesinirp-2013-jun-21.pdf>.
  - Provides examples of state regulations and recent utility plans
  - Key states used as case studies include: Arizona, Colorado, Oregon
- b. Marty Kushler and Dan York, “Utility Initiatives: Integrated Resource Planning,” American Council for an Energy-Efficient Economy (July 2014), <http://aceee.org/policy-brief/utility-initiatives-integrated-resource-planning>.
  - Traditional utility resource planning considers: demand to be met, reliability to be achieved, costs of available options, and applicable government policies and regulations
  - IRP attempts to take the traditional planning approach several steps further. It strives to:
    - Evaluate all options, from both the supply and demand sides
    - Minimize total costs (and not just average rates)
    - Create a flexible plan that allows for uncertainty and permits adjustment in response to changed circumstances.
- c. The Tellus Institute, “Best Practices Guide: Integrated Resource Planning for Electricity,” (2000) [http://pdf.usaid.gov/pdf\\_docs/Pnacq960.pdf](http://pdf.usaid.gov/pdf_docs/Pnacq960.pdf).
  - This guide provides the analytical framework and assessment methodologies needed to promote integrated resource planning in different economic, political, and geographic settings
- d. Trieu Mai et. al., “Resource Planning Model: An Integrated Resource Planning and Dispatch Tool for Regional Electric Systems,” NREL Technical Report (January 2013), <http://www.nrel.gov/docs/fy13osti/56723.pdf>.
  - Introduces a new capacity expansion model, the Resource Planning Model (RPM), with high spatial and temporal resolution that can be used for mid- and long-term scenario planning of regional power systems
- e. Siemens Power Technologies International, “Next Generation Integrated Resource Planning: Beyond Distributed Resource Planning and Grid Modernization,” White Paper (December 2015), [http://www.paceglobal.com/wp-content/uploads/2015/12/Next\\_Generation\\_IRP\\_DIRP\\_WhitePaper.pdf](http://www.paceglobal.com/wp-content/uploads/2015/12/Next_Generation_IRP_DIRP_WhitePaper.pdf).
  - Key Points:
    - Rapid growth of DER and large scale renewable generation creates the need to effectively integrate distribution and transmission planning with integrated resource planning under a single system framework

- Incorporating the distribution system is a significant expansion to the scope of the historic integrated resource plans (IRPs) and presents challenges
- f. James W. Gardner, “Integrated Resource Planning: The Basics and Beyond,” Regional Workshop on Energy Regulation & Regional Coordination: Lower Mekong Initiative, Bangkok, Thailand (October 14-16 2013), <http://pubs.naruc.org/pub/537D1370-2354-D714-51E5-7253869CB747>.
- Example of a presentation for international audiences on the basics of integrated resource planning and the current IRP model
  - New emphasis placed on cybersecurity, environmental and transmission planning concerns to update the IRP model going forward
- g. Antonette D’Sa, “Integrated Resource Planning (IRP) – Part 1: Recent practice for the power sector,” International Energy Initiative – Asian Regional Initiative, presented in Bangalore, India (March 2011), <http://www.iei-asia.org/IEI-IRP-RecentPowerSectorPractice.pdf>.
- Highlights how the IRP process in practice is differentiated between developing countries and industrialized countries
  - Note: only the abstracts are available online. Contact IEI-Asia for the full reports.
  - A report entitled “Part 2: Options for the implementation of an Integrated Resource
  - Planning (IRP) process in the Indian electricity sector” was also published, with the abstract available here: <http://iei-asia.org/IEI-IRP-IndiaOptions.pdf>.
- h. Adam Borison, “Electric Power Resource Planning Under Uncertainty: Critical Review and Best Practices,” Berkeley Research Group (November 2014), [http://www.thinkbrg.com/media/publication/514\\_Borison\\_ResourcePlanningUncertainty\\_WP\\_20140121.pdf](http://www.thinkbrg.com/media/publication/514_Borison_ResourcePlanningUncertainty_WP_20140121.pdf).
- This paper is designed to help address this difficulty by providing a critical review of the major approaches to resource planning under uncertainty and recommendations for best practices
  - At a high level, there are really four major, distinct approaches for incorporating uncertainty in resource planning: (1) scenario planning, (2) sensitivity analysis, (3) probabilistic analysis, and (4) option analysis. Each approach is described in the paper, followed by discussion of best practices for its implementation.
- i. Fredrich Kahrl et al., “The Future of Electricity Resource Planning,” prepared September 2016 by LBNL in partnership with E3, <https://emp.lbl.gov/sites/all/files/lbnl-1006269.pdf>.
- j. Eric Hirst and Charles Goldman, “Creating the Future: Integrated Resource Planning for Electric Utilities,” Annual Review of Energy (1991), available at <https://emp.lbl.gov/publications/creating-future-integrated-resource>.
- This paper reviews progress in the late 1980’s and early 1990’s in the IRP process and identifies the need for additional work. Key IRP issues facing utilities and public utility commissions (PUCs), discussed in this paper, include:
    - Provision of financial incentives to utilities for successful implementation of integrated resource plans, especially acquisition of demand-side management (DSM) resources
    - Incorporation of environmental factors in IRP
    - Bidding for demand and supply resources

- Treatment of DSM programs as capacity and energy resources
  - Development of guidelines for preparation and review of utility resource plans
  - Increased efforts by the US Department of Energy (DOE) to promote IRP
- k. Eric Hirst, Charles Goldman and Mary Ellen Hopkins, “Integrated resource planning - Electric and gas utilities in the USA,” Utilities Policy (1991), available at <https://emp.lbl.gov/publications/integrated-resource-planning-electric>.
- This paper discusses a few of the key issues related to resource planning, especially focusing on development of guidelines for preparation and review of utility integrated resource plans, resource planning for gas utilities
- l. Eric Hirst et. al., “Technical Competence of Integrated Resource Plans Prepared by Electric Utilities,” Resources and Energy (1991), available at <https://emp.lbl.gov/publications/technical-competence-integrated>.
- This paper discusses guidelines for the preparation and review of utility reports on their resource plans, focusing on the technical competence of the underlying analysis
  - Load forecasts, demand-side resources, supply resources, integration of resources, and treatment of uncertainty are discussed
- m. Eric Hirst and Charles Goldman, “Key Issues in Integrated Resource Planning for Electric Utilities,” (February 1990), available at <https://emp.lbl.gov/publications/key-issues-integrated-resource>.
- This paper reviews recent progress in IRP and identifies the need for additional work by utilities, regulatory commissions, and other organizations
- n. Eric Hirst et. al., “Assessing Integrated Resource Plans Prepared by Electric Utilities,” (1990), <https://emp.lbl.gov/publications/assessing-integrated-resource-plans>.
- This paper reviews more than 30 resource plans and related documents from electric utilities and government agencies.
  - Four broad topics are covered in the report (and used to evaluate the IRPs):
    - The clarity with which the contents of the plan, the procedures used to produce it, and the expected outcomes are presented
    - The technical competence (including the computer models and supporting data and analysis) with which the plan was produced
    - The adequacy and detail of the short-term action plan
    - The extent to which the interests of various stakeholders are addressed
- o. Eric Hirst and Charles Goldman, “Review of Demand-Side data needs for Least-Cost Utility Planning,” Energy (1990), available at <https://emp.lbl.gov/publications/review-demand-side-data-needs-least>.
- This study compares the data and assumptions available on supply resources with those available on demand-side resources and discusses: the types of data that are needed to assess existing patterns and trends in electricity use (baseline data), the costs and performance of demand-side technologies, and the effects of demand-side programs

- p. Charles Goldman, Eric Hirst, and Florentine Krause, “Least Cost Planning in the Utility Sector: Progress and Challenges,” (1989), available at <https://emp.lbl.gov/publications/least-cost-planning-utility-sector>.
- This study – commissioned by the DOE –reviews recent progress in least-cost planning throughout the US and identifies the need for additional work in relevant areas

### Introducing Consideration of System Resiliency into Integrated Resource Planning

- q. Maria Scheller and Ananth Chikkatur, “Integrated Resource Planning Models Need Stronger Resiliency Analysis,” ICF (2014), [http://www.ourenergypolicy.org/wp-content/uploads/2014/10/Integrated\\_Resource\\_Planning\\_Models\\_Need\\_Stronger\\_Resiliency\\_Analysis.pdf](http://www.ourenergypolicy.org/wp-content/uploads/2014/10/Integrated_Resource_Planning_Models_Need_Stronger_Resiliency_Analysis.pdf).
- Why integrated resource planning needs to include a better assessment of electricity system resilience
- r. Alliance for Affordable Energy, “An Integrated Resilience Plan for New Orleans City Council,” (August 2016), <http://all4energy.org/wp-content/uploads/2016/08/WEB-AAE-IResP-UD-08-02FINAL.pdf>.
- The case for integrating resilience planning into the traditional IRP process (load forecasting & transmission, the existing resource portfolio, consideration of externalities, energy losses & energy efficiency measures, supply alternatives & LCOE)

### Resources on IRRP components

Many studies and other resources exist to assist utilities or government entities conduct integrates resource planning processes at the local, state, regional or federal level. Technology-specific guides are also included below, which consider the specific challenges and opportunities for including new grid technologies in integrated resource planning.

#### Long-term procurement planning for generation and transmission

- s. Aspen Environmental Group and Energy and Environmental Economics, Inc., “Survey of Utility Resource Planning and Procurement Practices for Application to Long-Term Procurement Planning in California – DRAFT,” Prepared for the California Public Utilities Commission (September 2008).
- t. California Public Utilities Commission, “2010 Long Term Procurement Plan,” 2010, <http://www.cpuc.ca.gov/PUC/energy/Procurement/LTPP/>.
- u. California IDER and DRP Working Groups, “California’s Distribution Resource Plan – DRAFT,” (February 2017), <http://drpwg.org/sample-page/drpf/> for home page listing available studies & comments.

#### Valuing Demand-Side Resources

- v. The Brattle Group, “Electric Utility Integrated Resource Plan (IRP): Demand-side Resources,” presented July 16, 2014, [http://www.brattle.com/system/publications/pdfs/000/005/050/original/Electric\\_Utility\\_Integrated\\_Resource\\_Planning.pdf?1406066063](http://www.brattle.com/system/publications/pdfs/000/005/050/original/Electric_Utility_Integrated_Resource_Planning.pdf?1406066063).
- Presents two methods commonly used by utilities for modeling demand-side resources and energy efficiency
    - Creating supply curves by type of DSM program (i.e. PacifiCorp)

- Adjusting/ reducing load forecasts to account for DSM (i.e. Connecticut IRP)
- Discusses modeling demand response as supply-side and energy efficiency as demand-side
- w. California Governor's Office of Planning and Research, "California Standard Practice Manual: Economic Analysis of Demand-side Programs and Projects," published July 2002, [http://www.calmac.org/events/spm\\_9\\_20\\_02.pdf](http://www.calmac.org/events/spm_9_20_02.pdf).
  - The report outlines four discrete tests used to analyze the value of demand-side management technologies in California, as well as the strengths and weaknesses of adopting each approach
    - The Participant Test
    - The Ratepayer Impact Measure Test
    - The Total Resource Cost Test
    - The Program Administrator Cost Test
- x. Dave Lamont and John Gerhard, "The Treatment of Energy Efficiency in Integrated Resource Plans: A Review of Six State Practices," Regulatory Assistance Project (January 2013), <http://www.raponline.org/wp-content/uploads/2016/05/rap-lamont-gerhard-treatmentofeeinirp-2013-jan-28.pdf>.
  - States evaluated: Oregon, Idaho, Colorado, Ohio, Arkansas and Georgia
  - The paper investigates the interrelationship between a state's treatment of energy efficiency and its IRP process
- y. Kenji Takahashi, "Searching for Best Practices for Modeling Energy Efficiency in Integrated Resource Planning," presentation at ACEEE National Conference on Energy Efficiency as a Resource, <http://www.synapse-energy.com/sites/default/files/Modeling-EE-in-IRP.pdf>.
  - This presentation examines two approaches for modeling energy efficiency in the IRP process
    - As a competitive resource (TVA 2015, PGE, PacifiCorp, NWPCC, Florida IOUs)
    - As a load modifier (TVA 2012, IPL 2014, Duke Indiana 2014, LADWP 2010, Vermont 2010, SWEPCO 2012)
- z. S.A. Parker et. al., "Metering Best Practices: A Guide to Achieving Utility Resource Efficiency, Release 3.0," published by PNNL (March 2015), <https://energy.gov/sites/prod/files/2015/04/f21/mbpg2015.pdf>.

## Resource Assessment

- aa. C. Gross, "Power Generation Technology Data for Integrated Resource Plan of South Africa," Technical Update (August 2015), <http://www.energy.gov.za/IRP/2016/IRP-AnnexureA-EPRI-Report-Power-Generation-Technology-Data-for-IRP-of-SA.pdf>.
  - This technical update provides cost and performance data on renewable resource-based technologies such as wind, solar thermal, solar photovoltaic (PV), and biomass; fossil fuel-based technologies such as pulverized coal (PC), fluidized bed combustion (FBC), integrated coal gasification combined cycle, open cycle gas turbine (GT), combined cycle gas turbine (CCGT), and nuclear technologies
  - An overview of the biogas and underground coal gasification (UCG) process to produce methane and synthesis gas has been provided and Lead-Acid and Sodium Sulfur battery storage technologies have been added to this update to supplement the renewable energy technologies

- This update includes technology enhancements, market factors influence, enhancements to design, and revisions to cost and performance data
- bb. Karin Corfee, Shalom Goffri and Andrea Romano, “Private Generation Long-Term Resource Assessment (2017-2036),” Prepared for PacifiCorp by Navigant (2016),  
[http://www.pacificorp.com/content/dam/pacificorp/doc/Energy\\_Sources/Integrated\\_Resource\\_Plan/2017\\_IRP/PacifiCorp\\_IRP\\_DG\\_Resource\\_Assessment\\_Final.pdf](http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2017_IRP/PacifiCorp_IRP_DG_Resource_Assessment_Final.pdf).
- Uses PacifiCorp territories as case studies to follow up on evaluations of private generation market penetration measures and related methodologies for examining market penetration, technical potential and payback.
- cc. Bruce Tsuchida et. al., “Comparative Generation Costs of Utility-Scale and Residential-Scale PV in Xcel Energy Colorado’s Service Area,” prepared by The Brattle Group for First Solar (2016),  
[http://brattle.com/system/publications/pdfs/000/005/188/original/Comparative\\_Generation\\_Costs\\_of\\_Utility-Scale\\_and\\_Residential-Scale\\_PV\\_in\\_Xcel\\_Energy\\_Colorado's\\_Service\\_Area.pdf](http://brattle.com/system/publications/pdfs/000/005/188/original/Comparative_Generation_Costs_of_Utility-Scale_and_Residential-Scale_PV_in_Xcel_Energy_Colorado's_Service_Area.pdf).
- This report examines the comparative customer-paid costs of generating power from equal amounts of utility- and residential-scale solar PV panels in the Xcel Energy Colorado system
- dd. Entergy, “2012 Generation Technology Assessment,” Generation Technology Cost & Performance Technical Supplement to 2012 ENO IRP, [http://www.energy-neworleans.com/content/IRP/IRP\\_Technology\\_Assessment.pdf](http://www.energy-neworleans.com/content/IRP/IRP_Technology_Assessment.pdf).
- ee. Catalogue of Sections and Supplements for Xcel Energy’s “Upper Midwest 2016-2030 Resource Plan,”  
[https://www.xcelenergy.com/company/rates\\_and\\_regulations/filings/upper\\_midwest\\_2016-2030\\_resource\\_plan](https://www.xcelenergy.com/company/rates_and_regulations/filings/upper_midwest_2016-2030_resource_plan)
- Includes, but not limited to:
    - Updated strategist and modeling outputs
    - Estimated rate impacts
    - DR, Grid Efficiency and DERs as alternatives

### Valuing Transmission & Distribution Resources

- ff. U.S. EPA, “National Action Plan for Energy Efficiency,” Chapter 3: Energy Resource Planning Processes (2006),  
[https://www.epa.gov/sites/production/files/2015-08/documents/napee\\_report.pdf](https://www.epa.gov/sites/production/files/2015-08/documents/napee_report.pdf).
- Including energy efficiency in the resource planning process is essential to realizing its full value and setting resource savings and funding targets accordingly
- gg. Scott Madden, “Best Practices in Integrated Resource Planning,” published September 2015,  
<http://www.scottmadden.com/insight/best-practices-in-integrated-resource-planning/>.
- Three focus areas: least-regret planning, integrating new types of resources, and increasing stakeholder involvement
  - “The IRP process should fully incorporate in the analysis new types of resources like DG, EE, DR, storage, etc. that are testing the traditional utility business model of central station generation”
- hh. The Brattle Group, “Valuation of Electric Power System Services and Technologies,” Prepared for DOE-OE (August 2016),



[http://www.brattle.com/system/publications/pdfs/000/005/389/original/Valuation\\_of\\_Electric\\_Power\\_System\\_Services\\_and\\_Technologies.pdf?1484183040](http://www.brattle.com/system/publications/pdfs/000/005/389/original/Valuation_of_Electric_Power_System_Services_and_Technologies.pdf?1484183040).

- Distributed grid assets often have multiple benefits that are difficult to quantify because of the locational context in which they operate
  - The Electric Power Research Institute (EPRI) recently established a benefit-cost framework that proposes a process for estimating multiple benefits of distributed energy resources (DERs) and the associated cost. This document proposes an extension of this endeavor that offers a generalizable framework for valuation that quantifies the broad set of values for a wide range of technologies (including energy efficiency options, DER, transmission, and generation) as well as policy options that affect all aspects of the entire generation and delivery system of the electricity infrastructure.
- ii. PacifiCorp, “Transmission Benefits Evaluation,” (2012), [http://www.pacificorp.com/content/dam/pacificorp/doc/Energy\\_Sources/Integrated\\_Resource\\_Plan/2013IRP/2013IRP-SystemBenefitsTool-DRAFTWhtppr\\_11-5-12.pdf](http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2013IRP/2013IRP-SystemBenefitsTool-DRAFTWhtppr_11-5-12.pdf).
- Introduces System Operational and Reliability Benefits Tool used to evaluate the value of transmission investments for the IRP process
- jj. Rocky Mountain Institute, “Valuation of Renewable and Distributed Resources: Implications for the Integrated Resource Planning Process,” published 2006 by EPRI, [http://www.rmi.org/Knowledge-Center/Library/2006-09\\_ValuationRenewableDistributedResources](http://www.rmi.org/Knowledge-Center/Library/2006-09_ValuationRenewableDistributedResources).
- kk. ICF, “Integrated Distribution Planning,” prepared August 2016 for the Minnesota Public Utility Commission, <https://energy.gov/sites/prod/files/2016/09/f33/DOE%20MPUC%20Integrated%20Distribution%20Planning%208312016.pdf>

### Load Forecasting

- ll. Electricity Markets and Policy Group (LBNL), “Load Forecasting in Electric Utility Integrated Resource Planning,” published October 2016, <https://emp.lbl.gov/publications/load-forecasting-electric-utility>.
- This paper evaluates load forecasting methods, assumptions, and outcomes for 12 Western U.S. utilities by examining and comparing plans filed in the early 2000s against recent plans, up to year 2014
  - Researchers compared planned and procured resource expansion against customer load and year-to-year load growth rates, but do not find a direct relationship
  - Key findings:
    - load forecast accuracy may not be as important for resource procurement as is generally believed
    - load forecast sensitivities could be used to improve the procurement process
    - management of load uncertainty should be prioritized over more complex forecasting techniques
- mm. ISO New England, “Forecast Model Structures of the ISO New England Long-Run Energy and Seasonal Peak Load Forecasts,” published June 2016 for the 2016 CELT report, [https://www.iso-ne.com/static-assets/documents/2016/06/forecast\\_model\\_structures\\_2016.pdf](https://www.iso-ne.com/static-assets/documents/2016/06/forecast_model_structures_2016.pdf).
- Includes peak load and energy forecast modeling procedures used by ISO-NE, current to 2016

- Key topics covered include: observations regarding historical and projected energy consumption, seasonal peak load forecast distributions, and evaluation and testing of the forecasting methodology

nn. Justine Sears and Karen Glitman, “Review of Utility Integrated Resource Plans and Electric Vehicle Load Forecasting,” National Association of State Energy Officials (NASEO) and Vermont Energy Investment Corporation (VEIC) (September 2013), <https://www.naseo.org/data/sites/1/documents/publications/NASEO-Review-of-Utility-Integrated-Resource-Plans-and-Electric-Vehicle-Load-Forecasting.pdf>.

- Integrated Resource Plans (IRPs) or similar long-term plans from utilities across the U.S. were reviewed to investigate their inclusion of EVs in load forecasts
- Coordination with public agencies (mainly state Departments of Transportation, State Energy Offices, and State and Municipal Public Utilities Commissions) will facilitate optimal deployment of EVs

## Examples of IRPs

oo. Tennessee Valley Authority, “Integrated Resource Plan,” 2015 Final Report, [https://www.tva.gov/file\\_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/IRP/Documents/2015\\_irp.pdf](https://www.tva.gov/file_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/IRP/Documents/2015_irp.pdf).

- The IRP discusses ways that TVA can meet future electricity demand economically while supporting TVA’s equally important mandates for environmental stewardship and economic development across the Valley.
- As in the 2011 version, this report indicates that a diverse portfolio is still the best way to deliver low-cost, reliable electricity to those we serve.
- Public engagement outlined here: [https://www.tva.com/file\\_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/Environmental%20Reviews/IRP/2015\\_irp\\_record\\_of\\_decision.pdf](https://www.tva.com/file_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/Environmental%20Reviews/IRP/2015_irp_record_of_decision.pdf)

pp. Dominion, “Dominion Virginia Power's and Dominion North Carolina Power's Report of Its Integrated Resource Plan,” Before the Virginia State Corporation Commission and North Carolina Utilities Commission (Filed April 29, 2016), <https://www.dom.com/library/domcom/pdfs/corporate/2016-irp.pdf?la=en>.

- Includes as part of load forecasting section an in-depth discussion of rate design, including both residential and non-residential rate design analysis
- Demand-side resources section includes evaluation both of DSM tariffs and DSM programs (including approved and proposed)
- Comprehensive Risk Analysis considers portfolio risk assessment, operating cost risk assessments, among other factors
- Dominion hosts periodic stakeholder meetings, including in VA in 2010. Additional stakeholder feedback was to be sought following the release of the 2016 IRP.

qq. PacifiCorp, 2015 IRP and 2015 IRP Update, available at <http://www.pacificorp.com/es/irp.html>.

- PacifiCorp operates across six states—Oregon, Washington, California, Idaho, Utah, and Wyoming, five of which have IRP or other long-term planning requirements. Wyoming requires that an IRP produced for other jurisdictions by an entity serving the state also be filed with its PSC. PacifiCorp therefore plans





on a system-wide basis while also ensuring it meets each of the resource acquisition mandates and policies in the states where it operates.

[End]