IRENA
International Renewable Energy Agency

INSIGHTS ON PLANNING FOR POWER SYSTEM REGULATORS

International Renewable Energy Agency

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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. **www.irena.org**

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DISCLAIMER

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FIGURES AND BOXES

"Plans are worthless, but planning is everything"

U.S. President DWIGHT D. EISENHOWER, 1957

ABBREVIATIONS

ACER	Agency for the Cooperation of Energy Regulators (EU)
AfDB	African Development Bank
ANEEL	Agência Nacional de Energia Elétrica / National Electric Energy Agency (Brazil)
CCEE	Electric Energy Commercialisation Chamber (Brazil)
EC	European Commission
EGAT	Electricity Generating Authority of Thailand
ENTSO-E	European Network of Transmission System Operators for Electricity
EPE	Empresa de Pesquisa Energética/Energy Research Office (Brazil)
Eskom	Electricity Supply Commission (South Africa)
EU	European Union
FERC	Federal Energy Regulatory Commission (US)
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
IRP	Integrated Resource Planning or Integrated Resource Plan
ISO	Independent System Operator
ISO-NE	Independent System Operator of New England (US)
MOU	Memorandum of Understanding
NERC	North American Electric Reliability Corporation
NERSA	National Energy Regulator of South Africa
NPCC	Northeast Power Coordinating Council
NWPCC	Northwest Power and Conservation Council (US)
PPA	Power Purchase Agreement
PREC	Puerto Rico Energy Commission
PREPA	Puerto Rico Electric Power Authority (Puerto Rico)
PV	Photovoltaic(s) or photovoltaic generation of electricity
PVRR	(Net) Present Value of Revenue Requirements
REDZ	Renewable Energy Development Zone
REZ	Renewable Energy Zone
RFI	Request for Information
RFP	Request for Proposals
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SCADA	Supervisory Control and Data Acquisition
TSO	Transmission System Operator
TVA	Tennessee Valley Authority
UMTDI	Upper Midwest Transmission Development Initiative (US)

EXECUTIVE SUMMARY

The share of world electricity production taken by renewable power generation is expected to grow significantly by 2030, rising from today's share of 23% to levels between 30% and 45% (IRENA, 2016a). This technological change requires a recalibration in the way power systems are planned, in order to maximise the role of renewables in an affordable and secure manner.

Ongoing work by the International Renewable Energy Agency (IRENA) looks at the application of long-term modelling and planning tools in various jurisdictions.

A previous report (IRENA, 2017) examined long-term modelling and tools to expand variable renewable power in emerging economies. The present report complements that earlier work. It considers proven processes and regulatory practices for long-term power system planning, drawing primarily on experiences with integrated resource planning (IRP) from South Africa and regulated markets in the United States. Based on insights from those regulated markets, the study aims to guide power system planning processes and regulatory actions, with particular consideration given to ramping up solar and wind power, over the next few years.

Ultimately, this report has two main aims:

- To identify useful regulatory practices in an era of rapidly improving renewable energy technologies, drawing insights primarily from US and South African IRP processes.
- To encourage more effective power system planning in areas of both single and multiple jurisdiction.

IRP stands out as a valuable planning approach because of its essential premise: consideration of electricity needs and system development from multiple angles. In principle, such plans set out to provide a comprehensive and technology-neutral assessment of both supply- and demand-side resources. IRP may take account of the environmental and social impacts of different resource options. This comprehensive approach may also be useful in appreciating the implications of scaling up variable renewables (*i.e.,* solar and wind energy) in future electricity systems.

Box 1 **What is IRP?**

There is no universally agreed definition of integrated resource planning (IRP). The term may be used and understood differently in different markets. For the purposes of this report, we follow the definition commonly used in jurisdictions in the United States, which defines IRP as a planning mechanism incorporating supply- and demand-side resources in a technology-neutral manner to identify least-cost futures under a given set of constraints. In other markets around the world, different planning mechanisms are applied, and these mechanisms can incorporate considerably different sets of resources. Furthermore, similarly structured planning mechanisms may go by different names in some markets, while similar terminology can be used for considerably different mechanisms in other markets. Some of the insights drawn from US and South African IRP experiences may, nevertheless, be more widely applicable.

The process and many of the methodologies behind IRP are common to other planning mechanisms adopted elsewhere. The best practices derived from the IRP process can offer valuable insights and lessons to a broad range of planning practitioners. While the term "IRP" reflects the experience of certain markets, this report aims to support power system planning in a broader sense. The hope is to facilitate successful investment and procurement in any market experiencing comparable challenges in the creation of sustainable, future power systems.

The key elements for IRP – along with other planning mechanisms involving government decision-making – are outlined in Figure 1. This report discusses some of the key elements in greater detail.

While the core tenets of power system planning can remain intact, certain planning practices require thorough updates to accommodate renewable energy technologies, including variable renewables. Neglecting such aspects of planning might not only result in misrepresentation of renewables, but could ultimately hold back the performance of the power sector.

The IRP process can be resource-intensive and time-consuming. Yet it enables planners and decision makers to satisfy long-term power demands in the most acceptable manner, with the most affordable, risk-balanced resource portfolio, adjusted as needed to confirm with broader policy objectives.

Planners can employ the basic IRP framework, while tailoring the level of sophistication and rigour used in each step of the planning process to the capabilities and resources available. Effectively managed IRP processes address uncertainties regarding project selection and build stakeholder consensus. IRP processes can therefore facilitate financing, as these processes can provide stakeholders with confidence. They can also reduce investment processing time and allow for faster and more effective project evaluation and appraisal procedures by the government. If correctly implemented, IRP processes can accelerate energy service delivery at the lowest cost to consumers.

Meanwhile, as the nature of planning efforts and of the industry changes, the role of regulators is also evolving. The figure below summarises key enabling framework requirements and roles for

Figure 1 Key elements of IRP

Planners can employ the basic IRP framework while tailoring each step to the resources available

regulators, including ways to ensure sufficient empowerment of regulatory functions, as well as the provision of effective regulatory oversight.

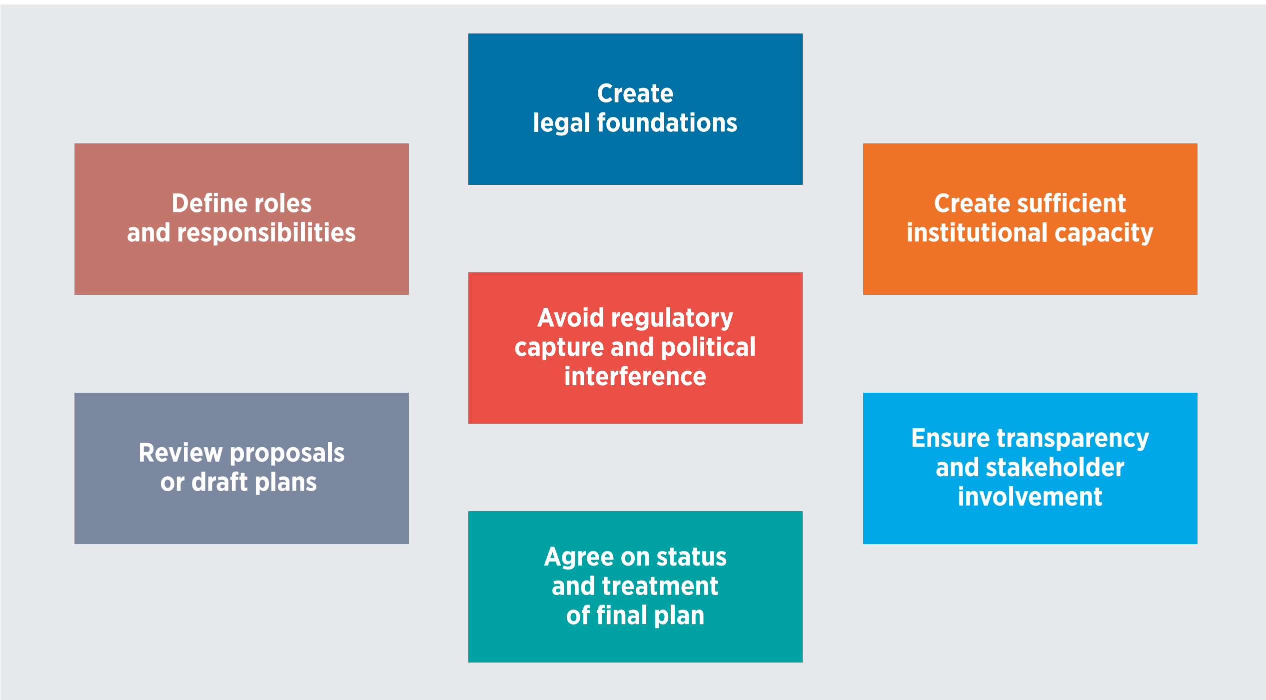
In regional groupings like the Southern African Development Community (SADC), the planning process involves co-ordination between multiple jurisdictions, each of which have sovereign rights over planning and implementation. Regulators play a different role in the regional context than they normally would in single jurisdictions. Specifically, differences arise over the roles and responsibilities – as well as the legal authority – given to regional regulatory bodies, which can sometimes limit the extent of regulatory involvement at a regional level. Special consideration needs to be given to the importance of cost allocation in regional efforts.

FROM PLANNING TO IMPLEMENTATION

A variety of mechanisms and approaches can reinforce the link between planning and actual implementation. These include:

- ensuring well-established linkages between the involved institutions
- using functioning investment facilitation mechanisms to achieve planned outcomes
- ensuring transparent and inclusive consultation with relevant stakeholders
- establishing regulatory linkages between power system plans, the subsequent individual component projects that represent the accurate implementation of those plans, and cost recovery of those investments through electricity rates and tariffs
- linking long-term plans to "action plans", which describe the specific steps required for implementation over time.

Figure 2 Key actions to empower regulators



INTRODUCTION 1

This report identifies proven practices in power system planning, highlights key planning elements, and discusses useful practices in achieving each aspect of this planning. Primarily, the report draws lessons from experiences with Integrated Resource Planning (IRP) within a regulated market context, as well as from regional planning approaches over multiple jurisdictions. These insights are drawn largely from experience in parts of North America, as well as in South Africa, where vertically integrated utilities have carried out sophisticated IRP development. In practice, their applicability in different markets may vary depending on the needs, capabilities and resources of whoever is doing the planning.

As used here, the term "planning practices" encompasses both broad planning frameworks and key planning elements. The analysis considers planning practices that apply at the level of a single jurisdiction, as well as those that are useful for regional (*i.e.,* multi-jurisdictional) planning. Special attention is given to the key changes in planning practices that can ensure better representation of renewable energy, including variable renewable power technologies based on wind and solar energy.

The resulting experiences shed light on the roles of governments and regulators in administrating planning processes – roles which can influence long-term resource procurement, such as volume, type and timing of investment into power generation technologies. They can also ensure a degree of risk allocation away from resource developers or owners. In this context, the role of utilities is often to execute the development of plans based on IRP along the lines of pre-determined processes, required planning elements and policy constraints, while following legally binding rules and regulations.

While this report discusses the role of government in the process of developing and implementing an IRP, the process discussed here is distinguished from other government-led planning processes exercised more often in an open-market context. In such a context, where government planning offices develop energy and/or power sector investment outlooks (sometimes referred to as energy/power sector master plans), such outlooks are often used to guide the development of energy policies and give indicative direction as to where investments should be made. The methodologies used in both planning processes are largely common. These include a focus on the use of quantitative modelling tools to develop a least-cost configuration of energy or power systems that is compatible with certain policy goals.

IRP stands out because of its integrated, comprehensive and technology-neutral assessment of both supply- and demand-side resources. Whilst this report draws on the experience of IRP in a particular context, many of the planning practices described can also potentially assist in jurisdictions which apply different planning mechanisms (in, for example, jurisdictions which do not host vertically integrated utilities).

The research and background for this report was obtained through a combination of expert interviews, online research into current power system planning practices in various regions, and the personal experiences of the authors.

The authors worked with several experts (listed in the Appendix) who have been involved with power system planning and finance efforts in one or more jurisdictions. These experts provided and shared their experiences working in jurisdictions that are recognised leaders in power system planning. The experts also shared their knowledge of some of the common challenges that are associated with jurisdictions still in early stages of power system planning.

The remainder of this chapter introduces the topic, identifies key concepts, and clarifies the objectives of this report.

Chapter 2 provides a brief introduction to planning processes and why and where they matter. Chapter 3 offers a summary of best practices for regulatory oversight. Chapter 4 provides a description of IRP commonly practiced at the state or country-level. Chapter 5 focuses on the challenges and best practices for the implementation of plans, while Chapter 6 addresses regional planning – instances where the planning process involves co-ordination between multiple jurisdictions, each of which has sovereign rights over planning and implementation. Finally, Chapter 7 describes the opportunities and requirements for planning practices to evolve in a way that ensures the faster adoption of renewables.

1.1 BACKGROUND AND CONTEXT

This report was developed as part of the Regional Action Agendas put forward by the International Renewable Energy Agency (IRENA). These call for country and regional planning to consider: cost-effective renewable power options; enabling frameworks for investment; cost reduction of renewable power financing; and capacity building to develop the skills required to build, plan, operate, maintain and regulate power grids and markets with high shares of renewable electricity.

"Open" (or liberalised) markets have progressively gained credibility, yet still accounted for only 6% of global investment in power-generation infrastructure in 2016 (IEA, 2017).[1] In contrast, regulated markets – those which facilitate resource investment with a degree of governmental involvement – remain dominant on the global level.

This report identifies proven practices in power system planning from key markets, notably regulated markets in South Africa and the United States, that may provide useful insights elsewhere. The report provides a foundation for research and analytics on power system planning in specific jurisdictions.

Reviews of planning practices in southern Africa have been undertaken in parallel to developing this report, specifically for the Southern African Power Pool (SAPP) and for planning practices in Namibia and Zimbabwe.

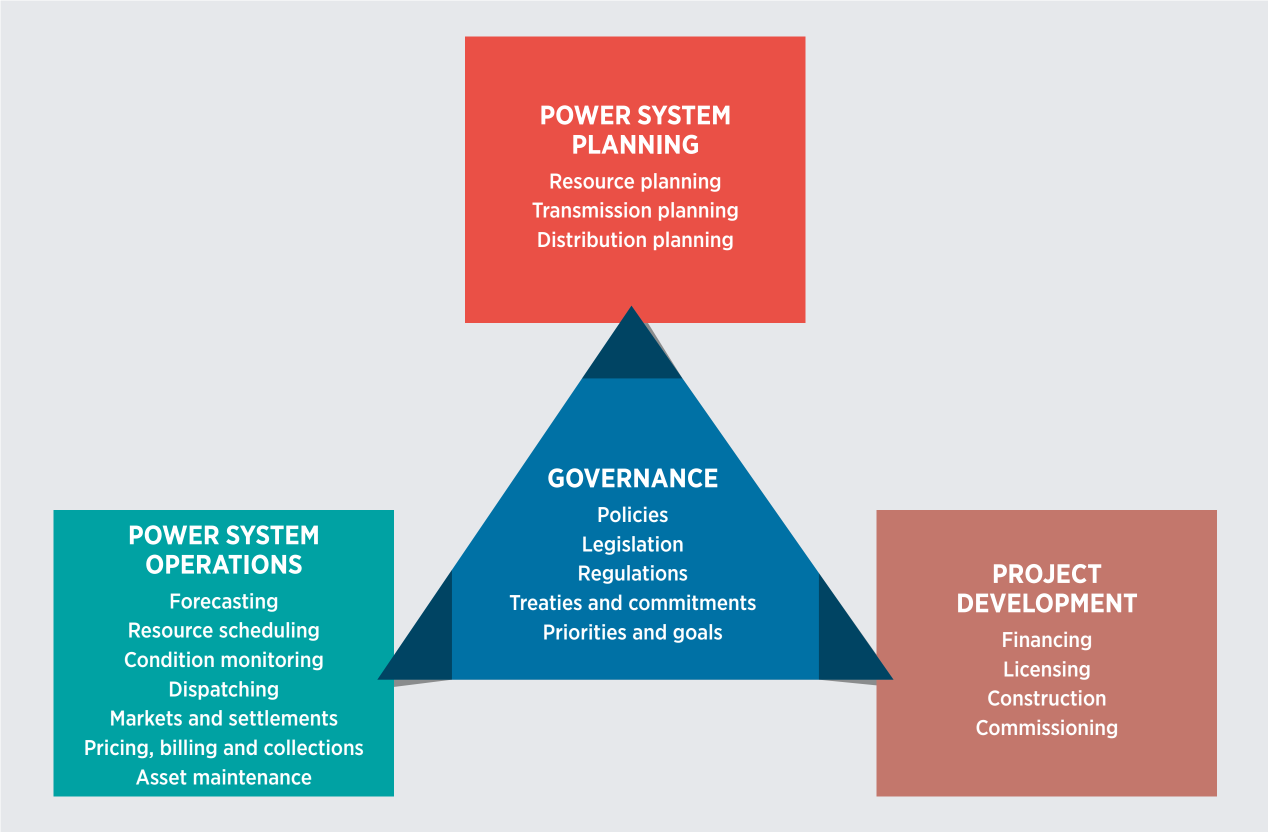
While power system planning practices are often central to least-cost resource development – and are the focus of this report – these practices are often just one part of a broader framework for the provision of sustainable and reliable electricity services at low costs, as shown below. This broader framework revolves around public policies and includes not just planning activities, but also project development and system operations.

This report complements IRENA's technical work focused on the application of long-term models and tools in various jurisdictions. IRENA (2017) provides: an overview of the four main stages of planning;[2] the main issues and concerns related to long-term planning and large-scale integration of variable renewables into the power grid; and the models and modelling tools utilized to support the expansion of variable renewable power. In describing planning practices, this work also establishes linkages to topics relevant to planning. These are covered in further IRENA publications, such as reports on: target-setting (IRENA, 2015b); auctions (IRENA and CEM, 2015); the water-food nexus (IRENA, 2015a); socio-economic benefits (IRENA, 2014); and costing (IRENA, 2016b).

1 Open markets currently include parts of Europe, North and South America and sub-Saharan Africa, as well as Australia and New Zealand. Competition among market participants is meant to optimise investment choices.

2 The referenced stages are: generation expansion planning, geo-spatial transmission planning, dispatch simulation and technical network studies.

Figure 3 Key elements to enable power system development and use



1.2 OBJECTIVES

There are two main objectives for this report:

- To identify useful regulatory practices in an era of rapidly improving renewable energy technologies, drawing insights primarily from South African and US IRP processes.
- To encourage more effective power system planning in areas of both single and multiple jurisdiction.

If incorporated into real-life planning practices, these objectives will strengthen the role and impact of long-term electricity plans in providing reliable, affordable and more sustainable electricity services. The resulting emergence of accurate, reliable and transparent plans, embedded into enabling frameworks, will unlock more timely and efficient investment – including investment in renewable energy technologies.

1.3 KEY CONCEPTS AND TERMS

Several key terms need to be defined at the outset. In particular, a clear distinction has to be drawn between the functional scope and the geographic or jurisdictional scope of different planning mechanisms.

"IRP" refers to a planning mechanism in which the costs and benefits of both demand- and supply-side resources are evaluated to develop the lowest total cost-mix of resource options under a given set of technical, economic, and environmental constraints.

"Resource" refers to any asset or programme that is used to satisfy customer demand for electricity services. This includes both supply-side resources (*i.e.,* the physical machinery and assets that generate electricity) and demand-side resources (*i.e.,* distributed generation and programmes or equipment that control or modify load – for example, through energy efficiency or demand response). Electricity storage may be considered either a supply-side or a demand-side resource, depending on how it is deployed.

Although the definition of "resource" also includes demand-side resources, only the IRPs typically consider the cost-effective demand-side options, including energy efficiency, distributed generation, demand-side management and storage. IRPs may also include consideration of environmental and social impacts of different resource options. Transmission and distribution planning is typically outside the scope of IRPs. IRP processes are commonly used to facilitate investment in vertically integrated markets. In other market setups, a similar planning process is adopted to guide long-term investment, often in the broader context of policy making (*i.e.,* what are often referred to as "master plans", "power development plans", or "generation expansion plans").

"Transmission planning" is another area of power system planning. It usually focuses exclusively on identifying the transmission assets needed to deliver electricity from anticipated future generation to anticipated future load, reliably and at least cost. On rare occasions, a non-transmission alternative means of serving load may be considered as part of a transmission planning process.

"Jurisdiction" refers to the political or territorial boundaries over which a public policy applies, or over which a governmental or regulatory entity has authority.

"Region" refers to a given geographical area encompassing more than one jurisdiction.

Because of the global scope of this report, and the great variety of political systems that exist, these terms must always be read in context. In some parts of the world, public policies affecting the power sector are made solely by national governments, while in other places a combination of policies enacted by regional, national and sub-national jurisdictions (state or local government) may apply.

This means that when we talk about regional planning, in some parts of the world, a "region" may consist of multiple sovereign nations (*e.g.,* within the SAPP, where electricity policies are developed at the national level), while in other parts of the world, it may consist of multiple sub-national jurisdictions (*e.g.,* within the United States, where electricity policies are adopted by both the federal government and by state governments). This does not imply that a US state is comparable to a sovereign nation in southern Africa, but simply indicates that "regional" planning describes plans encompassing more than one political jurisdiction that has policy-making authority over the power sector.

A more complete list of terms is provided in the glossary towards the back of this report.

1.4 METHODOLOGY

This report describes key principles and examples of good practices related to power system planning frameworks, including elements for developing and implementing IRPs and regulatory oversight. Useful practices were identified through research involving literature review, expert interviews, and the personal experiences of the authors. Rather than providing a lengthy catalogue of every option practiced somewhere in the world, the report relies heavily on illustrative case studies from regions and jurisdictions that have demonstrated the effectiveness of specific planning practices: the New England and Pacific Northwest regions of the United States, South Africa, and also, for regional planning, the European Union (EU).[3]

3 Appendix 3 of IRENA (2017) identifies dozens of nations that have developed some form of energy or electricity master plan, some of which could be considered IRPs.

OVERVIEW OF PLANNING PROCESSES 2

There is an old saying that "failing to plan" is the same as "planning to fail". Indeed, today's emphasis on power system planning can be seen at least in part as a response to the costly mistakes that have arisen from unplanned or poorly planned power sector development. For example, in the United States, simplistic (and ultimately, erroneous) assumptions about rapid load growth in the 1970s and 1980s led to about USD 100 billion of investment in generation projects that were never completed. More recently, in the northwestern part of China, wind turbines were installed more rapidly than the transmission needed to deliver their electricity to more populous areas of that country. This led to extremely high rates of forced curtailment in some cases, along with an undermining of the value of those investments.

2.1 THE BENEFITS OF PLANNING

Effective planning processes and effective regulatory oversight are the essential elements of successful power system planning and a key prerequisite for attracting timely and efficient investment.

The potential benefits of effective power system planning and effective regulatory oversight are thus numerous. A good power system plan will identify current and future needs for electricity service, and steer investment toward the most cost-effective resource options. Effectively managed planning processes address uncertainties regarding project selection and build stakeholder consensus. Resources included in an approved plan may be viewed as less financially risky by multi-lateral banks or other lenders, which can potentially translate into faster appraisals or lower costs. Large projects that require a long lead time to develop can also be planned and executed before an anticipated need becomes critical. These actions can help to establish stability in the power sector policy direction, expand affordable electricity services to more customers, promote more reliable services, address environmental concerns, support broader economic development goals, depoliticise system development decisions and further promote stakeholder consensus.[4]

The objective of power system planning is to provide the lowest cost and most robust resource portfolio over a variety of possible futures. How one defines "costs", however, varies considerably from jurisdiction to jurisdiction, as it relates to certain resource types (especially energy efficiency). Costs are often defined as traditional utility "system" costs (poles, wires and generation owned or purchased by the utility). Planning efforts that include the impact on other resources, however, or centre on customer-side resources such as energy efficiency, will often include total resource costs (which combine system costs and customer costs, along with water and other resource categories), and/or societal costs (typically total resource costs plus environmental considerations).

Increasingly, environmental costs and opportunities to develop cleaner resources also figure prominently in planning efforts. Public policy priorities, such as renewable energy targets, can be viewed as complements to other environmental targets (*e.g.* reduced local air pollution; reduced water stress)

4 The benefits of planning and the current planning gaps in the African context were discussed at an IRENA workshop, "Planning renewable energy strategies: Africa power sector", in January 2015.

and constraints on the planning process.[5] In recent periods, planning processes have been amended in many ways to more accurately account for the growing role of renewable-based generation and distributed resources in power systems (see Chapter 7 for a summary).

2.2 PROCESSES FOR INTEGRATED RESOURCE PLANNING

Resource planning, as the term is used in this report, refers to the development of plans for ensuring that adequate generation resources will be available to meet long-term power needs.

Traditional generation expansion plans look at just one side of this equation: the development or acquisition of "supply-side" generation resources to meet anticipated customer demand. IRPs differ from traditional generation expansion plans in that they give equal consideration to "demand-side" solutions which modify future load requirements and reduce the need to acquire generation resources. The inclusion of demand-side resources in the planning process allows planners to appropriately consider less expensive options (which may be partially or entirely beyond the control of the electric utility), before assuming that a larger generation resource is needed. These options may include distributed generation, energy efficiency, demand response programmes, and electricity storage. In areas that do not yet have universal electricity service, the costs and benefits of expanding the network can also be compared to the costs and benefits of microgrids, mini-grids, or off-grid solutions.

Planners in many parts of the world have been using IRP for years, even decades.[6] As shown in Figure 4, nearly 30 states in the United States now require some or all their electricity utilities to file IRPs with regulatory agencies.[7]

IRP can be resource-intensive, time-consuming, and require specialised expertise in economics, power system modelling and other disciplines. The IRP planning mechanism, however, enables planners and decision makers to satisfy long-term power demands with the most affordable resource portfolio, while satisfying all legal requirements and public policy objectives, with due consideration of risks and uncertainties. The rigour imposed by IRP can also help to avoid very costly mistakes. Although challenging, IRP can thus be a valuable tool in virtually any jurisdiction. It is also possible for planners to employ the basic IRP framework while tailoring the level of sophistication and rigour used in each element of the planning process to the capabilities and resources available.

Over time, IRP has evolved in the following ways:

- **Scenario planning**: In the past, IRP typically centred on a likely future (the forecast) and simple variations on the forecast (high- and low-load projections, for example). Now, the list of important drivers of least-cost resource selection is large and there is a growing list of associated material uncertainties. Uncertainties are not well embedded in historical data for which trend or traditional econometric techniques are effective. The preferred plan is increasingly not a plan that is optimal for a single forecast, or under a short list of likely futures, but rather represents a plan that performs well against a long list of risks and uncertainties.

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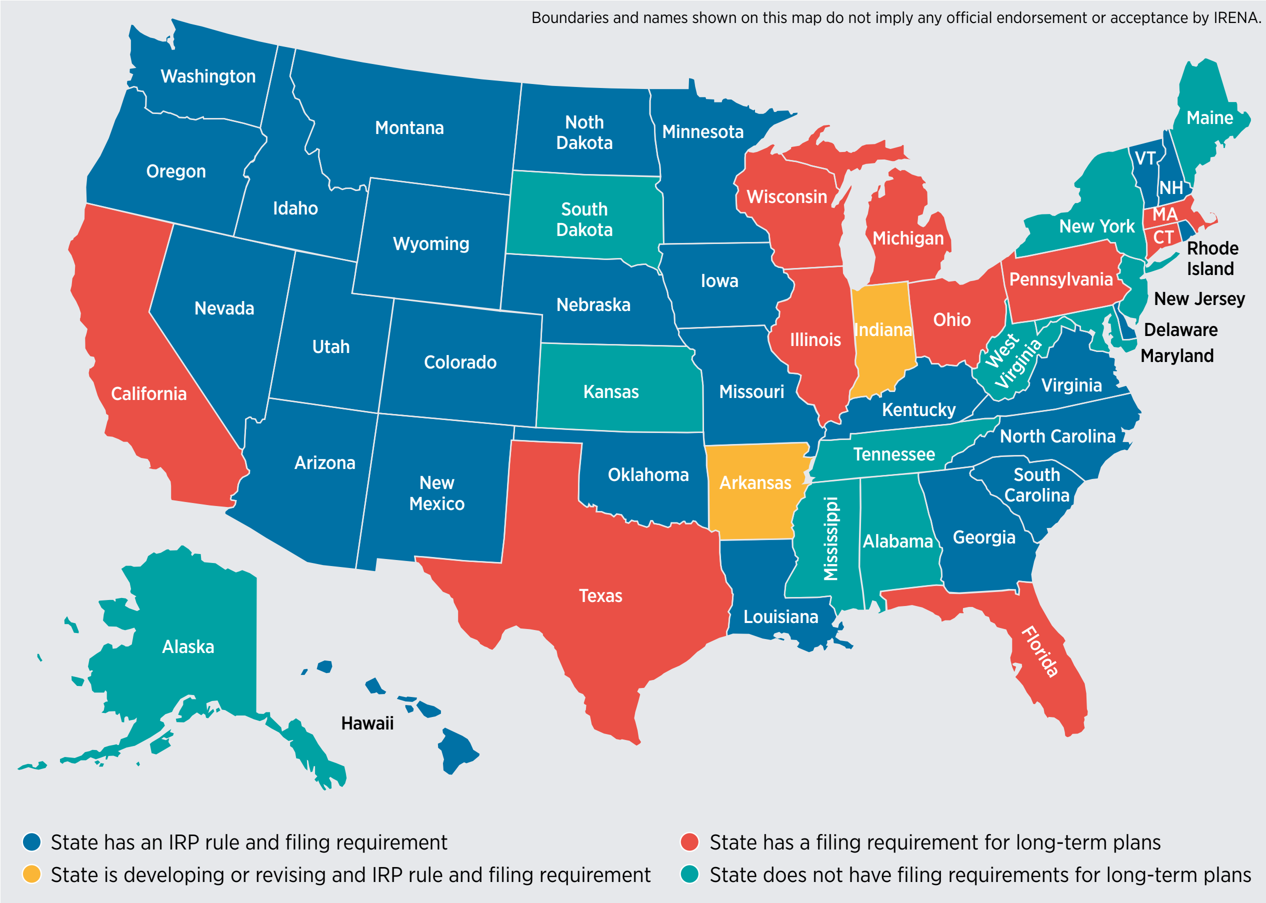
5 Although the word "constraint" has a negative connotation, the term is routinely used by planners to describe any condition that the plan must satisfy in order to be acceptable. For example, a modelling constraint might specify that the percentage of electricity generated by renewables in a particular jurisdiction must equal or exceed some percentage of total consumption in that jurisdiction in a given future year. Other constraints might specify that greenhouse gas emissions may not exceed a specified amount in a given future year, or that a minimum percentage of electricity consumed in a jurisdiction must be generated within that jurisdiction. These types of policy constraints, which are offered merely as examples of the many possible types of constraints, can be used to introduce policy objectives into the planning process.

6 As mentioned above, usage and understanding of the term "IRP" may differ between jurisdictions. Even so, any process that seeks to find the least-cost combination of supply-side and demand-side resources to meet future demand can provide useful insights, regardless of whether it is called "IRP", "energy master planning", "power development planning", or by some other name.

7 California has recently reinstituted an IRP filing requirement after discarding such a policy more than a decade ago in favour of separate (i.e., non-integrated) target-setting and procurement processes for utility-scale renewables, distributed renewables, energy efficiency, storage, and demand response resources. Stakeholders across the state convinced policy makers that the disjointed approach was confusing and made it impossible to know if utilities were obtaining a least-cost portfolio of resources. There was uncertainty, for example, about how much of the state's renewable energy goals should be met by utility-scale renewables and how much by distributed renewables.

Figure 4 States across the US with IRP or similar processes



Source: Wilson and Biewald (2013)

- **Stakeholder engagement**: The IRPs of the past relied on the interplay between the technical knowledge of central planners and the capacity of the regulator, or an appointed public advocate, to bring to bear effective challenges. This would be done either during the review of the plan, or during the review of projects that emanated from or were omitted from the most recent plan. Even as complex as that world was, it is a mere shadow of what has since emerged, with many categories of resources and providers, along with technical options and solutions that include customers themselves. Effective utilization of stakeholders' knowledge is now essential to the development of effective resource plans.

- **Regulatory review**: Where in the past the regulator may have played an important and central role in providing the critical review of plans and resources to ensure that the plan met legal and regulatory criteria, the role of the regulator today is shifting toward that of a convener who manages a process aimed at ensuring plans are well-formed. Ultimately, transparency in process and decision-making are keys to effective planning, along with buy-in from affected stakeholders, the public, and civil society.

The status of a final IRP varies greatly from jurisdiction to jurisdiction. In the United States, some regulators merely "acknowledge" the IRP documents developed by utilities as meeting the minimum procedural requirements, while others formally "approve" the IRP. Outside the United States, IRPs developed by utility planners may not be considered final until they are approved by the cabinet or parliament – which sometimes prevents formal adoption and implementation of what is otherwise a complete plan. Often an IRP includes an "action plan" for the more immediate future (often five years), and sometimes the action plan is subject to greater regulatory scrutiny or approval before the project breaks ground, or significant financial commitments are made.

In many jurisdictions, transmission planning and resource planning are done separately from each other. This is the case throughout Europe and the United States, as well as in South Africa. The reasons are manifold: unbundling of the generation, transmission, and distribution functions of the power sector; liberalisation and decentralisation of electricity markets; market-based generation planning; and others.

The key challenge arising in such circumstances is the co-ordination between transmission and generation. In these arrangements, transmission is usually considered to enable generation.

2.3 RELEVANCE OF INTEGRATED RESOURCE PLANNING WITH DIFFERENT MARKET STRUCTURES

Investment in electricity infrastructure can be facilitated through two main market mechanisms, with these differing in the roles and the allocation of risks amongst market participants. Investment into generation infrastructure is either facilitated through an open market environment, or through a regulated market environment. This first allows competitive decision making without direct

Box 2 Examples of IRP in different jurisdictions

New England (US)

New England is a six-state region in the northeastern United States, operating under distinct market conditions. The region has a rich mix of federal and state oversight of planning processes. The states of New England were among the early adopters of IRP, while most (but not all) later embraced retail competition in energy services.

The Pacific Northwest (US)

The Pacific Northwest is served by the Northwest Power and Conservation Council (NWPCC, or "the Council"). The NWPCC was probably the first entity globally to embrace IRP and continues to provide one of the most robust examples of power system planning around the globe. The examples provided in this report feature an ambitious plan for energy efficiency and demand response amidst a system that is already low-cost and predominantly hydro-based.

Puerto Rico (US)

The Puerto Rico experience is of interest for this report because Puerto Rico has embraced the concepts and principles of IRP, but is in the early stages of implementation. The state is an island, and so relies on the Puerto Rico government for power sector oversight of both transmission and resource planning. The Puerto Rico experience is interesting for many reasons, among them is that the utility itself is government owned (though the governor proposed privatisation in early 2018) and the sector has been slow to embrace new technology or liberalise. The government recognises that the sector is performing poorly. The utility, the Puerto Rico Electric Power Authority (PREPA), was self-regulated until 2014. The regulatory body created in 2014, the Puerto Rico Energy Commission, embraced the challenge of accelerating sector reforms. The IRP process was one of the package of instruments used for affecting the reform.

South Africa

South Africa is relatively new to IRP and is quite distinct from the others in that the government (specifically, the Department of Energy) acts as custodian of the IRP, but delegates the task to a planning team at the electricity company, the Electricity Supply Commission (Eskom). South Africa provides a good example of use of IRP to make steady progress in the deployment of renewables, while also addressing a problem with chronic and severe power shortages. Establishment of an Independent Power Producers Procurement Programme Office is a valuable enabling feature of implementation relative to renewables.

governmental contribution, while in the second, the government contribution can define volume, type, price, and/or timing of infrastructure investment.

Open markets deliver investment into generation infrastructure in parts of Europe, North and South America and sub-Saharan Africa, as well as Australia and New Zealand. In such a context, the role of government in long-term infrastructure development relates to setting clear objectives, policies and regulations, often informed by master plans, outlooks and other planning mechanisms. This reduced role of government in open markets explains why IRP may be of a more limited scope for governments in the abovementioned countries and regions. Planning remains important in both market structures, however. Meanwhile, despite the widespread adoption of open markets, in 2016, the IEA (IEA, 2017) found only 6% of total investment into generation infrastructure worldwide being facilitated through an open market environment.

In regulated market environments, under government influence, a certain degree of investment risk is shifted away from the investors and allocated to, and often socialised among, rate and/or tax payers (consumers). Arising from this re-allocation of risks towards consumers, there is a need for accurate government decision making to minimise consumer's risks. Successful planning is a key measure for this type of risk reduction and in achieving the desired outcomes and objectives.

Box 3 **Approaches to infrastructure expansion: Regulated resource investment and competitive wholesale markets**

Back in the 1980s, Chile was the first country in the world to restructure and deregulate some segments of its national electric power industry. The basic idea was to "unbundle" the generation, transmission, distribution, and retail supply of electricity. Generation investment and use (through wholesale market competition) and retail supply (retail competition) would be exposed to competitive market forces, at least partially,[8] whilst the distribution and transmission of electricity, including investment facilitation, would continue to be regulated.

Governments in Asia (the Philippines), Europe (applicable to all EU member states), the United States (around 50% of the country's generation capacity is located within regions which use competitive wholesale markets), and elsewhere have followed similar pathways of deregulation since, while often going beyond the Chilean example by abandoning all direct governmental influence on resource planning and investment facilitation.

To support their restructuring programmes, regulatory and organisational changes were made to enable the efficient functioning of the electricity sector. Where deregulation took place, centralised approaches to generation planning and procurement have lost their relevance as a centrepiece for investment facilitation within the sector. Where wholesale markets have been established, these markets have taken over this central function, but have been established to coordinate rather than be responsible for procurement. In jurisdictions using wholesale markets, generation planning is often used to provide guidance without any direct link to project implementation (e.g. through master plans that set out an indicative future energy mix), or to guide investors' internal decision-making processes.

The main differences in the move away from central planning approaches toward competitive markets include the shifted focus away from outcomes; and central judgement and mandatory payments to technology-neutral, but consistent investment incentives, with these awarded in a decentralised manner and with investors bearing their own investment risks.

The introduction of competition into the electricity industry through the use of wholesale markets is subject to a long-standing debate. This spans across academia, policy makers, and the industry. Furthermore, industry practices continue to evolve in the light of better knowledge, changing governmental objectives and emerging technologies. This report does not seek to take sides on such questions. Rather, it aims to provide guidance to decision makers from jurisdictions that apply central planning approaches for the direct facilitation of investment into their electricity sectors.

8 It is still the case that the Chilean government holds planning functions which directly inform the resource procurement process.

2.4 INSTITUTIONAL CAPACITY FOR PLANNING

Effective planning requires a skilled team of planners, access to high-quality data, computers, and software models. In small jurisdictions, relatively simple spreadsheet models may be sufficient, but larger jurisdictions and regions will typically require large, customised models tailored to their requirements.

Requirements for human resource capacity will vary with the context in which planning efforts are developed. Generally speaking, resource planners will need to have a good understanding of the power system, technology options, and costs of technologies. The regulators, energy ministry officials, or others responsible for oversight of the planning process will not usually need to have the same depth of understanding, or the same ability to run the software models, but may need to have sufficient understanding of the methods and tools to verify that planners have conformed to proven practices and met all the required planning objectives.

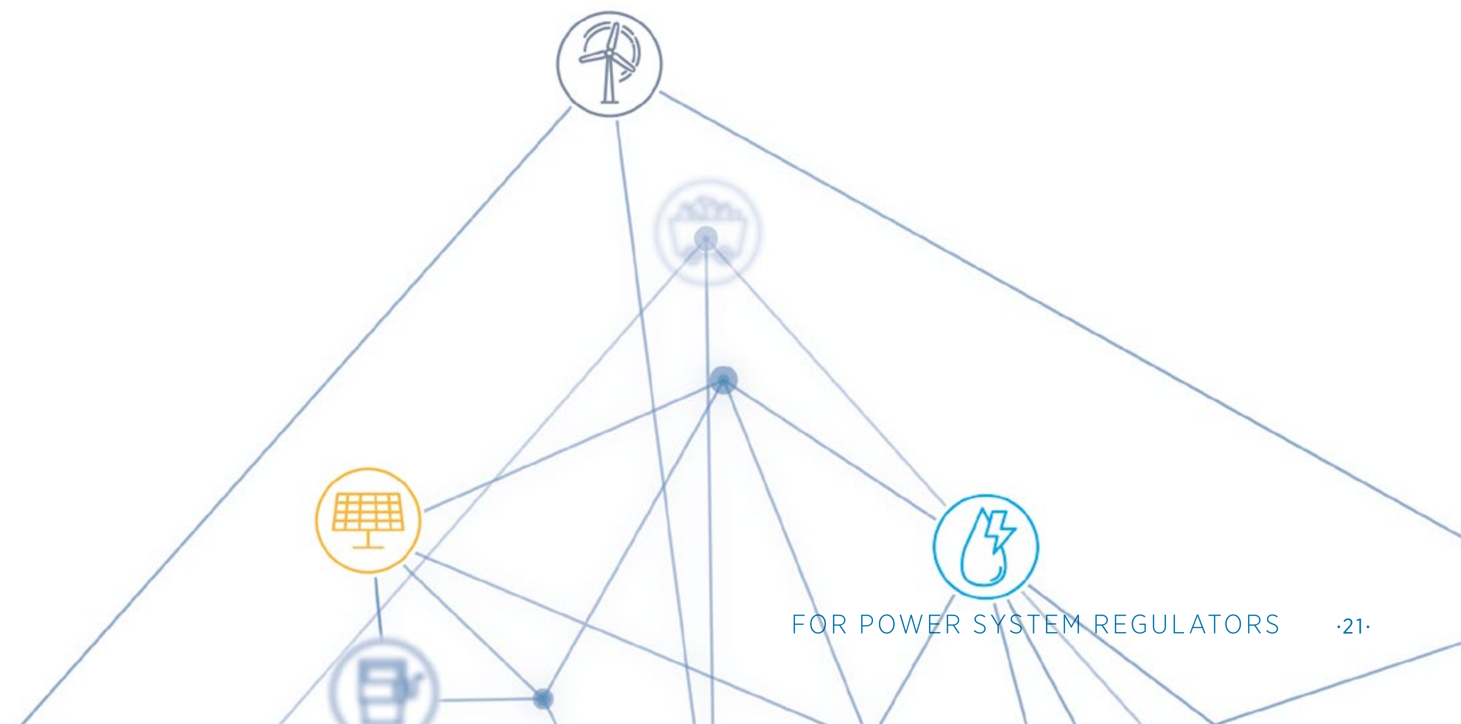
Where there is an active stakeholder group that includes power sector experts representing different interests, the entity overseeing the planning process might be able to rely, to some extent, on the judgment of stakeholders. They therefore might not need as much in-house expertise as would be necessary, if such stakeholders were not engaged. This is one of the key benefits of adopting processes that meaningfully engage stakeholders: this enables the regulator (or other overseer) to serve as a convener rather than as a participant, focusing on ensuring that the planning process is consistent with all applicable laws and regulations, and receiving and disseminating the information needed by the stakeholders.

To the extent that a planning process builds-in diverse stakeholder perspectives, the process can, in effect, be self-reinforcing. By this, we mean that the process has buy-in from the affected regions and stakeholders. Thus the plans are more likely to be implemented and to lead to results that are in line with the planning objectives.

2.5 REGIONAL PLANNING ASPECTS

In some regions of the world, multiple jurisdictions collaborate to develop regional power system plans. These plans typically involve a coordinated examination of generation resources that could potentially serve multiple jurisdictions, although often the focus is more on transmission interconnections between jurisdictions. Regional power system planning efforts share much in common with IRP, but also raise unique challenges that are worthy of separate consideration.

Chapter 6 reviews the proven practices that can be applied to regional planning, including principles of regional planning and regional planning elements. Planning practices, independent of whether they are being used in a single- or multi-jurisdictional context, are embedded into legal foundations and regulatory oversight. Chapter 3 examines these overarching aspects, which also need to be considered in regional level planning.



INSIGHTS FOR REGULATORY OVERSIGHT 3

Utilities across the globe develop plans for meeting their customers' electricity needs. They do this even in the absence of any externally-imposed planning requirement, and they do it with or without the oversight of a regulator, or other oversight authority. There can be distinct and dramatic differences, however, in planning processes, planning outcomes, and support for plan implementation, depending on whether the process is informal (conducted privately by the utility for internal planning purposes) or formal (*i.e.,* authorised or mandated via a legal requirement imposed on the utility, or another planning entity).

In the context of formal planning processes, regulatory roles have been evolving as the nature of planning efforts and the industry changes. Planning processes have, indeed, evolved over a long time, with IRP first being established as a planning framework back in the 1980s. That was well before the major regulatory reforms that led to the widespread development of independent power producers and wholesale market reforms . It was also before the even more recent, widespread uptake of wind and solar PV technologies and new opportunities for demand response.

This chapter elaborates on the regulatory roles and frameworks for and tasks of regulatory oversight, encompassing effective planning processes. The main focus is on single-jurisdictional IRPs. The chapter also elaborates on the main differences in regulatory oversight, as part of regional planning processes.

3.1 ROLES AND RESPONSIBILITIES FOR REGULATORS

Even in the early stages of IRP, however, the role of the regulator varied widely across jurisdictions. This went from pro-active review and approval of plan development and oversight of its implementation (*e.g.,* Vermont), to no role whatsoever (as in the case of Brazil and many municipal electric utilities in the western United States).

Regulators are rarely (if ever) responsible for developing plans themselves. Instead, they usually serve either as a regulator of the process, or as an approver of the outcome, or both. In the former role, regulators oversee a planning process which is implemented by a different planning entity. This is in order to ensure that core principles for good planning are adhered to, that all relevant laws and regulations are followed, and that all parties to the plan (or projects implemented from the plan) are given a fair opportunity to shape the final outcome. Regulators operating in this role don't attempt to judge whether the resource plan is optimal, only whether the process used to develop the plan was sound.

The alternative role is one where regulators take responsibility for technical review and approval of resource plans. Regulators operating in this latter role may need to employ their own technical experts, but may also require a funding source to retain expertise from outside.

Regulatory oversight of resource plans and transmission plans developed by for-profit utilities is essential, especially in markets without competition between generators and thus lacking choices for consumers. This is the case in some

US jurisdictions. In the absence of effective oversight, utilities might develop plans that are unnecessarily expensive for customers, but more profitable for shareholders.

Regulatory oversight of government-owned utilities varies widely in the United States. About a third of the states and Puerto Rico include regulatory oversight of some government-owned utilities (*e.g.,* municipal utilities). The national regulator, the Federal Energy Regulatory Commission (FERC), has regulatory oversight of federally-owned utilities and power marketing authorities (NARUC, 1997).

Some US states, like Vermont, for example, have established strong oversight of IRP itself. They then emphasize the role of the IRP in the ensuing approval of generation projects, with this typically requiring some form of regulatory review and approval.

Puerto Rico has established requirements for IRP and requires the regulator to adopt rules for the planning process undertaken by its government-owned electric distribution utility. The regulator is then responsible for the review and approval of the IRP, or its modification, as appropriate.

A case of "internal oversight" can be found in Brazil, where there is no regulatory oversight over the planning process undertaken by the independent planning office, the Empresa de Pesquisa Energética/ Energy Research Office (EPE). In this case, the diversity in the composition of the EPE's Board, Executive Board, Audit Committee and Advisory Council helps replace the otherwise necessary regulatory oversight.

The EPE is essentially managed and operated by representatives from various ministries, public representatives from each region, power generation companies, transmission and distribution companies, energy consumer representatives, renewables industry representatives and others.

South Africa's regulator is responsible for establishing rules that implement the IRPs developed in that country, and is then responsible for ensuring adherence to the rules by licensees.

Key point

Regulators rarely develop plans, but er oversee the integrity of the planning process or approve the outcome. In order to approve the outcome, regulators need to be able to perform a techno-economic review, increasingly also under recognition of renewable energy technologies such as wind and solar.

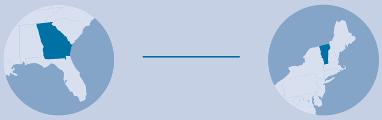
3.2 LEGAL FOUNDATIONS FOR EFFECTIVE PLANNING AND REGULATORY OVERSIGHT

Oversight of planning processes is frequently among the roles detailed in foundational laws that establish a regulatory authority and describe the duties and responsibilities of the regulator. These foundational laws will sometimes describe the principles that should apply in the development and (where applicable) approval of plans. The legal framework is typically very general in its description of this regulatory authority, but will often delegate to the regulator additional authority to establish detailed administrative rules for IRP, or other planning processes.

In some jurisdictions, foundational laws that establish a regulatory authority do not specifically mention planning processes, but are written in such a way that the regulator can assert that authority based on a more general authority to oversee the prudency of utility investments, operations, and charges. Alternatively, a separate law mandating a planning process may be established that describes the roles of both the utility and the regulator, how frequently plans will be updated, and what the objectives of the planning process are to be. Energy policy goals relating to energy access, reliability, affordability, renewable energy standards, or carbon emission targets often pre-date these planning requirements. They may therefore be referenced in the legislation (rather than repeated or described in detail) as required objectives that the plan must satisfy (see Box 4 below for two examples, from the states of Georgia and Vermont in the United States).

Puerto Rico established detailed requirements for the government-owned power company that is overseen by the Puerto Rico regulator in the Puerto Rico Energy Transformation and RELIEF Act (Act 57-2014). The Puerto Rica Electric Power Authority (PREPA), the government-owned provider of

Box 4 Legislative background to power system planning: Examples from two US jurisdictions



State of Georgia

Title 46: Public Utilities and Public Transportation

Chapter 3A: Integrated Resource Planning

§ 46-3A-2. Filing and approval of an integrated resource plan

(a) On or before 31 January, 1992, and at least every three years thereafter as may be determined by the commission, each utility shall file with the commission an integrated resource plan as described in this chapter.

(b) Not more than 60 days after a utility has filed its plan, the commission shall convene a public hearing on the adequacy of the plan. At the hearing any interested person may make comments to the commission regarding the contents and adequacy of the plan. After the hearing, the commission shall determine whether:

(1) The utility's forecast requirements are based on substantially accurate data and an adequate method of forecasting;

(2) The plan identifies and takes into account any present and projected reductions in the demand for energy which may result from measures to improve energy efficiency in the industrial, commercial, residential, and energy-producing sectors of the state; and

(3) The plan adequately demonstrates the economic, environmental, and other benefits to the state and to customers of the utility, associated with the following possible measures and sources of supply:
(A) Improvements in energy efficiency;
(B) Pooling of power;
(C) Purchases of power from neighbouring states;
(D) Facilities which operate on alternative sources of energy;
(E) Facilities that operate on the principle of cogeneration or hydro-generation; and
(F) Other generation facilities and demand-side options.

(c) Within 120 days after the filing of each integrated resource plan, the commission shall approve and adopt an integrated resource plan.

State of Vermont

Title 30: Public Service

Chapter 5: Powers and Duties of Department of Public Service and Public Service Board as to Companies Other Than Railroads and Aircraft

30 V.S.A. § 218c. Least cost integrated planning

(a) (1) A "least cost integrated plan" for a regulated electric or gas utility is a plan for meeting the public's need for energy services, after safety concerns are addressed, at the lowest present value life cycle cost, including environmental and economic costs, through a strategy combining investments and expenditures on energy supply, transmission, and distribution capacity, transmission and distribution efficiency, and comprehensive energy efficiency programs. Economic costs shall be assessed with due regard to:
(A) the greenhouse gas inventory developed under the provisions of 10 V.S.A. § 582;
(B) the State's progress in meeting its greenhouse gas reduction goals;
(C) the value of the financial risks associated with greenhouse gas emissions from various power sources; and
(D) consistency with section 8001 (renewable energy goals) of this title.

(2) "Comprehensive energy efficiency programmes" shall mean a coordinated set of investments or program expenditures made by a regulated electric or gas utility or other entity as approved by the Board pursuant to subsection 209(d) of this title to meet the public's need for energy services through efficiency, conservation or load management in all customer classes and areas of opportunity which is designed to acquire the full amount of cost effective savings from such investments or programs.

(b) Each regulated electric or gas company shall prepare and implement a least cost integrated plan for the provision of energy services to its Vermont customers. At least every third year on a schedule directed by the Public Service Board, each such company shall submit a proposed plan to the Department of Public Service and the Public Service Board. The Board, after notice and opportunity for hearing, may approve a company's least cost integrated plan if it determines that the company's plan complies with the requirements of subdivision (a)(1) of this section and of sections 8004 and 8005 of this title.

services, must submit a plan for approval by the regulator every three years. The law establishes a requirement that the IRP must be consistent with the rules of the regulator.

The South African Energy Regulation Act, 2006, gives authority to the minister of energy to promulgate requirements for new power generation. This authority led to the establishment of rules requiring Eskom to use IRP from 2009 onwards, including: in the adoption of planning assumptions; in the determination of demand forecast; in modelling and scenario planning requirements; in the determination of a base plan resembling the least-cost future; and in risk adjustment of the base plan, based on most probable scenarios and policy objectives, including renewable and alternative energies, demand side management and energy efficiency. South Africa's regulator establishes rules for oversight of the implementation of the integrated resource plan developed by the Department of Energy. Furthermore, the regulator is responsible for the review of license applications from Independent Power Producers (IPPs) seeking authority to operate in South Africa. Among the considerations required in filing those applications is consistency with the Department's IRP.

In Thailand, the Ministry of Energy, together with the Electricity Generating Authority of Thailand (EGAT), prepares long-term power development plans that are similar to IRPs. Authority for these activities is specified in the Energy Industry Act, B.E. 2550 (2007), which also created the Energy Regulatory Commission and assigned to the Commission a specific duty to provide opinions to the Minister of Energy on power development plans, the investment plan of the electricity industry, the natural gas procurement plan, and the energy network system expansion plan.

A well-formed legal framework provides an objective reference point for guiding government, regulators, stakeholders, and the public around a long-range process and vision. It identifies the main actors and their respective roles. A legal framework for IRP can ensure that all of the affected parties will fulfil their roles, and that they will have the authority to develop, implement, and then enforce provisions of the plan.

Formal planning processes are far more likely than informal planning processes to use transparent assumptions about all of the inputs and assumptions that go into a resource plan. Stakeholders are generally involved in formal processes, but not in informal processes. Formal processes usually result in well-documented, publicly available plans that are submitted to a regulator, or other oversight authority. In some cases, formal plans are not finalised until the oversight authority has reviewed and approved the plan, often with the benefit of further public input. Formal planning processes are more time-consuming and expensive, but also more robust and rigorous. Most importantly, they contribute to greater acceptance of the plan by financiers and the public at large, which increases the likelihood that the plan will be implemented.

Key point

Legislation strengthens planning processes, as roles and responsibilities for stakeholders, including a regulatory body, can be clearly defined, in addition to policy-driven planning objectives and other key elements. Regulators are often empowered to establish the detailed administrative rules and regulations necessary to guide both the establishment of a plan and its implementation. Setting the right objectives (*e.g.* a renewables target, socio-economic goals, environmental standards, or carbon prices) is a key factor for enhancing the role of renewables.

3.3 ENSURING TRANSPARENCY AND APPROPRIATE STAKEHOLDER INVOLVEMENT

For the reasons already outlined, stakeholders, transparent processes, and open access to data and planning materials are essential to most power system planning efforts. The role of the regulator here is to reinforce and empower those stakeholders and provide a transparent process that ensures a high level of trust and acceptance. Open access empowers stakeholders. It also helps to ensure effective co-ordination across governments, within government, and with and between interconnecting companies that deserve access to information about future plans for the network and the system. Regulation plays an important role in ensuring that: (1) rules are in place that encourage the active engagement of stakeholders and the public; and (2) those rules provide stakeholders with the opportunity to be heard by the regulator in the context of formal hearings, or written testimony and comments.

Most states in the United States that require IRP also include regulatory provisions to ensure that there are adequate opportunities for the public to participate and comment on the utility IRP (see, for example, NARUC, 1997; Wilson and Biewald, 2013).

The Energy Regulation Act, 2006 of South Africa requires that the IRP be gazetted.

Key point

Regulatory actions can ensure adequate stakeholder input and public engagement in the planning and subsequent review process. Transparency and confidence are key for any planning process, and in certain jurisdictions, are likely to encourage entry by new participants, such as renewable energy proponents.

3.4 REGULATORY REVIEW OF PROPOSED/ DRAFT PLANS

Most of the US jurisdictions that require utilities to develop IRPs require that draft plans be submitted to the regulator for review. States vary from that point forward, however, in whether the regulator reviews the analysis and conclusions embedded in the draft plan or merely reviews the process used to develop the plan.

The Puerto Rico regulator, for example, has authority to review, modify and approve draft IRPs submitted by the utility, while some states merely "acknowledge" or accept that the utility has submitted a plan as required. With either approach, it is usually the case that stakeholders have the opportunity to speak at a hearing or file testimony regarding the draft plan before the plan is accepted or approved by the regulators.

Which practice to apply here is largely dependent on the context. Review of draft plans by the regulator appears to be especially important in jurisdictions where there is little trust between government (or perhaps, portions of government) and the entity charged with the development and implementation of the plan. Establishing a review and approval process will help to forestall adverse regulatory actions later during implementation of the plan and help to ensure that resource plans are implemented consistent with statutory criteria. Puerto Rico provides an example of such a jurisdiction (Kunkel and Sanzillo, 2016).

Such review may be less of an issue in jurisdictions where the level of trust is high. The ultimate objective of the review is to ensure that there is a strong link between statutory criteria or objectives and the plan that is developed by the planning entity. Arguably, when government itself is responsible for planning, the risk may diminish. Even in relatively mature jurisdictions like Vermont, however, energy planning requirements placed on government may become sub-optimal in timeliness and frequency.

Key point

Regulatory reviews enhance the outcome and implementation of the plan, either through technical review or review of the process. Technical reviews can overcome levels of mistrust between government and planning entities, and avoid adverse regulatory actions during implementation of the plan. Where the level of trust is generally high, reviews to ensure that the process adheres with statutory criteria and/ or objectives, often suffice. Both types of review can enhance the role of renewables, especially in markets which need to overcome knowledge gaps, or other barriers for renewable energy technologies.

Planning is often central to least-cost resource development

3.5 STATUS/TREATMENT OF THE FINAL PLAN

Another crucial aspect of power system planning is the need to be clear about the legal and regulatory status of the final plan. In the United States, it is nearly universally true that the component projects described in an IRP are not pre-approved, even if a regulator has reviewed and approved (or merely accepted) the plan. Instead, the normal approach is one where each component project is still subject to either pre-construction approval by the regulator, or post-construction review of the prudency of those expenditures.

A project that was specified in the IRP is much more likely to be approved than one that was not included in the IRP. Nonetheless, the regulator will still review projects separately from the IRP because the prudency of a project at the time it is initiated depends on many variables (*e.g.,* load projections or fuel costs) that might have changed since the IRP was completed.

Some jurisdictions go so far as to use the IRP as a way to assign the "burden of proof" for infrastructure projects. If a project is in the IRP, any stakeholder who feels the project should not be approved has the burden of proving their case, whereas if the project is not in the IRP the burden of supporting the project falls on the utility or IPP that wants the project to be approved. As an example, Vermont makes provision in 30 V.S.A. §248b for approval of utility IRPs, but also requires consistency with approved plans when reviewing individual projects or contracts that come before the regulator, unless a deviation from the approved plan is justified.

Key point

Individual component projects remain subject to either pre-construction approval by the regulator or post-construction review of the prudency of those expenditures. An IRP-project is more likely to be approved, but utilities are often allowed to provide proof for a project not specified in an IRP. IRP-projects can also be contested by stakeholders during the pre-construction approval process.

3.6 CAPACITY BUILDING FOR REGULATORS

Capacity building around IRP is contextual. Different jurisdictions require a thorough vetting of the IRP or transmission plan itself, or the projects that come before the regulator that are linked to the plan through their inclusion or omission. At some point, the regulator must either marshal the expertise on its own, retain experts, or leverage the involvement of outside interests to ensure that the plan or its component projects are consistent with the objectives for the plan (ideally, with this established in law).

In jurisdictions in which the regulator is required to play a significant role in the technical review of plans, the regulator will ultimately have a choice between staffing up and training staff to meet the challenge, or relying disproportionately on trusted outside consulting experts. Regulators that are new to the role of providing oversight usually have little choice but to depend disproportionately on outside experts. This is the role being played by the Puerto Rico Energy Commission (PREC) in overseeing the development of the first IRP in Puerto Rico. Due, perhaps in large part, to a low level of trust between the utility and the government (even though the government owns the utility), the role of the PREC in providing oversight has been pronounced, even during the development stages. Technical support is being provided by a team of outside experts who have considerable international experience with planning.

Another path for the regulator is to build capacity within its own staff. To a certain extent, this will be required, over time, even for the PREC, as some level of expertise is required by staff to oversee the team of technical experts. Reliance on staff for review of all aspects of the IRP, or the component projects, is challenging, however, even for the most mature regulatory jurisdictions. Those with a small regulatory staff and limited internal resources may thus be candidates for a disproportionate reliance on outside experts. This will be most relevant in circumstances in which the utility is poised to commit large amounts of capital toward long-term resource commitments like a utility scale coal, nuclear, or hydro station.

Regulators that have the staff resources that can be built up may need to recognise the resource skills required. Typically, IRP reviews require similar skill-sets to those that are used in developing the IRP. This may include individuals with mathematics/computer science skills, engineers, resource economists, financial analysts, and power system planners. Transmission planning exercises often require the addition of electrical distribution and transmission engineers.

Regulators may also play the role of moderators. As the list of stakeholders grows, this role becomes more common. In this capacity, the regulator focuses on the process and procedures necessary to ensure that all perspectives are heard by a neutral hearing examiner, or staff member. This person must have the necessary skills to appreciate and distil the guidance developed through a well-formed process. This process may range from an open and collaborative exercise with a series of technical workshops to one that relies more heavily on formal procedures and lawyers. In the end, the process must provide sufficient rigour for the regulator to make findings, provide analysis, and render judgements with respect to the plan or the projects that are under review.

As discussed earlier, the role of the regulator is increasingly focused on this role as a moderator of disparate interests.

Key point

When playing a direct role in the review of plans, the regulator will need to develop internal expertise or obtain it from outside. Deep understanding of all technologies, including rapidly maturing renewable energy technologies, is necessary in the case of direct regulatory review. Where process management is the key task, regulatory skills are more focussed on capabilities to convene experts, including from the renewabel energy industry, who may be new to a planning process, and to ensure high-quality decision making between sometimes diverging views along the defined process.

3.7 AVOIDING "REGULATORY CAPTURE" AND POLITICAL INTERFERENCE

"Regulatory capture" is said to occur when a regulatory agency charged with protecting the public interest instead serves the interests of the industry or sector it regulates. Although regulatory capture can be the result of corruption, it can also happen if regulators base their decisions on information that comes only, or disproportionately, from the entities they regulate. In the latter case, regulators may make decisions that favour the regulated entities, due to incomplete information about other perspectives, or because they begin to see the world from a biased perspective – that presented by the regulated entities.

There are many ways to reduce, or avoid, the risk of regulatory capture and the erosion in public confidence that it creates.

Many jurisdictions have adopted policies that reduce the likelihood of overt corruption. Several types of policies can help. One common, easy step is to forbid regulators from accepting gifts of even minor value from any entity or employee of an entity they regulate. Many jurisdictions also require regulators who were previously employed by an entity they now regulate to recuse themselves from decisions affecting that entity, in order to avoid the appearance of favouring their former employer. Similarly, regulators who leave office may be restricted from immediately working for an entity they used to regulate, to ensure that they won't favour a regulated entity while in office in the hopes of securing a future job.

Another set of policies can reduce the likelihood that regulatory capture occurs due to an imbalance in the information received by regulators. Adopting transparent decision-making procedures, where decisions are based on a publicly available record of evidence, is probably the most important first step. Many jurisdictions also prohibit or require public disclosure by the regulators of *ex parte* communications*, i.e.* private communications between regulators and the entities they regulate on matters yet to be decided. It is also crucially important that decision-making processes include opportunities for stakeholders and the public – and not just the regulated entities – to enter evidence into the record, question and rebut evidence submitted by others, and comment on draft decisions.

Public confidence in power system plans can also be diminished if stakeholders perceive that decisions are unduly influenced by political pressure happening outside of the public eye. It is normal and appropriate for politics to influence the planning objectives that are a core input to any planning process, and even to influence the *criteria* used to select a preferred resource portfolio or transmission solution. Yet, regulators should guard against political interference that seeks to steer the process toward a desired solution that is inconsistent with the purported objectives, or decision criteria. In many parts of the world, regulators have been constituted as independent authorities in order to avoid even the appearance of this kind of political influence. In many jurisdictions, regulators are appointed by a governor or minister, but once appointed cannot be fired or demoted. It is also common for regulatory authorities to receive all or most of their funding from retail ratepayers, in order to diminish their dependence on funding from the treasury.

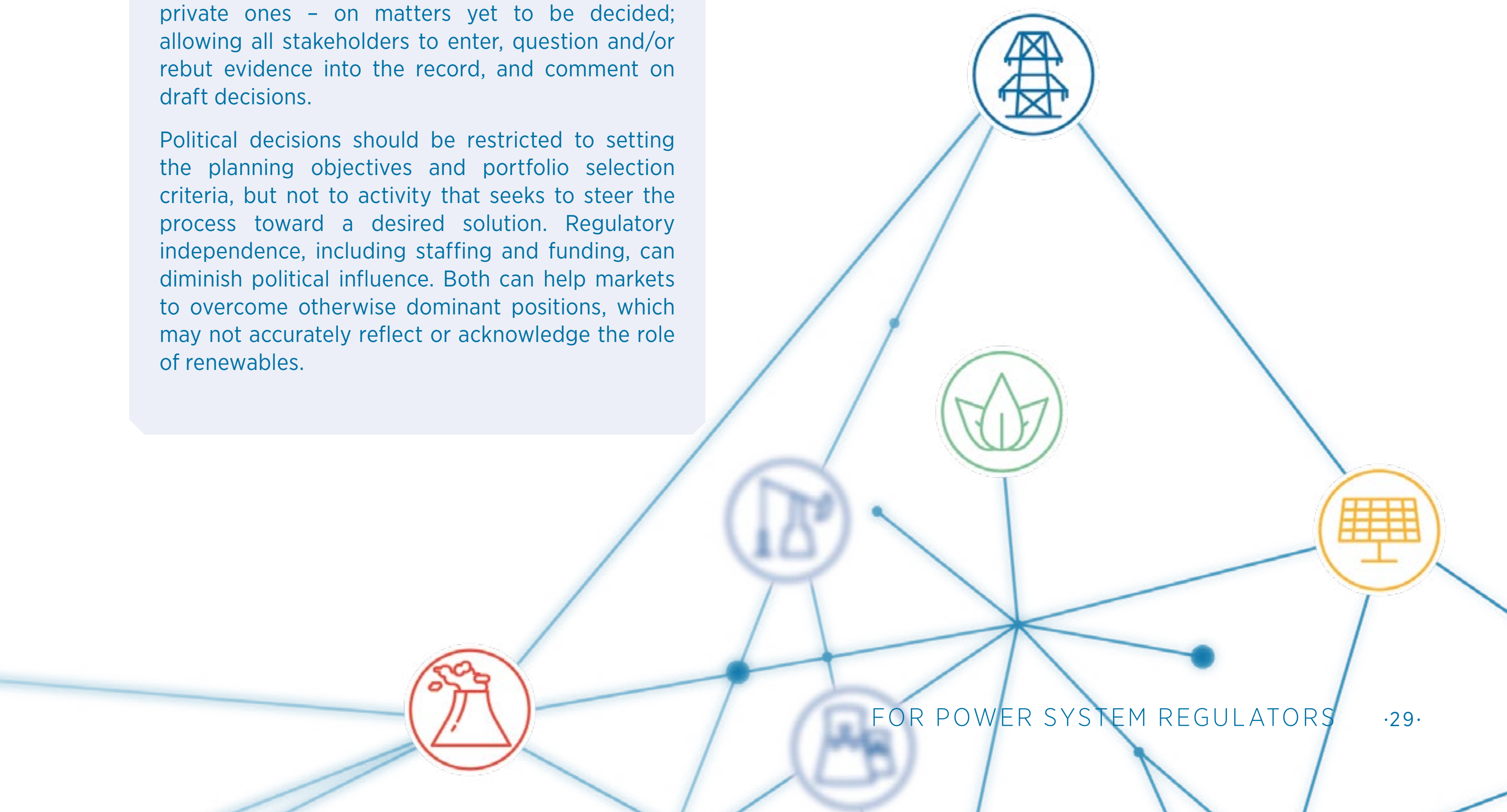
Key point

Avoiding regulatory capture can be achieved through adopting transparent decision-making procedures. These can include: public disclosure requirements for any communications – including private ones – on matters yet to be decided; allowing all stakeholders to enter, question and/or rebut evidence into the record, and comment on draft decisions.

Political decisions should be restricted to setting the planning objectives and portfolio selection criteria, but not to activity that seeks to steer the process toward a desired solution. Regulatory independence, including staffing and funding, can diminish political influence. Both can help markets to overcome otherwise dominant positions, which may not accurately reflect or acknowledge the role of renewables.

3.8 REGIONAL CONSIDERATIONS FOR LEGAL FOUNDATIONS AND REGULATORY OVERSIGHT

Effective regional planning processes are different from those limited in scope to a single utility or a single political jurisdiction. The challenge is to find an oversight structure that recognises and respects existing planning processes and authorities within each affected jurisdiction, while allowing for the consideration of power system resources and transmission lines that potentially provide benefits to more than one jurisdiction in a cost-effective manner (*i.e.* at a lower cost than would be required to obtain the same benefits if each jurisdiction acted independently). The institutions responsible for planning and oversight must have credibility with and support from all participating jurisdictions, and thus may have to be regional institutions. One solution to this problem is to create a stand-alone regional planning entity that creates power system plans, but is not responsible for procuring the identified resources. Another option is to assign long-term planning responsibilities to an existing regional institution, such as a regional transmission system operator or a regional power pool organisation, that also has responsibility for system operations. Finally, it is also possible to develop regional plans by convening stakeholders from multiple jurisdictions on an *ad hoc* basis without creating any permanent institutional capacity.



3.9 LEGAL FOUNDATIONS FOR REGIONAL PLANNING

The legal foundations for regional planning processes are likely to be more complex than those for single jurisdictions, unless an entity exists that has been vested with some form of legal authority spanning multiple jurisdictions.

Regional planning is occasionally mandated by federal laws affecting multiple jurisdictions, or by international agreements (*e.g.,* by treaty or compact), or by a memorandum of understanding (MOU). Yet regional planning also often occurs in the absence of a compelling legal mandate. Individual jurisdictions, operating under their own laws and regulations, may voluntarily agree to support and participate in regional planning efforts in order to identify and capture opportunities for mutual benefit. This kind of regional planning has been the historical norm for power pools spanning multiple jurisdictions.

In the United States, certain legal authorities are granted to the federal government while other authorities are vested in the states. The FERC has the authority to regulate interstate transmission of electricity and interstate electricity markets, while the states have authority to regulate most of the activities of their utilities. The FERC has used the authority granted to it by Order No. 2000, 18 CFR Part 35 (1999) to require certain forms of multi-state transmission planning (described in more detail elsewhere in this report), while many states have mandated IRP. The long-term plans of US utilities are thus shaped by this combination of federal and state planning requirements.

Another example can be found in Europe, where the European Network of Transmission System Operators for Electricity (ENTSO-E) was established and given legal mandates through the Third Energy Package of the EU (Directive 2009/72/EC), enacted in 2009. That legislation charges ENTSO-E with responsibility for network (grid) codes, transmission network infrastructure planning, and market design – including compensation for transmission system operators of the costs incurred as a result of hosting cross-border flows of electricity.

The NWPCC offers a third kind of example. In this case, the US Congress authorised the NWPCC's creation in the Pacific Northwest Electric Power Planning and Conservation Act of 1980. This vested it with regional planning authorities spanning four states, although that authority only took effect after the states appointed members to the NWPCC and consented to the agreement. Even so, three of the four states require utility-level IRPs that are coordinated with the regional IRP.

In regions where no entity has the legal authority to mandate regional planning, processes can nevertheless be initiated through mutual agreement of the participating jurisdictions. Such agreements can be formalized through treaties, compacts, or formal agreements. All of the same questions that must be answered when initiating a planning process within a single jurisdiction must again be answered, but this time in a context where participating jurisdictions may have different legal and regulatory frameworks, different public policies and planning objectives, different financial and technical capabilities, etc. The challenges inherent in this approach are significant and the resulting plans can only be expected to be implemented so long as the participating jurisdictions see benefit in doing so. In addition, there won't be an impartial party capable of ensuring that all parties fulfil their commitments, unless such an entity is created and adequately funded by mutual agreement of the parties.

One example of this kind of "regional planning by mutual agreement" can be found in a project called the Upper Midwest Transmission Development Initiative (UMTDI). UMTDI was started in September 2008 by mutual agreement of the governors of the US states of Iowa, Minnesota, North Dakota, South Dakota, and Wisconsin. The objective was to promote renewable energy development – primarily wind projects. This would be done by identifying "renewable energy zones" (REZs) within the five-state region; determining the transmission needs to access those REZs; and proposing an equitable formula for allocating the costs of those transmission projects to the utilities in each state.

UMTDI was led by an executive committee consisting of a governor's representative and a utility commissioner from each of the UMTDI states. Senior staff from the states assisted with analysis, as did planners and managers from the Midcontinent Independent System Operator (ISO), the regional grid operator.

Public consultation occurred at various stages of the analysis. Although the UMTDI agreement was not cemented in any binding legal requirements, it succeeded in identifying several multi-state transmission projects that were eventually constructed and that now benefit all the participating states. The UMTDI example demonstrates that regional planning can yield meaningful results so long as mutual benefits are possible for all participants.

Independent of whether regional planning occurs under laws, international agreements or without compelling legal mandate, the regional codes will need to include the same framework elements as a state IRP mandate. They may also need to be even more specific than a state law in describing how the planning process will be governed and what the roles will be for the affected governments, utilities, other experts, the public, and stakeholders. Perhaps even more important, the regional codes must include guiding objectives that are consistent with the objectives of each jurisdiction, so the regional plan can be used effectively by utilities in each jurisdiction. One of the best examples of a quasi-voluntary framework is the NWPCC, which also proves that, in the absence of an effective legal authority, heavy reliance and involvement of stakeholders and governments is required to achieve good planning results and their implementation.

Certain planning practices require updates to accommodate renewable energy technologies

3.10 EFFECTIVE REGIONAL REGULATORY OVERSIGHT

In most instances where there is a multi-jurisdictional planning process, as might be the case for an IRP by the NWPCC, there is no single regulator with jurisdiction to provide oversight. Some form of government oversight occurs, however, through the appointments to the board of the NWPCC, which provide some "internal oversight". Review by regulators then takes place at the sub-regional (state) level in the review of distribution utility IRPs. For other planning efforts that cross state boundaries in the United States, the federal regulator is responsible. This applies to regional planning and all forms of regulation that apply across borders. For jurisdictions that participate in organised wholesale electricity markets, oversight comes in the form of FERC approval of regional planning processes and wholesale market tariffs.

In Europe, regulators have a diminished role in reviewing regional transmission and system plans, compared to the role US regulators have over IRPs.

There are several directives and regulations that apply and establish both requirements for unbundling and a role for ENTSO-E and for the Agency for the Cooperation of Energy Regulators (ACER). There is, however, no overarching legal framework or universal European energy policy for the planning and/or implementation of cross-border transmission lines, or any aspects related to generation resources.

Key point

Regional planning can be mandated by: federal laws affecting multiple jurisdictions; by international agreements; or a memorandum of understanding. The norm remains regional planning occurring in the absence of a compelling legal mandate, under individual jurisdictions' voluntary agreements, driven by incentives. In most instances there is no regulator with jurisdiction to provide oversight, and review by regulators then takes place at the sub-regional level in the review of single-jurisdictional plans.

Regional planning codes must include guiding objectives that are consistent with the objectives of each jurisdiction so the regional plan can be used effectively in each individual jurisdiction. This consistency is particularly relevant for the inclusion of renewable energy technologies, in cases where their deployment relies on policy objectives.

BEST PRACTICES FOR INTEGRATED RESOURCE PLANS

4

Although IRP has emerged as a key practice in resource planning, the planning process involves many elements and many decisions for which more detailed practices can be identified. This chapter will examine some overarching principles that form the foundation of proven practices. It will then provide an overview of the planning process, before examining in more detail some of its more specific elements.

Countries that have relatively little experience with IRP may find that adopting all the associated planning practices may not initially be feasible, due to limitations in budget, staff, or expertise. This does not mean that a good IRP is out of reach, however.

Each specific process in the overall approach to an IRP can be tailored to the practical realities of local circumstances. Ultimately, having a plan – even one that doesn't conform to ideal practices in all respects – is better than having no plan at all. Adoption of proven practices can be a long-term goal for those who must begin with a more restrained approach.

4.1 OVERARCHING PRINCIPLES

With each element in the process of developing an IRP, certain guiding principles are essential to ensuring good outcomes. The most important of these overarching principles are as follows:

Clear guiding objectives: Objectives for planning are typically contained in laws, but can represent areas of agreement among stakeholders and/or regions involved. Reliability, energy security, cost minimisation, environmental objectives (*e.g.,* carbon reduction), and policy constraints (*e.g.,* renewable targets) typically lead the list of planning objectives. In regions with low access to electricity in rural communities, electrification is likely a core objective.

Consideration of all resources: Integrated resource plans are distinguished from other plans by the scope of resources considered. IRPs require comprehensive consideration of all relevant resources, including demand-side resources. Integrated consideration of all services provided by those resources is also featured. This includes consideration of energy, capacity, ancillary services, and flexibility.

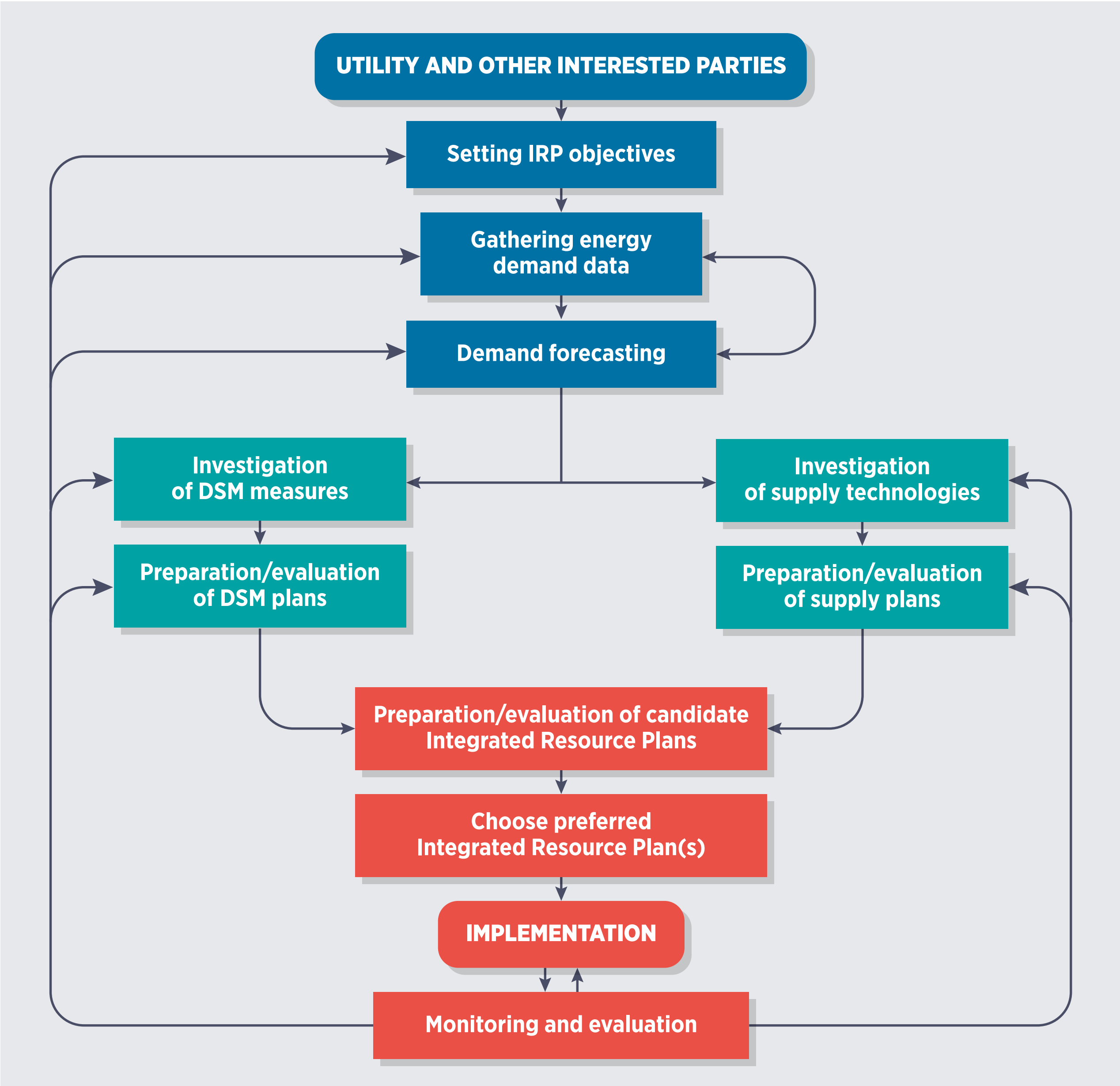
Use of best available data: The power system is transforming rapidly around the globe, thanks to new technologies and new public policy priorities. In particular, the capabilities and the costs of new technologies are changing at a rapid pace. Fossil fuel prices are volatile and renewable energy costs are declining so rapidly that data can become obsolete or misleading within a year or two of publication. IRP processes must endeavour to keep abreast of these changes by using the most current and locally-applicable sources of data, and even future cost learning curves for renewables, for all elements of the planning process.

Public and stakeholder participation: Another commonly cited principle among experts is reliance on public and stakeholder involvement. Diverse public and stakeholder engagement is especially important in planning processes that fundamentally rely on such efforts to gain necessary support among diverse constituencies. Stakeholder involvement can also reduce the burden on staffing and capabilities among oversight entities, if stakeholders commit their own resources and bring expertise to the planning process.

Focus on the outcomes, not just the plan: The purpose of an IRP is not merely to identify a preferred resource portfolio to develop or acquire. Throughout the process, planners should remain focused on the outcomes that a good plan can deliver, including achieving all relevant objectives, reducing investment risks, attracting investors, and earning public acceptance/support for necessary infrastructure investments.

Figure 5 offers an overview of a typical planning process to develop and implement an IRP.

Figure 5 The process behind integrated resource plans



Source: Tellus (2002)

DSM = demand-side management

4.2 INSIGHTS ON SPECIFIC PLANNING ELEMENTS

Planning entity

One of the first questions that arises whenever a jurisdiction contemplates developing an IRP for the first time is: what entity should lead the development of the plan? Who will have lead responsibility for assembling the necessary data, proposing potential resource portfolios, defining scenarios to analyse, and running the models?

In the United States, it is most common for the planning entity to be the same as the entity that is responsible for implementation of the plan. For example, in most of the United States, vertically integrated utilities that own generation, transmission and distribution system assets and sell electricity directly to retail customers are responsible for the development of integrated resource plans. This holds true in about 30 states (Lazar, 2016).[9] This approach has the advantage of incorporating the utility's operational knowledge into the development of a well-formed plan. Also, because most of the affected utilities are for-profit enterprises, this approach places responsibility for investment decisions with those whose money is at risk. Regulators must oversee the process, however, to ensure that the plans developed by for-profit utilities are designed to meet customer needs at least cost – and not designed simply to maximize shareholder profits.

Where planning mechanisms are practiced outside of the United States, it is more common for a government ministry or council to serve as the planning entity. This is often true where a single government-owned utility implements national energy policy and provides bulk power for the entire nation, directly and/or as a single buyer of electricity generated by IPPs. For example, in South Africa, the Department of Energy is responsible for the development of the integrated resource plan in close cooperation with Eskom, the government-owned vertically integrated electricity company. The Energy Regulation Act, 2006 of South Africa assigns responsibilities for IRP oversight and implementation to the Department of Energy and the National Energy Regulator of South African (NERSA). While this approach requires cooperation between government, the operational experts that work for the utility, and other market participants, it does have the advantage of assuring government support for the plan.

A third option can be found in the four-state region that covers the Columbia River Basin in the United States, where responsibility for regional integrated resource planning resides with the NWPCC, an organization that was created specifically to develop resource plans that are implemented by utilities throughout the region. Because the NWPCC's main purpose is planning, it has been able to acquire a great deal of expertise and modelling capability and, over time, to build strong relationships with the region's utilities and stakeholders. The NWPCC is not, however, a utility and it has also no authority to ensure that its plans will be implemented. It must continually earn the trust and respect of utilities and stakeholders if it hopes to have the plans put into practice.

Successful planning practices typically follow one of the three frameworks mentioned above. A fourth option, where a consultancy or non-governmental organisation develops the IRP, has rarely proven effective, even in cases where these IRPs were commissioned by a government authority. These organisations may have strong analytical capabilities, independent judgment, and other desirable attributes that can be useful in support of a planning process. This is particularly so in cases where another entity charged with leading the planning process lacks some of the necessary resources, skills, or software. Yet, consultancies and non-governmental organisations are not well-suited for leading the development of an IRP, because they have no responsibility for implementing the plans, no authority for overseeing implementation, and (usually) no lasting relationship with the utility or other stakeholders.

9 While there is no comprehensive database of utility IRPs in the United States, the Lawrence Berkeley National Laboratory maintains a list for most western utilities. Of the 23 IRPs that are on file, all are associated with vertically integrated utilities (http://resourceplanning.lbl.gov/).

This often results in an IRP that is too easily dismissed as representing the opinion of an advocate or disinterested outsider – a special, one-time-only study of what the utility's hypothetical future might entail, rather than a plan to be implemented. For example, in the last decade, detailed IRPs have been developed by consultancies for Malawi (2013), Mongolia (2012), and Namibia (2013). These IRPs were not officially approved by the respective governments and did not guide subsequent resource development.

Key point

Three approaches have generally proven successful:

- The utility serves as the primary planning entity.
- A government ministry serves as the primary planning entity.
- An organisation is created specifically to develop resource plans that are implemented by utilities and IPPs.

The role of renewables resulting from each of these approaches can depend on various factors, such as institutional aim, mandate and authority or access to data and technology knowledge.

Planning objectives

At the outset of every planning process, it is critically important to identify and reach agreement on the objectives that the plan is intended to meet. In an electricity utility IRP, the planning objectives historically focused on maximising reliability and minimising cost. The tendency was to focus on cost minimisation around a likely future (the forecasted base case), with expected loads (peak and energy requirements) defining the need to be met through the plan and planning efforts. Risk and uncertainty were sometimes addressed through after-the-fact adjustments to the "least-cost" plan, if that plan was found to be highly sensitive to modelling inputs.[10] Other policy objectives were similarly addressed through piecemeal adjustments.

Box 5 Resource adequacy as planning objective

One of the key reliability criteria is resource adequacy. This is determined by the characteristics of the generation resources and represents a probabilistic assessment of inadequate capacity. One criterion that has been widely adopted is to plan for a system with sufficient capacity such that there is no greater than a one-day-in-ten-year loss of load expectation. Resource adequacy assessments determine reserve margin requirements for the system. These requirements are often in the range of 10-15% of projected peak demand, but can be even higher depending on the performance characteristics of existing generation. Governments can play a crucial role in establishing resource adequacy objectives – for example, by determining acceptable loss of load expectations or reserve margin requirements that planners must satisfy. Setting high standards for resource adequacy will result in high costs for infrastructure that is redundant (in the case of transmission) or rarely used (in the case of peak generation), while lower standards will result in more frequent outages, with their accompanying economic impact. When it comes to evaluating these trade-offs, the needs and preferences of consumers, their ability to shift or curtail load in response to resource availability, and the economic consequences of less reliable service could all be important factors to consider.

Increasingly, however, an expanded list of objectives is being addressed at the front end of the IRP process (Dixit, S. et al, 2014). In South Africa, for example, planning objectives include minimum capacity contributions from renewable energy from IPPs that must be met or exceeded. They also include maximum greenhouse gas emissions levels that may not be exceeded. Both requirements were established through Department of Energy determinations based on government policy.[11]

10 To illustrate this with a hypothetical example, gas-fired generation might be a very inexpensive resource if future gas prices are low, but very expensive if fuel prices are high. Planners might expect future gas prices to be low, but adjust the plan after-the-fact to include less gas-fired generation than the "least-cost" resource portfolio would dictate, as a way to hedge against the possibility of high future gas prices.

11 IRENA (2015b) lays out a comprehensive framework which can inform policy makers as they embark on the task of establishing or revising such objectives.

Other environmental requirements (*e.g.* water limitations) might also be identified as planning objectives at the outset of the IRP process. A plan is then developed that simultaneously satisfies these objectives and the traditional reliability objective at least cost, rather than developing a plan that doesn't meet those objectives, which must then be adjusted. (Risks and uncertainties can still be considered through sensitivity analyses and scenario modelling.)

In many parts of the developing world, expanding access to electricity is another particularly important objective to add to the list. Rural electrification plans are typically developed separately from IRPs, and the goals of those electrification plans then serve as important objectives that the IRP seeks to satisfy at least cost. If a rural electrification plan does not yet exist, it might be helpful to develop one before proceeding with the IRP. Alternatively, the IRP could evaluate scenarios based on possible goals, patterns, or timetables for electrification.

Included in the planning objectives of many jurisdictions in the United States is further specification of the costs to be minimised. Many jurisdictions now take a broad societal view of costs that is not limited to the utility's actual costs of service. For example, this can include an imputed cost for the environmental impact that the utility does not actually incur, but which reflects the cost to society of that impact.

As an example, the NWPCC defines its objectives for planning to include adequate, efficient, economical, and reliable power supply, and due consideration of environmental objectives. The plan identifies the least-cost resource portfolio after incorporating defined objectives for renewable energy and environmental requirements as constraints on the range of possible solutions. An imputed price of carbon emissions is included in the analysis of least-cost solutions. The NWPCC process involves testing each potential resource portfolio against 800 different futures (reflecting different risks and uncertainties) and then selects the least-cost plan subject to the level of risk exposure that is deemed acceptable (sometimes characterised as an "insurance policy").

Key point

Limit the scope to cover only those supply-side and demand-side resources that are acquired or developed by a regulated utility, or is within a governmental agencies' direct responsibility. Match the geographical scale of the planning process to the service territories of the utilities that will implement the plans, or the entire jurisdictions' territory, if a governmental body or specifically created organisation serves as the jurisdictions' planning authority.

Coverage and geographical scale

Outside the United States, the term "integrated resource plan" or "integrated energy plan" is sometimes used to describe a comprehensive energy plan covering all sources of energy, including transportation fuels. In the United States, where IRP was first practiced, resource planning is fundamentally about planning for the energy resources that are developed or acquired by regulated utilities. A resource plan is said to be "integrated" not because it is comprehensive in coverage, but rather because it integrates both supply-side and demand-side resources. Because the term IRP is used differently in different regions of the world, it is important at the outset of an IRP process to clearly delineate the types of resources that will be covered by the plan.

Although most US states require electric utilities to do IRPs, fewer require gas utilities to do them, and none require transportation fuel companies (which are not utilities in the United States) to do them. The United States has many combined gas and electricity utilities, but even so, there are very few examples of combined gas and electricity IRPs. Many US state governments have also developed comprehensive energy plans that cover all sources of energy, including transportation fuels and home heating fuels, but those are separate from the IRPs developed by utilities.

IRP processes are usually mandated by a law or regulation that is only applicable within a specific political jurisdiction. In those US markets which rely on vertically integrated utilities to plan and implement, separate IRPs will usually be developed if there is more than one utility per jurisdiction (though there are some examples of IRPs that cover more than one utility within a jurisdiction). In South Africa, where the Department of Energy holds the planning authority, the entire jurisdictions' territory is covered in the plan.

Key point

Limit the scope to cover only those supply-side and demand-side resources that are acquired or developed by a regulated utility, or is within a governmental agencies' direct responsibility. Match the geographical scale of the planning process to the service territories of the utilities that will implement the plans, or the entire jurisdictions' territory, if a governmental body or specifically created organisation serves as the jurisdictions' planning authority.

Time horizon

Planners will need to decide on a time horizon for the IRP, *i.e.,* how far into the future it will look. Of the US utilities that develop IRPs, nearly all use a ten-year to 20year time horizon (Wilson and Biewald, 2013). A small number of utilities in the United States and in other countries use longer time horizons, however. For example, Black Hills Energy in the US state of Colorado and NB Power in the Canadian province of New Brunswick use 25-year planning horizons.

The reasons for using a long planning horizon relate to the durable nature of the infrastructure that is being developed and the long lead times needed to develop these assets. Most traditional generation resources have asset lives of 20 to 50 years (or more). Hydro, coal, and nuclear plants are often in service even longer. Even shorter-lived plants such as solar panels and wind turbines typically have effective lifetimes between 15 and 25 years. Thus, it is not surprising that plans for acquiring these durable assets will have long time horizons. Also, the planning and construction horizon for large, capital-intensive projects such as hydroelectric facilities or nuclear power plants can be more than ten years. Natural gas, wind, and solar assets may have much shorter lead time requirements of just one to three years. If the planning process does not have at least a ten-year horizon, it may not be possible to fairly consider assets that have long lead times. Infrastructure that can be developed more quickly will be favoured, regardless of whether it represents the least-cost, long-term option.

The NWPCC relies on a 20-year horizon, whilst South Africa relies on a 20+ year horizon.

In jurisdictions where universal access to electricity has not yet been established, power systems develop dynamically and there are comparatively greater uncertainties with respect to supply and demand. This heightened uncertainty, however, argues for more frequent updates to the IRP, rather than a shorter time horizon.

Key point

Plan for periods of 20 to 25 years. To do otherwise will truncate long-term benefits usually in favour of less capital-intensive resource commitments. The long-term planning horizon is likely to also benefit most renewable energy technologies due to their capital-intensity.

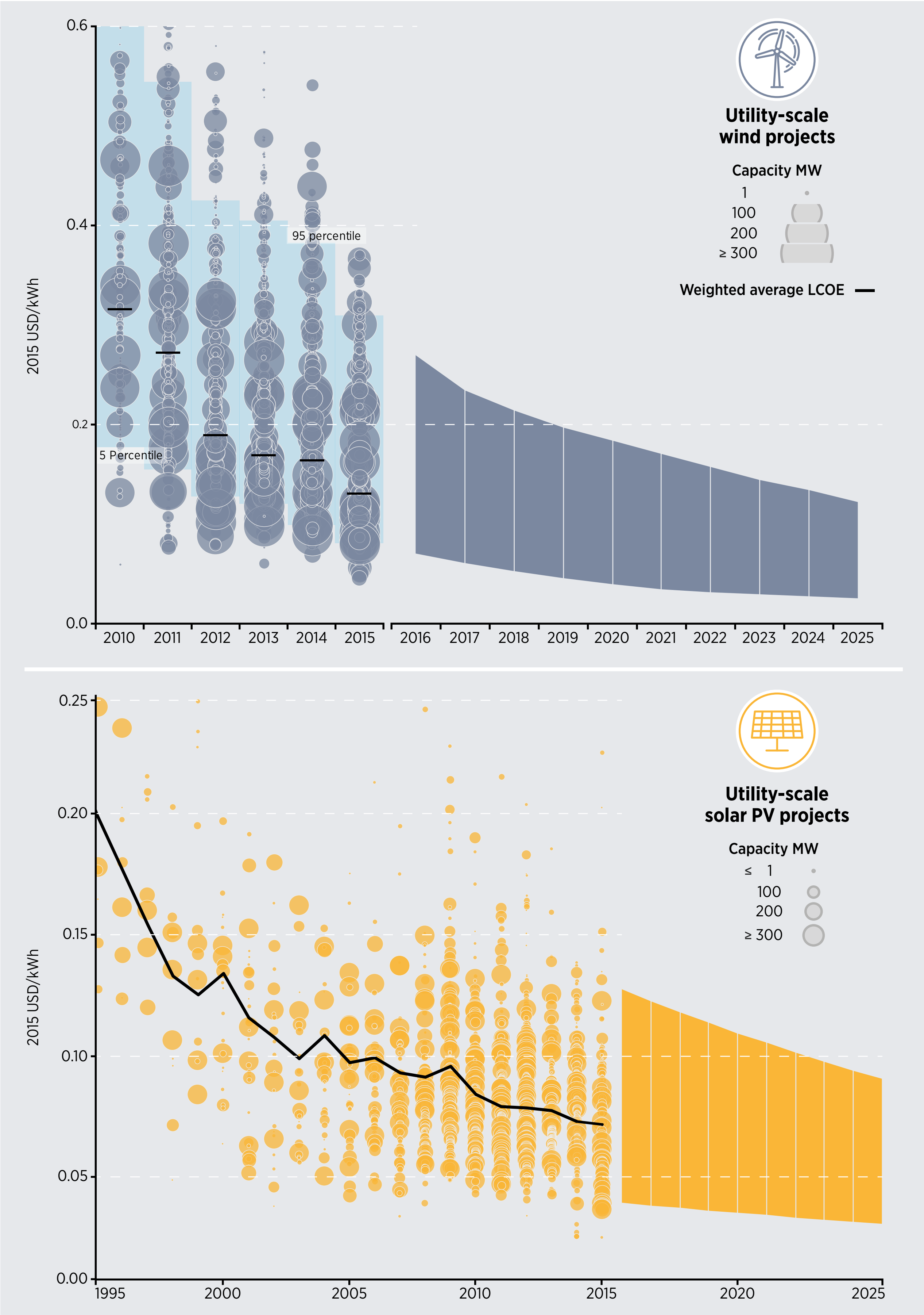
Updating frequency

To maximise the accuracy of IRPs for resource acquisition, the IRP must be based on reasonably current information. As IRP input parameters continuously evolve, it is important to periodically update the resulting plan to reflect the changes in assumptions and planning conditions. Thus, an important decision for policy makers and planners is to decide how frequently the IRP will be updated. Relevant factors that impact the appropriate frequency of updates include changes in fuel prices, load and load forecasts, capital costs, market conditions, and environmental regulation.

Updates can become increasingly necessary under current conditions, where renewable energy technologies' costs are significantly declining within short timeframes. Technology costs (and associated costs of generating electricity) of some renewable energy technologies, particularly wind and solar power, have rapidly declined in recent years and are expected by nearly all industry observers to continue declining into the future. See, for example, Figure 6, for the recent and projected cost data from IRENA.[12]

12 The projected costs for wind and solar PV in 2017 seem to slightly overestimate the actual costs as calculated in a more recent IRENA publication (see IRENA, 2018). This again speaks to the relevance of using the most recent data for renewables costs.

Figure 6 Global range of electricity generation costs for wind and solar projects



Source: IRENA (2016b)

If planners rely on past or current costs for those rapidly-improving technologies, they will almost certainly overestimate future costs. This could lead to the development of a resource plan that under-invests in renewable resources and over-invests in more conventional technologies that are not experiencing similar cost reductions. Some jurisdictions now use future cost curves for renewable technologies, instead of a static future cost, to minimise that risk. They might assume that the cost of solar and wind power, for example, will gradually decline throughout the planning period based on technology learning curves.

Developing an IRP is a resource-intensive process. Deciding on how frequently to update the plan requires balancing the costs of planning with the benefits of using up-to-date information for making resource acquisition decisions. It is most important for the plans to be up-to-date in relation to major capital projects, as well as the feasibility and costs of alternatives to potential future projects like energy efficiency and demand response, that may or may not be subject to formal review by regulators. Wherever high levels of investment in the power sector are happening at a rapid pace, the risks associated with using outdated information are greater, as is the value of frequent IRP updates.

The frequency with which plans are updated varies by jurisdiction. In the United States, IRP updates happen every two to five years. In adopting its first plan in 2011, South Africa recognised the need to update frequently in a "living" document and planned to update their plan every two years (South Africa Government, 2011). Given the many changing conditions in the industry, this aspiration is sound. Some jurisdictions, for example Brazil, update their resource plans annually – but this is generally only feasible if the update is partial (rather than comprehensive), or if the planning process is less rigorous than an IRP following proven practices.[13] Australia's National Transmission Network Development Plan is also updated annually.

In general, countries or utilities facing severe resource limitations may feel that frequent updates are simply not affordable, but they would be wise to consider the possibility of even higher costs resulting from bad resource decisions based on an outdated plan. Figure 7, from the PJM ISO in the United States, shows how annual regional forecasts of future load have declined in recent years – by thousands of megawatts. This example illustrates the importance of frequently updating plans and of using the most current available data. If utilities and IPPs in the PJM market were to invest in infrastructure assets today based on the load forecast from five years ago, they would over-build the system and risk losing huge amounts of money on stranded assets. Similar risks apply at the scale of single-jurisdiction IRPs.

Key point

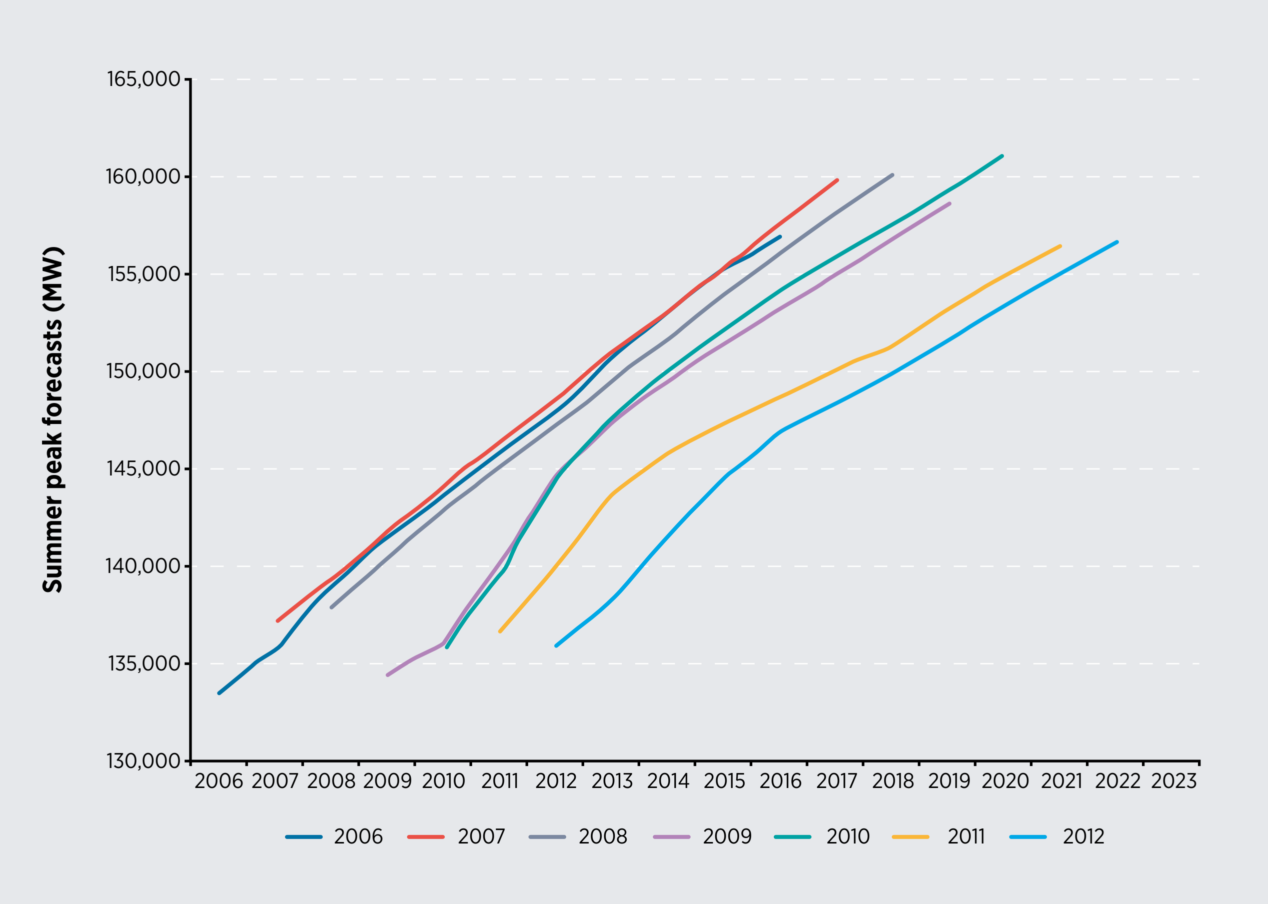
Plans must continually respond to changing forecasts for the economy, fuel prices, and market conditions for electricity. In an environment of evolving technologies and rapidly declining costs for renewable resources, assessments can become out-of-date very quickly. Regulatory requirements that call for frequent updates (*e.g.*, at least every two to three years) reinforce this message. Conduct less comprehensive updates and reviews at least on an annual basis and include estimates on future costs.

Stakeholders and public engagement

The benefits of stakeholder involvement and transparency in power system planning are widely recognised (for example Dixit, S. et al, 2014). Stakeholders commonly include power sector participants, but also public sector representatives of jurisdictions affected by the plan. Public and stakeholder engagement in the IRP process is almost always sought voluntarily if it is not required by authorising legislation or regulations. Public participation helps ensure that broader public concerns and priorities are considered, as well as the sometimes-considerable knowledge of unaffiliated experts that offer additional information and perspectives. In areas that have

13 A partial update, for example, could maintain most of the data inputs and scenarios previously analysed but apply new data for a limited set of specific variables. Comprehensive updates to the plan could be done less frequently.

Figure 7 History of PJM peak load forecasts, excluding territory expansions



Source: PJM (2016)

PJM is a US regional transmission organisation that co-ordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia.

seen little deployment of renewable energy, such as many parts of Africa, it may be especially important to invite input from renewable energy industry experts.

Public and stakeholder engagement can come in multiple forms. Broadly speaking, two levels of engagement can be considered: 1) Active stakeholder involvement, where stakeholders are actively involved in the planning process in order to validate and verify the assumptions pre-emptively; and 2) Transparency (or "passive involvement"), where information is provided to the public in a later planning stage to explain why something is needed, why a certain solution is proposed, and what costs are to be expected. Early engagement with stakeholders and the public helps to identify potential problems before options have been foreclosed. Well-formed engagement leads to better plans and broader buy-in from the public and governing institutions, including during the implementation stages of the plan.

For example, the regulator in the US state of Arizona recommends that utilities form a stakeholder group to advise their planning efforts. It further recommends that the group be comprised of customers, IPPs, and other stakeholders. Many US states (*e.g.,* Vermont) also rely on a ratepayer-funded public advocate to provide technical expertise during the development and review of utility IRPs. Public hearings, where stakeholders have an opportunity to participate in the regulatory review of the plan, are usually part of the IRP process.

Box 6 **Stakeholder and public engagement in IRP development: The US Pacific Northwest**

The need to reflect variations in public opinion across one US region is reflected in the membership of the Northwest Power and Conservation Council (NWPCC). This is comprised of two voting and paid members from each of the states that are covered by the organisation's geographical footprint. These members are appointed by the governor of their state. Beyond this, the NWPCC includes the participation of experts and stakeholders as advisors to the planning efforts. The statute that created the NWPCC requires the establishment of a scientific and statistical advisory committee, and authorises the creation of additional advisory committees, as and when the NWPCC deems necessary. The planning process is a 24-month process and the last plan (the seventh plan) relied on seven advisory groups. The groups are comprised of unpaid experts that are nominated and ultimately appointed by the NWPCC. The advisory groups have been organised around load forecasting, system planning, energy efficiency, generating resources, and the resource strategy. The role they play is in providing data and feedback.

Public and stakeholder involvement in the NWPCC process is essential to achieving buy-in to the planning efforts. The NWPCC process is fairly unique in that the NWPCC does not implement plans and has no direct authority to implement plans. Rather, the weight of the plan for the utilities, regulators, and governing bodies is derived from their direct involvement and the credibility that results from that.

Beyond the stakeholder involvement, there is also public involvement. The latter occurs in many ways. With respect to the NWPCC process, staff are encouraged to engage with the public and the planning director meets monthly with the stakeholders and the public outside of the advisory group process. There were typically two public hearings in each of the four states before a plan is adopted.

Examples can also be found outside the United States. South African planners are not required by statute to engage stakeholders or the public, but nevertheless include a public engagement process as part of establishing an IRP (DoESA, 2017). The Energy Regulation Act, 2006 of South Africa also authorises the regulator to engage committees of technical experts or stakeholders in the process of reviewing matters that it deems appropriate (including IRPs). Funding for such committees must come from licensees.

Key point

Stakeholder inclusion can add to expert knowledge, while engagement fosters acceptance for a plan. Public engagement further allows the understanding of priorities and manages concerns. In the early stages of renewables deployment, stakeholders can bring information on 'new' technologies otherwise not considered. They will also often point towards the socio-environmental considerations of technological choices.

Open access: Data, methods and models used

The planning process is a data-intensive exercise relying on information from many different sources, including the electricity utility (if applicable), IPPs, other energy service providers, and government. Data on fuel prices and economic forecasts can be provided by major national and international organisations, such as the International Energy Agency (IEA) and development banks. Information can also be obtained from collaborators in the planning process, including stakeholders and customers. To the extent that formal markets are involved, information can be obtained about markets from online sources and the operators of the markets. Online access to non-commercially-sensitive information about markets should be widely shared.

Extensive data is needed for even basic load forecasts. Ideally, the data to be used is readily available internally from the utility (*e.g.,* customer loads by class) or other entity conducting the planning. Supervisory control and data acquisition (SCADA) systems and advanced meter infrastructure can provide valuable information about loads and, increasingly, net loads (*i.e.,* loads net of any customer-generated electricity).

Information on customer generation should be maintained by the interconnecting utility.

Finding current information about relatively new or emerging technologies, such as renewable energy and energy storage resources, can be particularly challenging. The best sources of data for these technologies may come from industry stakeholders. Critical to understanding least-cost solutions is to understand how the costs of newer technologies are changing. Technology cost learning curves can be helpful for anticipating the further expected significant cost reductions of renewable energy technologies (see Figure 6). Stakeholders and utilities can be helpful in providing current data for costs and learning curves.

Instead of production cost forecasts, there are cases which experiment with the use of real-world prices to overcome planners' data gaps during a planning process. At the heart of this change to the planning process is the integration of Request for Information (RFI) and Request for Proposal (RFP) prior to establishing the procurement needs. In other words, the planner uses feedback on the project developers' own cost estimates from a bidding process to parametrize models and develop resource portfolios (see also Chapter 5).

It is important to establish data resources that are tailored to the needs of the jurisdiction. Finding current, locally relevant data can be a challenge in many, if not most, developing countries. For example, this was identified as an issue by Southern African Development Community (SADC) members, including South Africa. The Energy Regulation Act, 2006 of South Africa identifies the adoption of planning assumptions as the first step in its IRP process.

Open access to data, as well as access to analytical methods and models, is important not only for ensuring robust results, but also for inter-agency (and inter-governmental) coordination of plans and planning efforts, and for building trust with the public, civil society, and the stakeholder communities affected by the plans. Planners, specifically utilities, are commonly suspected of driving results by artificially constraining the range of resources or scenarios. Open access to data can mitigate these concerns.

There are various ways to model plans, generally requiring the use of power system optimization or simulation models. Most of these models are developed by third-party vendors, who license utilities and other planners to use the software (Wilson and Biewald, 2013). A variety of other models may also be used to address other data elements in the analysis. The most sophisticated power system models tend to be proprietary and expensive, and require substantial training to use. Even so, the regulator overseeing an IRP process has to provide stakeholders with temporary access to such models in the context of formal proceedings, so that there is reasonable understanding of the workings of the model, while also respecting the commercial concerns of model developers. In jurisdictions that find proprietary models too expensive, or where staff do not have the requisite training, outside consultants working under the direction and oversight of the planning entity may offer a more practical and affordable alternative to in-house modelling.

One of the most difficult challenges for modelling stems from a mismatch between the long-term focus of an IRP and the short-term variability in some of the renewable generation technologies that are growing most rapidly – especially wind and solar generation.

It is fairly easy to assess the expected long-term average capacity factor of renewable generators, but considerably harder to account for their short-term variability when modelling system impacts and costs. A failure to account for that variability, however, could lead to a sub-optimal or even an inadequate resource plan, if the contribution of variable renewables to resource adequacy (or "firm capacity"), or the need for flexible resources that can respond to such variability, are overestimated or underestimated.

An IRENA project called AVRIL (Addressing Variable Renewable Energy in Long-term Energy Planning) focuses on this very challenge, with some of the results being presented in IRENA (2017). The report offers technical guidance to practitioners in the field of energy modelling, including a catalogue of practical methodologies for modelling variable renewable generation sources in long-term resource plans. One of the key findings of the AVRIL project is that increasing the resolution of power system models in time and space can lead to more accurate representations of the contributions of variable renewables to firm capacity.

Ultimately, the goal of open access to data and models is to build stakeholder confidence in the inputs and the results. Stakeholders need to be engaged, if they are to develop, share and approve high-quality information.

Key point

Planning results are extensively driven by the quality of data and models used, and transparency about their use can foster quality and acceptance. There are many sources from which to obtain data, including stakeholders and research institutions. There have also been considerable developments in enhanced modelling practices. The use of costs from real-world projects is being tested to reduce the knowledge/data gaps on renewable energy technologies, and new modelling approaches improve the understanding of these technologies' interplay with the power system.

Load forecasts, scenario development, and establishing need

Load forecasts have traditionally been recognised as the first key step in the resource planning process. Historically, forecasting efforts have been focused on estimating future energy demand (loads) by the class and coincident peak demands of the system.

Load forecasts are often based on top-down statistical and econometric methods (linear or log-linear extrapolations of past trends) that use economic and demographic patterns of growth and electricity prices as the independent drivers of load. End-use (or bottom-up) forecasting can also be employed to develop load forecasts looking forward. End-use forecasting is data intensive and requires an analysis of loads built up from the user perspective.

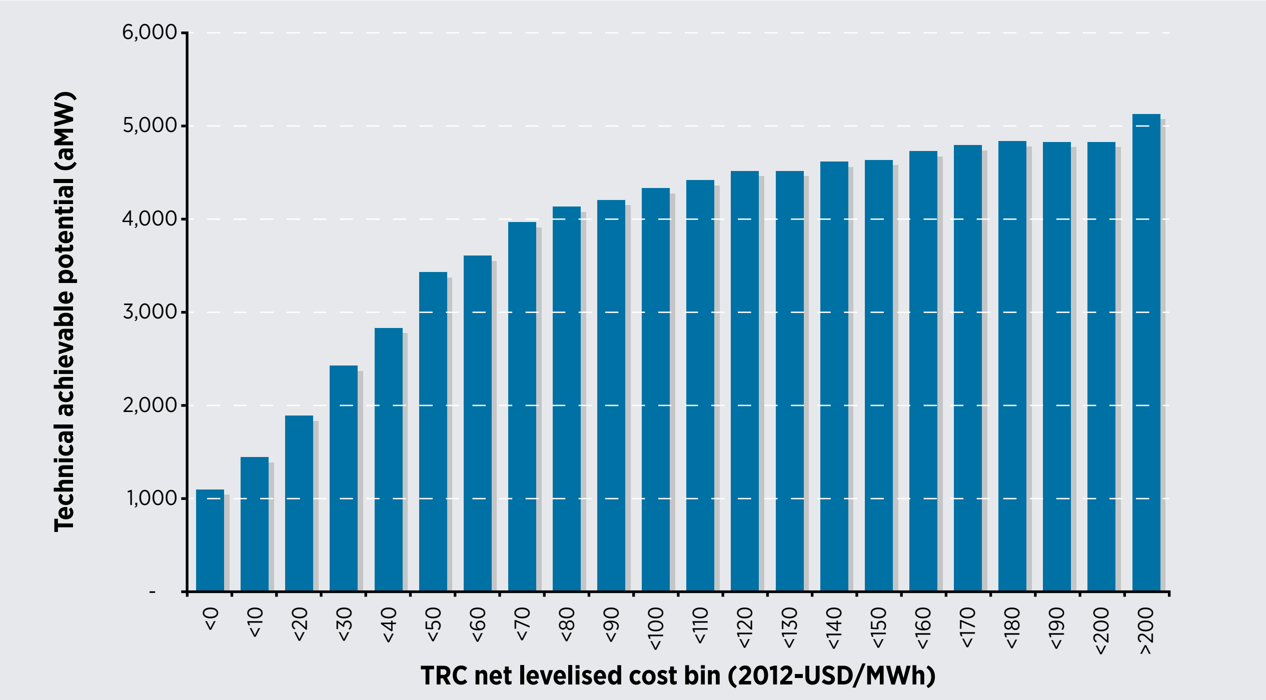
Planners have two options in considering the effect on future loads of demand-side management (*i.e.,* energy efficiency and demand response) programmes. Yet, strictly speaking, of the two, only the second option can render an IRP-type of plan (see the definition of IRP in Chapter 2). The first and most common approach is to adjust the load forecast based on the expected impact of energy efficiency standards and demand-side management programmes. That impact can be incorporated into load forecasts as either an integral component, as an after-the-fact adjustment, or both. The phrase "naturally occurring" energy efficiency is sometimes used to describe the fact that most consumer products become more efficient over time through normal competitive pressures to manufacture better products. Naturally occurring efficiency is typically captured in historical trends, and so may largely be captured through traditional top-down forecasting approaches. Future forecasts, however, may need to be adjusted, if there are major new policy interventions. These may include energy efficiency standards or programmes for common consumer products (*e.g.,* lighting), or demand response programmes for industrial customers that could have a material impact on future loads not captured in the historical trends.

The alternative approach in considering the effects of demand-side management programmes is not to adjust the load forecast, but instead, to treat energy efficiency and demand response as resources that can be added to the resource portfolio to satisfy demand.

The NWPCC, for example, develops supply curves such as the one shown below that indicate how much energy efficiency is potentially available at varying prices. Instead of assuming a certain amount of energy efficiency will be achieved, the model includes as much efficiency in the resource portfolio as proves to be cost effective, compared to other available resources. This approach allows energy efficiency to compete with supply-side resources on a level playing field and for optimization amongst resource options.

The analysis of utilities in the future must capture not only peak and average loads, but also understand the impact of variable energy renewables. One approach that is increasingly gaining traction is to focus forecasting and planning efforts on net loads – *i.e.,* loads after the impact of variable renewable generation has been considered. Net loads, rather than gross loads, will define the operating characteristics of the system that will need to be built and operated to provide reliable service.

Figure 8 Technical achievable conservation potential by levelised cost in 2035



Source: NWPCC (2016)

aMW = annual average megawatts

MWh = megawatt-hours

TRC = Total resource cost. This includes all quantifiable costs and benefits directly attributable to conservation measures, such as changes in consumption of other fuels, operations and maintenance expenses, non-electric costs or benefits such as water savings, and environmental costs and benefits.

Increasingly, flexible dispatchable resources like natural gas combined cycle generation and demand-response may be needed to deliver the flexible services required.

Because of the technical nature of load forecasts and their importance, they can take a long time to prepare. But in a power system facing rapid changes, load forecasts are in danger of becoming out-of-date prior to the completion of the IRP (Wilkerson, J. et al, 2014). The term "forecast" implies that planners have a good level of insight into how net loads might materialize. recent experience, however, suggests that developing an accurate baseline forecast is increasingly difficult, even for experts.[14] Given that there are many drivers of future loads, and that the science of long-range forecasting has not adapted well to the growing list of future uncertainties, the central emphasis on a baseline forecast may be misplaced. Uncertainty increasingly predominates, and the need to evaluate multiple forecast scenarios grows.

In the future, electrical load levels will be defined not by historical patterns of usage but by technological change and adoption, demand for energy efficiency services, price level and design, demand for new technologies (*e.g.,* plug-in electric vehicles), consumers as producers, electrification of villages, and storage and demand response. At least partly, some of these factors can be within the planners ability to control or manage (*e.g.* through rate design or incentives). So, even while forecasting is undermined by the break from past trends, determining future load levels may require some examination of the drivers that are within the planner's control and their own confidence in their ability to drive demand in ways that can be effectively managed and delivered.

14 Even at the national level in the United States, official forecasts have consistently over-estimated electricity demand. As an example, the government's 2002 forecast of US electricity demand in 2013 (11 years later) erred by 19.3%, after load growth failed to materialize following the many energy efficiency improvements made in lighting and equipment, with state and federal standards and utility investment in programme.

To capture the significance of uncertainty, it is important to test identified resource portfolios against several possible future load scenarios that may be influenced by various variables. These variables may include: population growth; economic growth; electrification of energy end uses; wholesale market prices (in regions with existing or developing wholesale markets); fossil fuel prices; and deployment of behind-the-meter generation and storage resources. Scenarios should at least consider the low, high, and medium development of these variables. They can also be informed by traditional forecasting methods, and/or by government and utility plans for development and electrification. Opportunities for electrification of transportation, and opportunities for consumers to develop their own resources using rooftop PV, community wind, and local storage options, can also inform these scenarios. Stakeholders can and should be involved in developing or reviewing the baseline load forecast and alternative scenarios, as is done for the NWPCC IRPs (NWPCC, 2013).

Net loads for energy efficiency, distributed resources and large-scale renewables require consideration, because net load is the load that the system operator needs to satisfy through the operation of dispatchable utility resources. Distributed resources which are not behind-the-meter, however, can also be included as a resource in addressing energy requirements, reducing uncertainty, or providing flexible resources that may help to balance the system in the face of increasing levels of variable resources, such as wind and solar.

Key point

Load forecasts are key to efficient planning, and IRPs consider demand response as a resource to supply that demand. Due to the variety of uncertainties associated with load forecasting, good planning processes involve stakeholders and apply possible load forecast scenarios. With the development of renewables, the relevance of scenarios may grow, and the concept of net load is commonly applied.

Resources included

Integrated resource planning efforts typically consider the full complement of supply-side and demand-side resources.

Distributed generation resources – including customer-sited and community-scale generation, such as rooftop solar PV – must increasingly be recognized for their impact on the system load (net of customer generation), and as a resource that can reduce the need for central station resources. (When combined with some forms of storage and demand response, distributed generation resources can also reduce the impact on distribution and transmission systems.) In countries where universal access to electricity has not yet been achieved, it may also be appropriate to consider mini-grids or micro-grids as an alternative to expanding the transmission grid, or as a temporary solution.

Almost all jurisdictions with IRP requirements require consideration of demand-side resources and energy efficiency. This practice likely began with the first IRP developed by the NWPCC, back in 1980. Increasingly, variable energy renewable resources are competitive with fossil fuel resources and will be included in IRPs because they qualify as a portion of a least-cost resource portfolio. In cases when renewable energy resources are not (yet) contributing to a least-cost mix, or only to a limited extend, their inclusion into an IRP will often satisfy public policy objectives for the power system. South African regulations require consideration of demand-side and energy efficiency resources, with the 2011 IRP identifying a substantial contribution from renewable energy to its resource mix.

The analysis of potential resources typically begins with a broad-based survey of technologies and costs that are generally available at the time of the analysis (see, for example, *Renewable Power Generation Costs in 2017* (IRENA, 2018) and the *Global Atlas for Renewable Energy* (IRENA, n.d.). This may be provided through an analysis by a third-party engineering firm, or based on knowledge of the planner, depending on its size and staff capabilities. Resource identification may also involve the identification of energy efficiency resource potential through a baseline assessment, also typically performed by a specialized consulting firm. A similar assessment may apply to other demand-side resources, including demand response. The identification of potential resources can be supplemented by more generalised public inquiries, or requests for information, from the public, stakeholders, and potential vendors of third-party and IPP solutions.

Key point

Consider all resources, including demand-side resources and an expanding list of renewable resources, in the development of the least-cost resource portfolio.

Resource characteristics and assessment

Before selecting combinations of resources that can form a potential resource portfolio, it is necessary to identify the types and amounts of resources that are already installed, or could be available, as well as their capabilities and operating characteristics.

The availability of some resource types is limited by natural factors. This is especially true for renewable resources (*e.g.,* hydro, solar, or wind), but can also be true for thermal resources in certain circumstances (*e.g.,* due to the availability of cooling water). Assessments of these resources usually begin with local knowledge of available potential in the region. Local knowledge may be enhanced as needed with detailed technical studies by experts. The *Global Atlas for Renewable Energy (*IRENA (n.d.) compiles resource assessments from around the world in a searchable online format.[15]

Resource assessments can also include consideration of energy efficiency potential. Some amount of energy efficiency will generally be available at a lower cost than all other resources. Jurisdictions with advanced IRP processes regularly update this potential as a contribution to setting targets for energy efficiency.

The assumed costs of new resources will greatly influence the outcome of any resource planning effort. The influence of new resources can vary geographically, depending on factors such as: regional variations in the delivery costs for fossil fuels; the quality of available renewable resources; financing costs; and other variables. Where possible, it is advisable to base resource cost assumptions on local cost data. An examination of actual costs from recent projects or procurements can be helpful in making assumptions about the future costs of new resources. It is important to understand the impact of cost-drivers on specific projects or procurements, in order to allow for the incorporation of their actual costs.

Resource assessments also identify the characteristics of the resources that can help to meet the planning criteria. These characteristics will, of course, include costs (capital and operating),[16] potential contribution to peak load capacity (or, increasingly, net peak), and potential hourly, daily, or annual energy contributions. In a world with increasing requirements for flexibility, driven in part by the contributions of variable energy renewable resources, the capability of a resource to provide ancillary services, such as fast ramping, should also be included in the resource assessment. The previously mentioned AVRIL project's resulting publication (IRENA, 2017) maps out the key characteristics of variable renewable energy sources in terms of their impact on the functional properties of the power system, and discusses how good planning practices can address that impact.

Key point

Resource characteristics can define costs and generation performance, thanks to factors such as variability and uncertainty. Renewable energy technologies' performance partly depends on natural factors which have to be understood and incorporated into the planning process. This is increasingly being done through renewable energy resource assessments, which are best performed for specific geographical locations in order to capture spatial variations in natural factors.

15 The web platform, hosted through the IRENA website, allows users to find maps of renewable energy resources for locations across the world.

16 IRENA offers a wealth of periodically updated publications on the costs of renewable energy globally and in specific regions. Refer to http://www.irena.org/costs/.

Option and resource portfolio identification and selection

In the context of an IRP, resource portfolios are bundles of resources that are capable of satisfying future electricity needs within the study area. Resource portfolio identification usually begins with the characterisation of existing resources. Future resource portfolios are built around the existing resources, with adjustments for any expected generating unit retirements. Additional resources may then be added to each resource portfolio, as needed to meet future electricity requirements.

Capacity expansion optimisation models are commonly used to identify potential resource additions. These models are designed to identify the types of resources that need to be added to the system, and what year they need to be added, to minimise the cost of meeting future capacity and energy needs. The load forecast and the characteristics of resources, explained in previous sections of this report, are inputs to the model.

IRPs commonly evaluate a manageable number[17] of potential resource portfolios, which allows planners to assess the performance of a variety of potential resource portfolios against a variety of unpredictable, uncontrollable futures. The resource portfolio that minimises costs according to the baseline load forecast is just one potential resource portfolio. Other potential resource portfolios can be developed using the same capacity expansion model, but with specified constraints or with different objective functions. For example, a constraint could be added to the model to identify a resource portfolio that achieves any given renewable generation target.

One other possibility is that resource portfolios can be identified based on stakeholder input. For example, if a very large hydroelectric plant or a new nuclear power plant are being discussed or considered by government officials, resource portfolios could be built that include those resources, even if they would not be selected by the capacity expansion optimisation model. The inclusion of stakeholders in this selection process is important to prevent biased selection.

When planning objectives include the adequacy of generation resources, the selected portfolio needs to be assessed during periods when the system is most stressed. Historically, the system has been viewed as most stressed during periods in which loads peaked on an annual basis. Planners thought of resource adequacy in terms of the need for baseload, load-following, and peaking generation capacity, while transmission and distribution systems were designed to accommodate peak loads. This peak-centric view of planning is gradually changing with the advent of larger amounts of variable renewables that require increasing levels of flexibility from the system at times other than annual peaks.

Planning efforts in the future will need to match not only capacity needs to net peak (peak load net of customer resources), but also the additional ramping capabilities of the system in meeting fluctuating loads and production. Increasing the spatial and temporal resolution of power system models will likely be necessary.

The next step in the IRP process is to model how all of the identified resource portfolios perform against a variety of possible futures. This can be done with the same capacity expansion model, but often involves more detailed system modelling, using hourly dispatch simulation models. Dispatch models are more difficult and costly to use than capacity expansion models, but they provide a more accurate reflection of hourly system operations and costs and can identify any possible deviations from operational security thresholds. Regardless of the type of model used, the key decision here is to determine the function(s) that will be used to compare potential resource portfolios.

In the United States, the traditional function used to select a preferred resource portfolio is to choose the resource portfolio that minimises the net present value of the revenue requirements (PVRR) needed to operate the system under the baseline forecast, using an appropriate discount rate to reflect the value of future costs. Other functions, such as the PVRR under non-baseline scenarios, or the greenhouse gas emissions of different scenarios, may be reported in the IRP, but are not

17 The number of portfolios that is "manageable" will depend on the funds available to the planning team.

generally used to select the preferred resource portfolio. Some IRPs, however, now use statistical methods to evaluate PVRR under multiple possible futures.

When multiple possible futures are considered, planners have a variety of options for selecting a preferred resource portfolio. They can, for example, choose the resource portfolio that is least-cost for the greatest number of future scenarios. They can also assign probability weightings to each scenario, and calculate the weighted average cost of each. Alternatively, They can choose a risk-based selection function that seeks to minimise the risk of a bad decision, rather than minimising cost under the baseline scenario. The NWPCC, for example, has chosen to evaluate potential resource portfolios using a risk-based measure called "TailVaR90", which reflects the average PVRR value for the worst 10% of simulated outcomes. Several other potential measures of risk are described in the NWPCC's IRP (NWPCC, 2006).

Another approach to selecting a preferred portfolio is to use a decision-making process based on multiple criteria. Instead of focusing only on cost, or risk-weighted estimates of cost, other planning objectives – such as energy security, resource diversity, domestic content, or greenhouse gas emissions – could be included in a weighted scoring system. Another method would be for decision-makers and stakeholders to be provided with the opportunity to rank the alternative portfolios, according to the information about these criteria supplied. Alternatively, one common way to incorporate greenhouse gas emissions into portfolio selection is to assign a cost to each ton of emissions, which would then factor into the calculation of PVRR values for every portfolio. The "carbon price" would be an input parameter, treated similarly to fuel costs, and the sensitivity of modelled results to this price could be tested through scenarios.

It is important for planners to clearly explain the criteria used to select a preferred resource portfolio, and that their choices are informed by input from stakeholders. Regardless of the criteria evaluated, it is also essential that the IRP process be executed in a manner that applies the selected metrics in a reasonably transparent and logical manner, without inappropriately screening out resource options or plans that deserve consideration at the next stage (Wilson and Biewald, 2013). Doing so will not only result in the best plan, it will reduce the possibility of political interference in the process and enhance stakeholder and public acceptance of the outcomes.

Key point

The identification of possible resource portfolios needs to evaluate load forecast scenarios and also consider policy objectives. The selection of the preferred portfolio is done through various methods, involving quantitaive and/or qualitative decision making processes. These optionalities require transparency to enhance stakeholder acceptance. The variability and uncertainty arising from larger shares of renewables can also require the testing of possible resource portfolios against the operational security standards of a given power system.

Planning with uncertainty

With the emergence of new technologies for renewable energy, energy efficiency, and storage, and rapidly declining costs for these technologies, it is increasingly apparent that forecasting the future based on past trends is inadequate. It is more important than ever for planners to acknowledge the significant amount of uncertainty about future electricity needs and the resources to meet those needs, and to evaluate a range of possible future scenarios that reflect those uncertainties.

Planners need to consider several categories of major uncertainty and risk. These include: load uncertainty and the risk of overbuilding or underbuilding infrastructure; lead times for construction; fuel prices; carbon regulation costs; market uncertainty; variable generation output (for hydro, solar, and wind); and other factors.

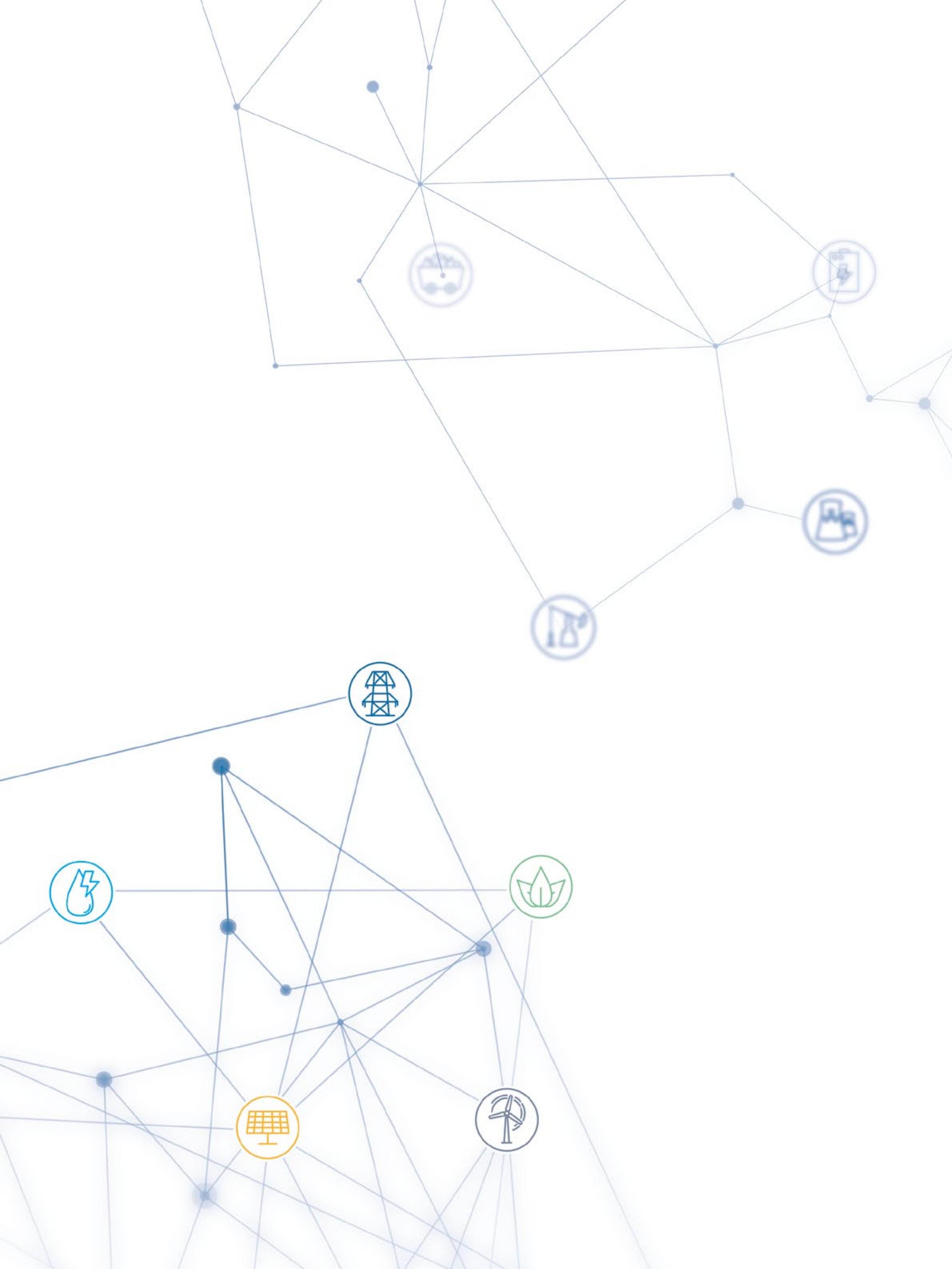
Planning for uncertainty, however, can be built into the decision framework at the front end of the planning process. In effect, the optimal choice becomes the plan or resource portfolio that best matches the trade-off between the lowest cost plan, and that which performs best against the identified risks.

For example, the NWPCC addresses uncertainty using Monte Carlo simulations. These simulations choose random values for each source of uncertainty according to their probability of occurring. Use of Monte Carlo simulations is needed to reduce the modelling exercise to manageable levels, from an analytic and computational perspective. The most recent version of the plan relies on 800 such simulations for each resource portfolio, with over a thousand variables (NWPCC, 2006). They calculate the net present value for 20 years of operation under each future, then look at the 80 most expensive futures and use those numbers as their measure for quantifying risk. The planners deliver a least-risk plan and a least-cost plan to the NWPCC and stakeholders for consideration. Policy makers can then decide what their appetite for risk is before selecting the preferred resource portfolio.

Most jurisdictions undertaking an IRP will not have the resources to conduct as thorough an evaluation of sensitivities as the NWPCC does, but good IRP planning requires incorporating risk and uncertainty into the evaluation of potential resource portfolios to the extent that is reasonable for each jurisdiction. Traditional approaches to stress testing the least-cost solution against only a short list of key uncertainties are thus now yielding to a more robust analytical method. This approach involves a combination of effective models that can easily evaluate a plan under many potential futures, with these randomly selected from a strong list of variables presenting risk and uncertainty.

Key point

Acknowledge the significant amount of uncertainty associated with modelling parameters and assumptions, and evaluate a range of possible future scenarios that reflect those uncertainties. Incorporate risk and uncertainty into the evaluation of potential resource portfolios to the extent that is reasonable. Go beyond traditional approaches to stress testing the least-cost solution against only a short list of key uncertainties, by using more robust analytic approaches. The incorporation of renewable energy technologies certainly adds to the need to apply good planning practices with uncertainty.



INSIGHTS ON PLAN IMPLEMENTATION 5

Plans differ from studies in that they offer an expression of what the planners actually intend to do. Studies can be and are executed by every stakeholder with an interest in the sector, with these studies commonly used to inform a targeted group of stakeholders, including a designated planning authority and government. Studies are informal, with no need for government to require and/or ensure adherence to any of the abovementioned planning practices in their production, as they are statements by individual stakeholders. As such, they do not constitute official documents with power over the direction of the sector.

Studies more typically describe possibilities, without a commitment to being carried out. Plans should therefore be developed with an eye toward actual implementation. There are a variety of mechanisms and approaches that reinforce the connection between plans and their realisation. The mechanisms that exist are sometimes direct and sometimes incidental to the planning efforts.

5.1 INSTITUTIONAL LINKAGES

In many regions, most of the planning that occurs is performed by the institutions that are ultimately responsible for the implementation of the plans. In some regions, this involves the utility or system operator. This holds for transmission planning in Europe and most resource and transmission planning in the United States. Elsewhere in the world, government may be an active partner in the implementation of plans. In South Africa, for example, this involves the energy department that is responsible for the sector and for oversight of the vertically integrated utility, Eskom.

At the sub-national level, some states like Vermont rely on separate planning processes to identify the amount of cost-effective energy efficiency resources available, and then rely on a third-party institution for the delivery of those cost-effective energy efficiency services. Planning efforts here are overseen by the sector regulator, and institutional responsibility for the delivery of energy efficiency services is established through a stakeholder engagement effort overseen by the sector regulator. Vermont's "energy efficiency utility" is then both the lead entity in development of the resource plan (for energy efficiency services) and the entity that is paid to deliver on those services.

In Brazil, the National Electric Energy Agency (ANEEL)[18] and the Electric Energy Commercialisation Chamber (CCEE)[19] are responsible for the procurement of all components of the annual electricity expansion plans, developed by the EPE, and published by the Ministry of Mines and Energy. In South Africa, the Department of Energy is responsible for the procurement of renewable energy from independent power producers through the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). The program

18 ANEEL is the Brazilian electricity market regulator.

19 CCEE is a non-profit entity, established under private law, regulated and overseen by ANEEL, with assigned expert functions, such as the implementation of auctions, PPA registration, and administration of energy reserve requirements.

provides an indirect link between the entity responsible for the IRP (the Department of Energy) and the process for procurement of generation resources. The establishment of this programme has proven instrumental in the delivery of renewable generation resources by IPPs in South Africa.

A strong institutional linkage is needed between the entity responsible for developing the plan and the institutions that are responsible for delivery.

5.2 MARKET LINKAGES

In many jurisdictions, the connection between plans and procurement targets is direct and subsequent. As an example, in ISO-NE, the planning process identifies the capacity required for meeting system needs, which is afterwards solicited and procured through a capacity market mechanism (in the case of generation resources) and a Request for Proposals (RFP) process (for transmission), both of which are specified in federally approved tariffs.

In Brazil, ANEEL has organized over 40 auctions since 2004, either directly, or through the CCEE. The auctioned capacities are directly linked to the annual electricity expansion plans, developed by EPE, and published by the Ministry of Mines and Energy. Since 1999, all transmission capacity has been acquired through competitive auctions (Brattle, 2014).

In South Africa, the REIPPPP is an auction-based price determination mechanism, designed to contribute toward renewable energy procurement targets established in the IRP (IPP Office South Africa, 2016). This programme has performed well in the context of the 2010 IRP (Eberhard, A. et al., 2014).

As the above examples suggest, competitive mechanisms such as auctions are becoming a widespread practice for identifying competitive prices to procure the resources identified in an IRP or power system plan. CEM and IRENA, 2015 offer further information on the benefits of auction-based approaches, and suggestions for their implementation.

New types of planning processes are currently being tested to better integrate the initial steps of the procurement process into the planning process. This is being largely driven by the acknowledgement of uncertainty and risks resulting from the costs of emerging technologies, including renewable energy resources. The Hawaiian Electric Company (HECO), for example, has proposed a new planning process which better accounts for growing resource diversity and complexity (HECO, 2018). The aim is to use market-based approaches to select competitive technologies as part of a plan's resource portfolio, and also to identify their underlying costs for service provision.

The novelty in this updated planning process lies within the simultaneous optimisation of technology choices across resources, transmission and distribution needs. It also lies in letting market actors propose suitable technological solutions at their own proposed costs. While it is too early to draw conclusions on the effectiveness of such an approach, it does seem very much worth further consideration, testing and monitoring by the planning community.

Power system plans also have an important role in guiding and facilitating the engagement of multilateral development banks, such as the World Bank Group or the African Development Bank (AfDB), in electricity infrastructure projects. At various stages of a project cycle – which defines the project development process of moving from conception to realisation – power system plans are an essential means of dialogue and negotiation. The AFDB, for example, works in close cooperation with regional member countries in defining development strategies and operational programmes, which are manifested in reports entitled "Country Strategy Papers" (AfDB, 2018).

These papers are usually prepared on a three- to five-year basis and are updated annually. The AFDB does not do the planning for the respective countries in the context of these papers, but rather evaluates existing power system plans or studies. These country strategies not only guide the AfDB's involvement, but also serve as major instruments of policy dialogue.

During the drafting of each country strategy paper, the AfDB tries to identify county projects which are "deemed implementable and considered technically, socio-economically, financially, and

Key markets offer examples of proven practices in power system planning

environmentally justified" (AfDB, 2012). During the project identification phase in particular, country strategy papers – and therefore countries' existing power system plans – are the key instruments in putting projects forward. In the most recent strategy paper for the United Republic of Tanzania (AfDB, 2016), for example, AfDB commitments are meant to contribute to the national government's objective of increasing electricity access in the country from 24% in 2013 to 32% in 2020. These AFDB-supported targets, in turn, stem from the Electricity Supply Industry Reform Strategy and Roadmap 2014-2025 (United Republic of Tanzania, 2014).

Clear linkages are needed between planning goals and procurement and finance mechanisms.

5.3 STAKEHOLDER AND GOVERNMENT ENGAGEMENT

Once again, the NWPCC provides a good example of the central importance of stakeholders to plan implementation. As characterised earlier, the stakeholder engagement process used in the development of the NWPCC plan involves the appointment of stakeholders (state government officials) to positions of leadership on the NWPCC, and relies on seven committees of unpaid experts to advise the process. It also emphasises public and stakeholder processes throughout the planning efforts. State planning has largely been consistent with regional resource plans since about the year 2000. This linkage exists despite the fact that there is no legal enforcement mechanism that ensures the implementation of the NWPCC plan.

Effective strategic engagement is needed with all utilities, stakeholders, government officials and other entities that are ultimately responsible for the implementation of plans.

5.4 REGULATORY LINKAGES

In the United States, states establish linkages between approved IRPs and the cost recovery of investments that are made under those plans. In most states, formal filing of IRPs is required as part of state regulations. In some states, like Vermont, there is an opportunity for regulators to review and approve the plans. Approval of IRPs is viewed by utilities as a way of increasing their likelihood of cost recovery by building a linkage between reasonableness in the plans and later, in the cost-recovery proceedings that may follow.

Regulatory linkages between successful planning efforts and the implementation of plans can run far deeper than direct review of cost-of-service filings in relation to planning efforts. Effective regulation may include mechanisms that help to align utility incentives (or remove disincentives) with efforts to develop and implement least-cost plans. Efforts that exist may be embedded in multi-year rate or alternative rate plans that attempt to provide stronger linkages between utility performance and public service and policy objectives, including investments in clean energy and energy efficiency (Littell et al., 2017).

Having an approved IRP or transmission plan also reduces the incentive for developers to offer the utility unsolicited bids for new resources. Because an effective planning process identifies the preferred portfolio of resources, or the most cost-effective transmission and non-transmission alternatives, the burden and pressure of reviewing unsolicited bids can be greatly reduced.

An effective linkage has to be created between power system plans, the subsequent component projects that represent accurate implementation of those plans, and cost recovery.

5.5 ACTION PLANS (EMBEDDING LINKAGES IN THE PLAN)

The traditional mechanism for linking IRPs to implementation activities has been to simply embed the activities in the plan itself, in the form of an "action plan". These are simply components of the plan that describe the steps that need to occur sooner rather than later.

Even though IRPs should have a longer planning horizon, a good plan will include a specific discussion of the implications of the analysis for near-term decisions and actions, and will also include specific plans for getting those near-term items accomplished. Demand-side measures take time to implement, and supply-side resources require months or years of lead time to gain permissions and to construct. Planning entities should thus provide a clear discussion of the steps they plan to take to implement, acquire, or construct resources that will meet energy and peak demand needs in their service territories in the one- to five-year period after the plan is filed. The availability of these near-term resources has a direct effect on the resources needed throughout the remainder of the planning period. Because of this, it is prudent for the utility to detail the ways in which it will go about acquiring those resources in its IRP (Wilson and Biewald, 2013).

The action plan included in an approved IRP also serves as a clear signal to the utility, to IPPs, and to those responsible for financing power system investments about the timing and kind of investment needed. Private investors can move forward more confidently with projects that are identified in an approved action plan. Public investors (*e.g.,* the Treasury that finances investments by a state-owned utility) will similarly have confidence that projects in the action plan are part of a least-cost or least-risk long-term plan for power system development.

Observed performance relative to this action plan then becomes a reference point for regulatory scrutiny in resource procurement decisions and cost-recovery proceedings. In the United States, action plans are commonly prescribed in regulations or rules for IRPs by a US state commission and are embedded in the IRPs prepared by distribution utilities. Around the world, they are also included in regional plans.

A clear, direct linkage is needed between long-range planning efforts for the power system and the intervening steps that the utility or others will need to take to successfully implement the plan, over a shorter-term horizon.

INSIGHTS FOR REGIONAL POWER SYSTEM PLANNING 6

In some regions of the world, jurisdictions collaborate to develop regional power system plans, often called master plans. These plans typically involve a coordinated examination of generation resources that could potentially serve multiple jurisdictions, but often the focus is more on transmission interconnections between jurisdictions. Demand-side resources, though rarely considered at the regional level, have emerged as a key consideration for the same reasons that they matter for single-jurisdiction resource planning.

Several mechanisms for regional planning have been tested and used in parts of the world where a synchronised electricity grid crosses jurisdictional boundaries. Some of these mechanisms have emerged specifically to support the increased development of renewable resources. Each mechanism has the potential to address different challenges and opportunities in regional planning, and each lends itself to a different regulatory oversight structure.

The most familiar mechanisms for regional planning include:

- **Regional resource plans, or regional IRPs:** These can be developed by a regional entity vested with authority across multiple jurisdictions, or by a private utility that operates in multiple jurisdictions and shares resources across jurisdictional boundaries, or by a consultancy, as a special study.
- **Regional transmission plans:** These can be developed by a regional transmission organisation to ensure resource adequacy and identify cost savings across utility boundaries.
- **Regional power system plans:** Known as "master plans", these can be developed in a way that combines elements of resource planning and transmission planning.
- **"Renewable Energy Zones":** Entities from multiple jurisdictions can collaborate to jointly identify and develop these. Such zones coordinate the large scale development of renewable-based generation and the transmission needed to deliver the resulting power to load centres, without planning other aspects of the power system. This approach, which can also be employed within a single jurisdiction, is explained in greater detail in Chapter 3 and Chapter 7.

Regional power system planning efforts share much in common with IRP or single-jurisdictional transmission planning, but also raise unique challenges that are worthy of separate consideration. This chapter will review proven practices that can be applied to regional planning. For issues where IRP and regional planning are not substantially different, readers will be referred back to the appropriate part of the IRP discussion above, rather than repeating that information. Unlike earlier sections, which have focused on core IRP aspects other than transmission, this chapter focuses both on regional IRP and regional transmission plans.

At the regional level, in particular, integrated planning has to take transmission into account.

Moreover, single- and multi-jurisdictional transmission planning are relatively similar. This report elaborates on transmission planning mostly in the context of regional planning. Major aspects on this regional dimension, however, are also relevant to single-jurisdictional planning.

As was the case with IRP, adopting proven practices for regional power system plans may not initially be feasible in all regions due to practical considerations. In those cases, adoption of key practices tested and proven in other markets can be a long-term goal toward which planning practices evolve.

6.1 OVERARCHING PRINCIPLES

The principles for regional power system planning are similar to those of single jurisdiction planning, and need not be repeated here in great detail. In summary, the region should have well defined objectives that centre on reliability and cost. The region should have a well formed and effective stakeholder and civil society engagement process. The region should allow an unbiased consideration of all resources and mechanisms in place, in order

Box 7 Featured examples of regional power system planning

Brazil

Since 2004, the Brazilian Energy Research Office (EPE) has been the main entity responsible for the implementation of electricity system expansion planning within the National Interconnected System (SIN). EPE is a state-owned company equipped with specialised technical staff, with its functions co-ordinated, guided and monitored by the Ministry of Mines and Energy. The SIN covers most of the Brazilian landmass, leaving out one isolated system found mainly in Northern Brazil, with the plan to connect both systems within a decade. The Ten-Year Energy Expansion Plan is prepared annually by the EPE and published by the Ministry of Mines and Energy. The plan summarises generation as well as transmission studies and optimises a portfolio of generation and transmission assets through cost-benefit analysis.[20]

The EU

The EU represents a work-in-progress with respect to power system planning practices. The EU has successfully established a regional organisation, the European Network of Transmission System Operators for Electricity, that offers the potential for co-ordinated transmission planning across many countries. Country-specific planning still predominates transmission planning, however, and there is little resource planning. This is largely due to a reliance on deregulated wholesale electricity markets to drive generation investment decisions. Limited regional oversight of the transmission planning processes comes through the Agency for the Cooperation of Energy Regulators (ACER).

New England (United States)

Regional planning occurs through a regional power system operator (a.k.a. an ISO, or regional transmission organisation). The New England region includes a mix of one vertically-integrated utility system (Vermont) and five restructured states that allow retail competition. Oversight of individual distribution systems comes mostly through state regulation, while most oversight of regional planning efforts is federally regulated by the US Federal Energy Regulatory Commission (FERC). Vermont is unique in New England in that it has a single state-wide transmission company that owns no generation or distribution assets, yet planning efforts for that transmission company still include consideration of non-transmission alternatives.

The Pacific Northwest (United States)

Transmission planning occurs through separate regional transmission owners, with federal oversight. Implementation of NWPCC plans is performed by participating member utilities at the state level with state regulatory oversight.

20 The Brazilian authorities regard the 10-Year Energy Expansion Plan as indicative, as investors are ultimately responsible for deciding whether to build new power plants, through offers submitted in energy auctions held on an annual base.

to recognise the resource potential and impact of renewable energy, energy efficiency, and demand response. The full complement of services delivered through, or required by, these resources should be included in decisions on their development.

Regional planning differs from sub-regional, jurisdiction-specific planning in that the authority to ensure that all parties uphold commitments to the region is either not present, or exists at a higher level of government (*e.g.,* a federal government with authority over multiple jurisdictions). In most jurisdictions, a mechanism should be in place to secure accountability. Alternatively, there should be a co-operative engagement such that participation by sub-regional governments implies shared ownership and responsibility of the plan. Some form of regulatory oversight is also warranted. Chapter 3 discusses in greater detail these special regional considerations with regard to regional legal authority and regulatory oversight.

One aspect of regional planning that differs substantially from single jurisdiction planning is the need to determine how the costs of resources and transmission serving multiple jurisdictions will be allocated to those jurisdictions. This is always a crucial decision that can determine the success or failure of a regional plan, and thus it must be guided by strong principles of equity and fairness. Because regional plans are usually developed as a co-operative and collaborative effort among the participating jurisdictions, equity and fairness in cost allocation will determine whether the plan will be implemented. Any jurisdiction that feels ill-treated on the issue of cost allocation will not support or join in the implementation of the plan.

6.2 OVERVIEW OF THE PLANNING PROCESS

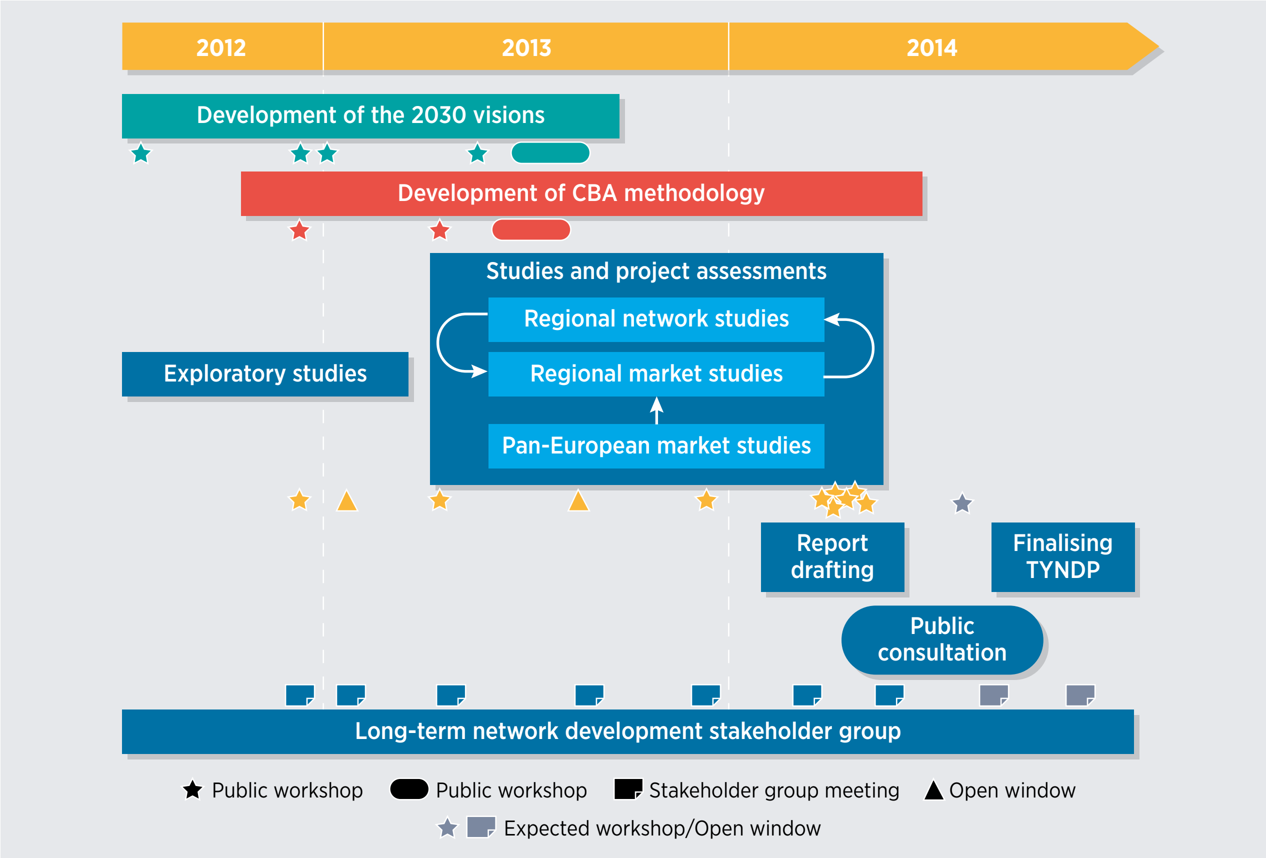
The basic elements required for the development of regional plans are essentially the same as those for single-jurisdiction plans. They revolve around: developing forecasts of future power system needs; determining the need for new resources to meet those needs; identifying the preferred resources to develop or procure (based on optimisation criteria, including costs and reliability); seeking stakeholder input and regulatory approval; and implementing the plan. Regional planning may differ from single-jurisdictional plans in some of the details of how these steps are executed.

In particular, regional planning often requires a merging of top-down, regional analyses of needs and resources with a compilation of bottom-up, single-jurisdictional assessments of needs, resources, and public policies.

As noted above, one of the basic steps in a regional planning process that is fundamentally different from a single-jurisdictional plan is the process of agreeing on an allocation of the costs of resources that serve the needs of more than one jurisdiction. This usually requires that the participating jurisdictions agree on a methodology for determining not just the costs, but also the benefits – and how those benefits will be distributed geographically.

As an example, Figure 9 summarises the process used by ENTSO-E to develop its Ten-Year Network Development Plan. This is a transmission-only regional plan, but it shows all the key steps that would be desirable for a more-comprehensive power system plan: establishing visions/objectives; developing a cost-benefit analysis (CBA) methodology to inform cost allocation; conducting system studies; engaging expert stakeholders; and public consultation (ENTSO-E, 2018).

Figure 9 ENTSO-E's process for developing the Ten-Year Network Development Plan



Source: ENTSO-E (2014)

CBA = cost-benefit analysis; TYNPD = Ten-year network development plan

6.3 INSIGHTS ON SPECIFIC PLANNING ELEMENTS

The key practices for regional power system planning share much in common with those for single-jurisdictional plans. This section will focus on practices specific to the development of regional plans, while referring back to the IRP discussion in Chapter 4, where key practices are essentially the same as for single-jurisdiction planning. Most of the examples cited here will come from the EU and the United States, as those large markets have the longest history and most successful examples of regional power system planning, including regional transmission planning.

Planning entity

In most parts of the world, regional power system planning is performed by different entities than those that develop single-jurisdictional plans. The entities conducting regional planning are typically created for, and focused on, guiding the development of a transmission system serving multiple utilities and political jurisdictions. In some cases, these entities are also responsible for operating the system.

Regional planning efforts are commonplace today in many regions. This may happen under the auspices of a Transmission System Operator (TSO), or associations of TSOs (*e.g.,* in Kazakhstan, Panama, Turkey, Ukraine and the EU countries). It can also happened through an ISO, as in Australia, Argentina, Guatemala and Peru, along with the parts of the United States covered by Midcontinent ISO, New England ISO, New York ISO and PJM (Mercados, 2013).

In Australia and most of the United States, along with a few other countries, the regional planning entity is an ISO. ISOs are similar to the European

TSOs, but they also operate wholesale electricity markets and assume day-to-day operation of the grid from the transmission owners. In effect, the transmission system is operationally unbundled from other categories of services, including generation and retail sales. The long-range planning undertaken by these ISOs includes planning for the transmission system, but also planning for system adequacy – a limited form of resource planning that focuses almost exclusively on peak capacity needs.

In the EU, power system planning occurs primarily at the national level and is focused on planning the development of the high voltage transmission system. Competitive wholesale markets are relied upon for the delivery of the mix of resources that might otherwise be developed through a resource planning or IRP framework. Regional transmission plans are then assembled by ENTSO-E, the association of European TSOs, in the form of a European transmission system plan. As discussed earlier, European TSOs are the owners of the transmission services that have been unbundled from generation and retail.

In Brazil, the EPE is responsible for conducting regional power system planning across multiple states.[21]

The entity responsible for regional planning within the SADC community is the Southern African Power Pool (SAPP). The SAPP must work through the subcommittee structure of the SADC Secretariat[22] to create support for the planning efforts of SAPP.

In either case, the planning entity will need to have the ability and willingness to communicate and co-ordinate with planners working on single-jurisdictional plans.

In regions that emphasise the role of competitive generation services, useful practices may include a reliance on either corporate or operational unbundling. Experts interviewed reinforced the virtue of this separation. This unbundling and the reliance on competition does not fully substitute for the benefits of long-range system planning, however. Even while some form of ISO or TSO is predominant in regions that emphasise unbundling, there is a recognition of the need to provide some form of resource planning capability at the regional level (or as an aggregation of sub-regional planning efforts).

Key point

The planning entity should be an organisation that has the explicit support and endorsement of all covered jurisdictions. Ideally, this will be an institution that has a legal obligation, recognised by all participating jurisdictions, to develop regional plans. In the absence of a legal mandate, the institution will need to be recognised and respected by all participants as having the technical and human resources needed for sound planning. In either case, communication and co-ordination with planners from single-jurisdictions is key to the development of good plans. The role of renewables supported by that entity can depend on various factors, such as institutional aim, mandate and authority, or access to data and technological knowledge.

Planning objectives

Unlike the planning objective of an IRP, regional planning objectives centre on reliability and cost only.[23] Regional planning objectives also include market access and opportunities to use transmission to meet the public policy obligations of participating members. Here, "cost" includes not just the cost of the transmission system, but also the cost of generation. As one of the experts we consulted expressed it, for transmission, the objective for planners is to remove transmission capacity as a constraint to effective operation of the generation infrastructures, and to the pursuit of public policy objectives for renewables and carbon reduction.

Regardless of whether being applied to single jurisdiction or multiple jurisdiction planning, reliability objectives for transmission planning are usually deterministic – meaning that the system

21 Obviously, Brazil is a single nation, but in both generation and transmission, its power sector consists of a complex mix of nationally owned companies, state-owned companies, and private companies. Power system planning in Brazil addresses many of the challenges of regional planning and is cited multiple times in this report.

22 The principal executive institution of SADC, which is responsible for strategic planning, facilitation and co-ordination and management of all SADC programmes.

23 See Chapter 4 of this report for a detailed description of additional objectives for a single-jurisdictional IRP.

is designed to have enough redundant capacity to operate reliably, even if one or two critical elements of the system (*e.g.,* transmission lines) are unexpectedly removed from service. These are called "N-1" and "N-1-1" (or N-2) contingencies.[24]

In Europe, these objectives are not yet harmonised. Some EU countries have national standards set by government, while others allow transmission system operators to set their own planning standards. In contrast, the North American Electric Reliability Corporation has been delegated authority by the Canadian and US governments to establish mandatory, enforceable reliability standards that cover topics such as critical infrastructure protection, emergency preparedness, and interchange scheduling (NERC, 2018).

One such standard relates specifically to transmission planning, and this standard becomes an important objective for any North American transmission plan. An example of these criteria as applied by one transmission company in the northeastern US is provided in the textbox.

For resources, the sole objective applied in regional planning often remains least-cost resource adequacy.[26] This is a significant deviation from single-jurisdictional IRPs, which also focus on additional aspects related to resources (*e.g.* least-cost system).

Unlike with single-jurisdictional IRPs, cost is typically reviewed using a present value analysis that includes both the costs of building new transmission and the associated costs of operating the integrated system. This analysis is typically performed over several years. Thus, the planning objective is not simply to minimise transmission costs, but to minimise regional power costs, including generation costs.

Box 8 **Transmission reliability criteria: The North American example**

The criteria used to plan the electricity system in New England are set by the federal and regional reliability organisations, including ISO-NE, NERC and NPCC.[25] A failure to comply with the NERC standards may result in significant fines. Discretionary fines may apply to help forestall blackouts affecting areas beyond the area under the utility's immediate control.

As required by the standards, planners measure system performance under three increasingly stressed conditions to determine whether the system will remain within mandatory performance criteria under various operating scenarios. Planners analyse the system under three kinds of conditions:

- All facilities in service (no contingencies; expressed as N-0).
- A single element out of service (single contingency; expressed as N-1).
- •Multiple elements removed from service (due to a single contingency or a sequence of contingencies; expressed as N-1-1).

Under the N-1-1 scenario, planners assume one element is out of service followed by another occurring after a certain period. After the first element is out, the operators make adjustments to the system in preparation for the next potential event. In the meantime, operators switch in or out certain elements, resetting interregional tie flows where that ability exists, and turning on peaking generators. In each scenario, if the software used to simulate the electricity grid shows the system cannot maintain acceptable levels of power flow and voltage, a solution is required to resolve the reliability concern. These standards continue to evolve.

24 Alternatively, probabilistic standards could be established based on, for example, an evaluation of the likely frequency and duration of service interruptions, but this approach is far less common. It requires detailed, sophisticated modelling and is generally considered to be less transparent to stakeholders than using a deterministic standard.

25 NERC is the North American Electric Reliability Corporation, the entity designated by the Canadian authorities and the US Federal Energy Regulatory Commission as the electric reliability organisation for North America. The NPCC is the Northeast Power Coordinating Council, which has been delegated authority by NERC to set regional reliability standards, conduct monitoring, and enforce compliance.

26 Resource adequacy is described as one of the objectives in Chapter 4 on single-jurisdictional IRPs.

Regional planning involves co-ordination between multiple jurisdictions

Regional planning objectives are commonly required to include the public policy objectives of the participating jurisdictions. In the United States, FERC Order No. 1000, 18 CFR Part 35 (2011) requires that all regional transmission planning processes must consider transmission needs driven by public policy requirements, such as renewable energy policies, that are established by state or federal laws or regulations. This is also the case for Renewable Energy Zone (REZ) planning efforts. In the latter case, REZ plans are developed with the expressed and specific objective of identifying the transmission assets needed to meet state renewable energy policy goals, or to develop large-scale, cost-effective renewable energy resources.

With the legally binding Renewable Energy Directive 2009/28/EC, Europe offers a practice in which regional policy objectives are to be reflected in national actions across EU countries, including in transmission plans. The directive sets goals for the use of renewable energy by 2020 on an EU-wide level, as well as for individual countries.[27] These targets function as inputs for individual countries efforts to establish their set of actions across all sectors, including determining a target share for renewables in the power sector.

With this target share in the power sector, the infrastructure expansion of the remainder of the national systems is likely to be altered (in terms of timing, location, volume, type, use and price of infrastructure). EU countries all use wholesale markets for the facilitation of resource investment. However, for the delivery of network infrastructure, regulatory oversight and investment approval presents the need for government to also ensure that network infrastructure plans are being laid out in accordance with the target share.[28]

Key point

Regional planning objectives center on reliability and cost, representing aspects of generation and transmission infrastructure. Regional objectives should also be included, thus enabling the achievement of the public policy objectives of each participating jurisdiction. Cases exist where regional policy objectives for renewables deployment alter single-jurisdictional planning processes.

Coverage and geographical scale

The scope of coverage for regional planning is generally restricted to electricity system planning for systems that serve multiple jurisdictions. Regional planning for other energy resources is not commonly practiced, despite the fact that some types of infrastructure (*e.g.,* natural gas pipelines) may serve needs in multiple jurisdictions.

The geographical scale of regional power system plans varies largely with the historical circumstances and entities involved. In the United States, the scale is typically region-specific and involves one or more states sharing an interconnected, synchronised electricity grid. Because planning is commonly undertaken by ISOs, the scale of regional power system plans often conforms to the boundaries of an ISO.

In the EU, regional planning is largely an aggregation of plans from national TSOs, and sometimes at sub-national level, through regional TSOs. ENTSO-E is the association of 42 TSOs that spans the EU and beyond. Currently ENTSO-E functions largely in the role of aggregator of national and sub-national transmission plans. No long-term resource planning is occurring at either the regional level or the country level, due to the reliance on markets for generation resources, combined with single-jurisdictional level planning approaches, to ensure generation adequacy.

27 There is an ongoing process of revising the directive, with the aim of deepening the EU-wide renewables targets, and extending them to 2030.

28 See, for example, German Government (2009) on how network planning was altered through the implementation of the directive.

The establishment of some regional scale in power system planning can enhance reliability and reduce costs through economical energy exchanges. Scale can be achieved through the establishment of larger operating systems that couple transmission planning and (usually) markets, as exists in roughly two-thirds of the United States.

Key point

Restrict coverage to electricity system planning and establish a regional scale through the establishment of larger planning footprints that couple and represent the plans from multiple participating jurisdictions. Regional approaches should be embraced at the single-jurisdictional level.

Time horizon

The time horizon for transmission planning (either single jurisdiction planning or multi-jurisdiction planning) is often shorter than the time horizon for IRP. Australia's National Transmission Network Development Plans use a 20-year planning horizon. Brazil produces its Ten-year Energy Expansion Decennial Plan to assess the need for new transmission investments at a very high level. In addition, it produces five-year transmission expansion programme documents that incorporate the latest results from generation procurement auctions and provide technical and budgetary details on the transmission needed to interconnect the planned generation assets. Transmission planning in the EU focuses on the Ten Year Network Development Plan (ENTSO-E, 2018). In the US, ISOs develop plans spanning 10 to 15 years.[29] In regions that rely on competitive wholesale markets to ensure resource adequacy, planning is often performed with an even shorter timeframe of three to five years.[30]

When selecting a time horizon for regional plans, the same factors mentioned for IRPs also apply, as do similar planning practices. The time horizon has to be sufficiently long to allow for realistic consideration of new generation resources and new transmission lines (or non-transmission alternatives). If it can take up to ten years to develop a new, long distance, high voltage transmission line, the planning horizon should not be shorter than ten years.

Key point

Plan for periods of 20 to 25 years for resources, less for transmission. For transmission, the time horizon should be sufficiently long to allow for realistic consideration of new transmission lines (or non-transmission alternatives) and consider lead times. If it can take up to ten years to develop a new transmission line, the planning horizon should not be shorter than ten years.

Updating frequency

There are no major differences between single- and multi-jurisdictional plans in terms of the need for updating. Refer to Chapter 4 of this report for suggestions on the frequency of updates.

Stakeholders and public engagement

Single- and multi-jurisdictional plans are broadly similar in terms of engaging with stakeholders and the public. Refer to Chapter 4 of this report for suggestions on engaging with stakeholders and the public.

Open access: Data, methods, and models used

The issues for data access and models are not very different for regional plans compared to IRPs. The sources of data can be different, as can the actual simulation models, but the similarities outweigh the differences. Most of the points made in Chapter 4, on IRP, apply here as well, though a few additional points merit some attention.

To obtain the data needed to effectively plan at the regional level, regional power system operators and resource planning organisations are partially dependent on utilities and IPPs operating in single-jurisdictions. This can sometimes constrain what they are able to share in terms of open access to data for planning purposes. ISOs that operate wholesale energy markets may also be constrained

29 The ISO-NE creates a biennial Regional System Plan that is mostly focused on transmission (ISO-NE, 2018). This has a ten-year horizon. California ISO creates a transmission plan with a near-term horizon of five years and a more distant horizon out to ten years (CAISO, 2016). The Midcontinent ISO Transmission Expansion Plan extends out ten years (MISO, 2017). The PJM Interconnection Transmission Plan is updated annually and extends out for a 15-year horizon (PJM, 2015).

30 The current auctions related to the PJM Reliability Pricing Model anticipate deliveries up until the year 2020/2021.

in their ability to share market information that could interfere with competition. For the most part, however, these regional planners tend to allow extraordinary public access to the information they collect and strive to make that information accessible to stakeholders. Good examples here include the California Renewables Grid Initiative, the ISO-NE process, and the NWPCC process.

The models used for planning transmission systems are typically proprietary models developed by specialists and industry leaders. A great deal of information about these models and their capabilities is available from IRENA (2017). Even when the models are proprietary, mechanisms may be established through the regulatory process to provide stakeholders with temporary access to the models and appropriate opportunities to review inputs and results, with protections in place to protect the commercial interests of the software vendors.

Key point

Regarding open access, there are many similarities with single-jurisdictional processes. As an additional consideration, regional planners may face constraints in obtaining the disclosure of data and models used by single-jurisdictional stakeholders.

Load forecasts, scenario development, and establishing need

Historically, the approach to load forecasting and scenario development for regional planning has mirrored the approach used for IRPs. Regional load forecasts are much more likely to depend on a bottom-up approach, with data from each participating jurisdiction aggregated into a regional result. As with an IRP, however, in the past, the mechanism for planning ultimately relied on a baseline forecast and alternative future scenarios relative to the baseline forecast. As with IRPs, these forecasts were established largely by projecting historical trends into the future. Scenarios for higher than expected load growth, and lower than expected load growth, were frequently developed and evaluated.

These methods may still work, but the increasing complexity and demands of the power system and the demands require much more detailed investigation. Transmission planning is spatial planning. The dynamic nature of distribution and renewable generation means that it is not possible to rely simply on past trends to capture the future. Planning must incorporate government development plans that will foster new loads. This may be by, for example, building or electrifying new communities or fostering industrial growth. Planning must also integrate the impact of distributed resources and energy efficiency that may have had little or no impact on load historically, but could be very significant in the future. Plans must also identify binding needs and/or opportunities for renewable resources and potential renewable corridors.

All this may require a much more challenging field of investigation. That challenge could prove insurmountable without the assistance of a well-formed pool of stakeholders to assist in the development of potential futures and resource characteristics. ISO-NE forecasts, for example, are developed with the cooperation of a diverse group of stakeholders.[31] Smart grid investments that enable planners to intelligently map the system and trends spatially, in ways that were not possible in the past, can also help meet this challenge. Transmission planners may also need to increase their capabilities to assimilate smart grid data to allow for consideration of growing dynamics in the system.

Given the growing list of drivers and uncertainties, planning and investment in 30+ year investments must consider how these investments hold up under a wide range of futures that may be less likely to be captured through simple variations on past trends. Future plans and investments are likely to be dictated more by a multitude of futures. These might include considerable growth (*e.g.,* with electrification of villages or the transportation sector), or decline, with, for example, the addition of distributed resources and isolated mini-grids.

31 ISO-NE (200) provides an example of a sophisticated forecast approach and analysis by a regional power system operator in the United States.

Key point

There are many similarities with single-jurisdictional planning processes in this element. Spatial planning of transmission network infrastructure will often have to be enhanced in order to accurately capture the impact of location-specific renewable energy technologies, as well as of changes and growing dynamics at the distribution level.

Resources included

Regional power system plans usually focus on identifying generation projects and transmission interconnections that can serve multiple jurisdictions. Because of the regional nature of these plans, the highest priority generation projects will tend to be very large power plants (*e.g.*, hydroelectric projects). Developing such schemes as part of a regional plan can help facilitate the process of allocating costs across participating jurisdictions. In areas such as the EU and the United States, where generation resources already exist to meet most system needs, the emphasis tends to fall on transmission assets that can relieve system congestion and free-up access to lower cost generation, or transmission that helps with the integration of ever-increasing amounts of variable renewable energy.

Demand-side resources that can reduce the need for generation and transmission assets are only rarely considered in regional plans, but experts suggest that this is now emerging as a key practice. As an example, for 90% of the futures considered, NWPCC expects that existing resources combined with additional energy efficiency and demand response can satisfy 100% of the region's needs within the planning horizon. At the national level in the US, FERC Order No. 1000, 18 CFR Part 35 (2011) now requires consideration of non-transmission alternatives in the evaluation of regional transmission requirements. The order specifies that non-transmission alternatives include demand-response, energy efficiency, distributed generation, and storage. In Europe, EU members began debate in 2016 on a package of potential legislation labelled *Clean Energy for All Europeans*, which includes electricity market reforms based on an "efficiency first" principle that prioritises investments in demand-side resources (including end-use energy efficiency and demand response) whenever they would cost less, or deliver more value, than investing in generation or transmission assets (Rosenow, 2016).[32]

Planners should treat all supply-side and demand-side resources on a level playing field. The resources that can meet future electricity demand most reliably and at lowest cost, while satisfying all public policy objectives, should be selected for inclusion in the plan. Planners should not include a new transmission asset in their regional plans if an alternative has been proposed that meets their needs equally, or better and at lower cost. To be able to evaluate all possible grid and non-grid solutions on a level playing field, the emergence of new types of planning processes – as currently being tested in Hawaii, for example (see Chapter 5) – could be supportive in the future.

Changes in retail rate designs and system operation practices can also potentially reduce the need for generation and transmission assets. These options are, however, generally evaluated in special studies, rather than power system plans.

REZ planning represents a different kind of regional planning effort. This is because it is focused specifically on realising large-scale renewable energy potential and on planning for the transmission needed to deliver the energy loads in a co-ordinated fashion. The only resources included in these plans are renewable generation assets and transmission lines, and these plans do not address the remainder of the regional power system's needs. The above-mentioned UMTDI, covering five states, presents such an example.

32 The debate has resulted in specific legislative proposals being made by the European Commission, which are currently being discussed by the European Parliament and the Council of the EU.

Key point

Similar to single-jurisdiction planning, planners should treat all supply-side and demand-side resources on a level playing field. This requires the simultaneous assessment of transmission and its alternatives to identify the resources that can meet future electricity demand most reliably and at lowest cost, while satisfying all public policy objectives. The use of renewable energy zoning approaches can inform regional transmission development in optimisation with renewable energy resources, and permit those resources to be developed.

Resource characteristics and assessment

REZ plans will often begin with an assessment of the potential for new, large-scale renewable energy resource development in areas that do not currently have adequate transmission to deliver that energy to load. The previously cited UMTDI example began after several Midwestern US states recognised that some of the states with ambitious renewable energy goals had limited cost-effective resources, while other states with less ambitious goals had ample, but as yet untapped renewable generation potential.

Other types of regional plans may devote significantly less attention to characterising and assessing generating resources than IRPs or REZ plans do. In some cases, regional planning efforts focus exclusively on identifying the transmission assets needed to efficiently deliver power from an assumed generation fleet to service peak loads. Those plans will typically look at the capabilities and characteristics of transmission assets in a very detailed and granular way.

It is also true that regional transmission plans and regional power system plans, even when they consider resource adequacy needs, are often developed in regions served by competitive markets (the EU and parts of the United States). In these regions, planning may focus only on identifying generation capacity and ancillary service needs, without trying to identify the least-cost means of satisfying those needs. Instead, the assumption is that markets will be operated to identify the least cost-option which can fill those needs, typically through an auction mechanism. Where that is true, power system planners may need to identify the amount of needed capacity, but may not need to characterise or assess the capabilities and costs of different generating resources.[33]

Some regional plans will, nevertheless, need to consider both transmission and non-transmission resources. This necessitates the same kind of resource characterisation, and the same practices, as those described for IRP.

Option and resource portfolio identification and selection

The process for regional power system planning, parallel to the IRP process, begins with an examination of resource needs and the options for meeting those needs. The methods for identifying possible resource portfolios can be the same for regional plans as they are for IRPs: capacity expansion models can be used to identify a least-cost option under baseline assumptions, and then other resource portfolios can be identified that are associated with alternative assumptions, or that are designed specifically to address public policy interests. For example, a resource portfolio with lots of energy efficiency and demand response could be identified as a non-transmission alternative, or a resource portfolio that includes higher-than-expected levels of future renewable energy could be brought into play.

As the demand for power and the system's portfolio of resources evolves, power flows change. Transmission planning requires, as its highest priority, an examination of whether existing lines can adequately deliver electricity from generation to load under future conditions. Planners can then look at whether there are areas of transmission congestion that create a need for additional – or higher-cost – generation capacity, which could be alleviated at a lower cost by adding transmission capacity. Transmission models can

33 Energy-only markets have not always delivered the generation capacity needed for resource adequacy, especially where there were barriers to entry to the markets, or market fundamentals made the profitability of new generation highly uncertain. One approach adopted in some US ISOs has been to create forward capacity markets that solicit competitive bids to provide capacity in future years. A review of the merits of capacity markets or mechanisms to assure resource adequacy through energy-only markets is beyond the scope of this report.

identify deficiencies and areas of congestion, but they do not identify possible solutions. Instead, transmission planners will propose candidate transmission lines that could be added to the grid and model how well those candidates address the deficiencies, or the congestion.

After identifying potential solutions to meet power system needs, the process of selecting a preferred solution is most commonly focused on satisfying two objectives: reliability and affordability (increasing access to electricity is more commonly the focus of single-jurisdiction power system plans). Portfolios comprised of generation resources, transmission lines, and non-transmission alternatives will be selected with those two goals foremost in mind. Participating jurisdictions' other public policy goals, such as renewable energy targets or goals for single-jurisdictional resource adequacy, can also be factored into resource portfolio selection.

The reliability of the interconnected regional power system, or any power system, is characterised by two basic functions: resource adequacy and operating reliability.

- "Resource adequacy" refers to the ability of the electricity system to supply the aggregate electrical demand and energy requirements of the end-use customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.
- "Operating Reliability" refers to the ability of the bulk power system to withstand sudden disturbances, such as electricity short circuits, or unanticipated loss of system elements from credible contingencies, while avoiding uncontrolled cascading blackouts or damage to equipment (NERC, 2013).

Key point

Regional power system plans seek to identify not just a portfolio of resource options, but also candidate interconnectors. A wide set of possible futures, public policy objectives and risk assessments should be included in the identification of possible resource portfolios and interconnectors. The inclusion of transmission requires additional assessment of possible futures against the operational security standards of the entire power system.

Planning with uncertainty

The methods for considering uncertainty are essentially the same for regional power system plans as for single-jurisdiction plans. Refer to Chapter 4 of this report for a description of proven practices for planning with uncertainty.

Cost allocation and recovery

One important difference between regional power system plans and single-jurisdiction IRPs, or transmission plans, is the need to determine how to share and allocate costs across the region. Cost recovery through tariffs (ideally, harmonised regional tariffs) is closely related to transmission planning and to the associated governance of the planning efforts, as well as follow-through efforts to implement plans.

There is considerable debate on the fundamental principles that should guide cost allocation, generally revolving around two options. The first option is a "beneficiary pays" principle. The second is a "socialisation" principle.

In the US, FERC Order No. 1000, 18 CFR Part 35 (2011) articulates a vision and rationale for the "beneficiary pays" approach based on several explicit cost allocation principles, including:

34 ENTSO-E (2018) offers an example for a CBA methodology for regional transmission assets.

- Costs must be allocated in a way that is roughly commensurate with benefits.
- Involuntary allocation of costs to non-beneficiaries is prohibited.
- Transparent processes must be used to determine benefits and identify beneficiaries.
- Cost allocation methods may vary depending on whether a transmission project is associated with reliability, relieving congestion, or achieving public policy goals (FERC, 2011).

In application, these simple principles can lead to very difficult and sometimes contentious debates about how to quantify benefits. Any regional planning effort requires participating jurisdictions to reach agreement on a methodology for determining the monetary benefits that each jurisdiction could expect to realise from the construction of regional projects.[34] Once the costs of regional investments are allocated to the jurisdictions that benefit, those costs can then be recovered from ratepayers using traditional cost-of-service rate design principles.

The second option for cost allocation is based on the principle of "socialising" the costs of regional projects serving multiple jurisdictions. The US State of Texas, for example, adopted a socialisation approach to allocating the costs of its REZ initiative. Proponents of this approach argue that the reliability benefits of regional projects cannot be easily assigned to beneficiaries because all parties in the system enjoy these benefits. Therefore, they argue, costs of regional projects should be spread over all users connected to the regional transmission system. This approach is simpler to administer, but may be perceived as less fair than the "beneficiary pays" approach.

Key point

There is a need to establish upfront clarity of – and transparency in – the allocation of investment costs across participating jurisdictions ("beneficiary pays' or "cost socialisation"). Allocated costs should be linked to cost recovery mechanisms such as rate design. There are cases which foster socialisation of the cost of transmission infrastructure associated with the development of renewable energy resources.

SCALING UP RENEWABLES 7

In jurisdictions that apply long-term electricity planning to facilitate investments, amended planning can support the uptake of renewable energy technologies, such as wind and solar power generation. At the same time, the greater deployment of renewable energy technologies can have a significant impact on power systems, so that an amendment to planning can be required to ensure reliable system integration of these resources at least cost.

Planning must evolve in order to capture the potential benefits of these technologies while addressing new challenges. IRENA (2017) offers an in-depth look at the implications of variable renewable energy deployment for the application of planning tools and methodologies. At the same time, planning practices must evolve, too. The preceding chapters describe planning practices in a general way, with additional attention paid, where necessary, to details specific to amended planning practices for and with renewable energy.

The list below summarises the key changes required in planning practices to properly exploit and integrate renewables through the use of long-term power system planning:

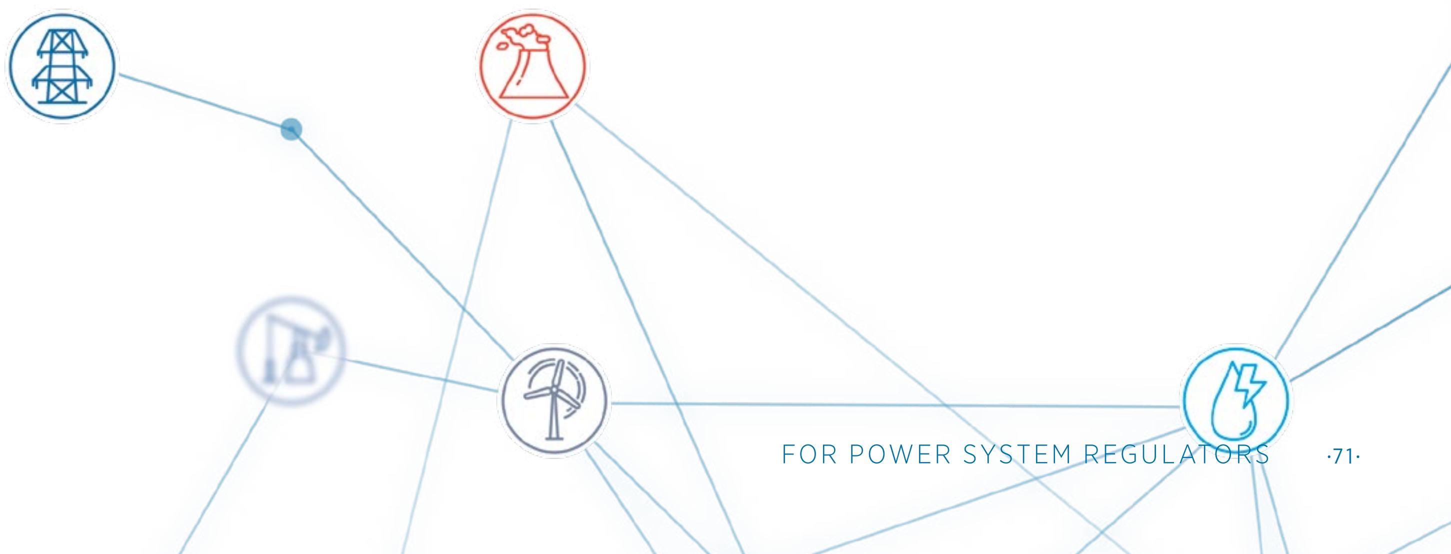
- A legal planning framework seems best suited to ensure planning takes place in an organised manner, provides linkages to the relevant policy objectives of the energy/electricity sector, and in the process, assigns clear roles and responsibilities to stakeholders – including the regulators. Stronger technical roles for these in the planning process can enhance the role of renewables, especially in markets which need to overcome predominant knowledge gaps, limitations to planning institutions, and/or other barriers to renewable energy technologies.
- Regulators involved in the technical review and approval of plans will require a deep technical understanding of renewable energy technologies and economics. Given the broad range of technologies and dynamic technology development, this requires sufficient staffing and commitment. Alternatively, regulators can become the guardians of a planning process, which, in the process, can and should encourage transparency and the participation of stakeholders representing the renewable energy industry.
- To perform well and ensure a sound planning process, the regulator has to be able to avoid regulatory capture and undue political interference in the planning process. The application of transparent communication and decision-making procedures, as well as strong regulatory independence, can help jurisdictions to overcome positions which do not accurately acknowledge the role of renewables.
- The role of renewables can be strengthened through establishing clear policy objectives in their support (*e.g.* direct targets for renewables; environmental and/or social standards; pricing of externalities; security considerations). These are best included *ex ante* to the modelling. On a regional level, consistency between planning objectives across jurisdictions is at the heart of any regional plan which seeks to be accepted and its results to be implemented. This consistency is particularly relevant for the support of renewable energy technologies, as their inclusion often relies on policy objectives.
- Because renewable energy technologies are less mature than fossil fuel technologies, their capabilities and costs have been changing much

more significantly and rapidly. Costs for wind and solar PV have been steadily declining, to the point where these resources are fast becoming the least expensive source of power in many regions. This requires the use of high-quality renewable energy resource assessment methods with high spatial resolution. It also requires attention to the use of the most current data, while increasing the value of frequent updates to planning assumptions and model inputs. Amended planning processes, which integrate market-based price determination into the identification of feasible technology options, may soon emerge as good practice.

- Technology learning curves, which show how the costs of an emerging technology decline as deployment increases, can offer useful insights and improved estimates for the likely future costs of renewable energy technologies. Nevertheless, the incorporation of renewable energy technologies certainly adds to the need for good planning to take account of uncertainty, as the set of resource options broadens.
- Compared to other generating resources, wind and solar PV typically have lower operating costs. Once operational, these systems can produce power for decades at almost no cost and with relatively little routine maintenance. These developments render their costs of electricity generation not just reasonable. Longer planning horizons will also be able to capture the associated compounding advantages compared to conventional power generation technologies.

To ensure sound planning, the regulator has to avoid political interference

- For renewable generation assets to be most cost-effective, the spatial aspects must be incorporated into planning processes to account for the trade-off between resource characteristics and transmission infrastructure. Planners can work to maximise system-wide cost-effectiveness by performing holistic cost-benefit assessments across resources and transmission. Furthermore, the difference in commissioning times between renewable resources and transmission infrastructure creates a distinct challenge for planners, akin to the old question about whether the chicken or the egg came first: generation and transmission must often be planned in a co-ordinated fashion, because one makes no sense without the other. This is the impetus for REZ initiatives and newly emerging planning processes to optimise all technology options simultaneously. Regional planning will require clearly defined methods for cost allocation, with current practices indicating a preference towards the cost socialisation of infrastructure associated with the deployment of renewables.
- Because renewable energy is more suitable than fossil fuel generation for distributed, behind-the-meter deployment, planners might not have full control or visibility of where, when, or how much capacity will be (or already has been) added to the system. Planners will need to estimate future behind-the-meter deployment, and then assess the viability of their plans in light of the uncertainty.



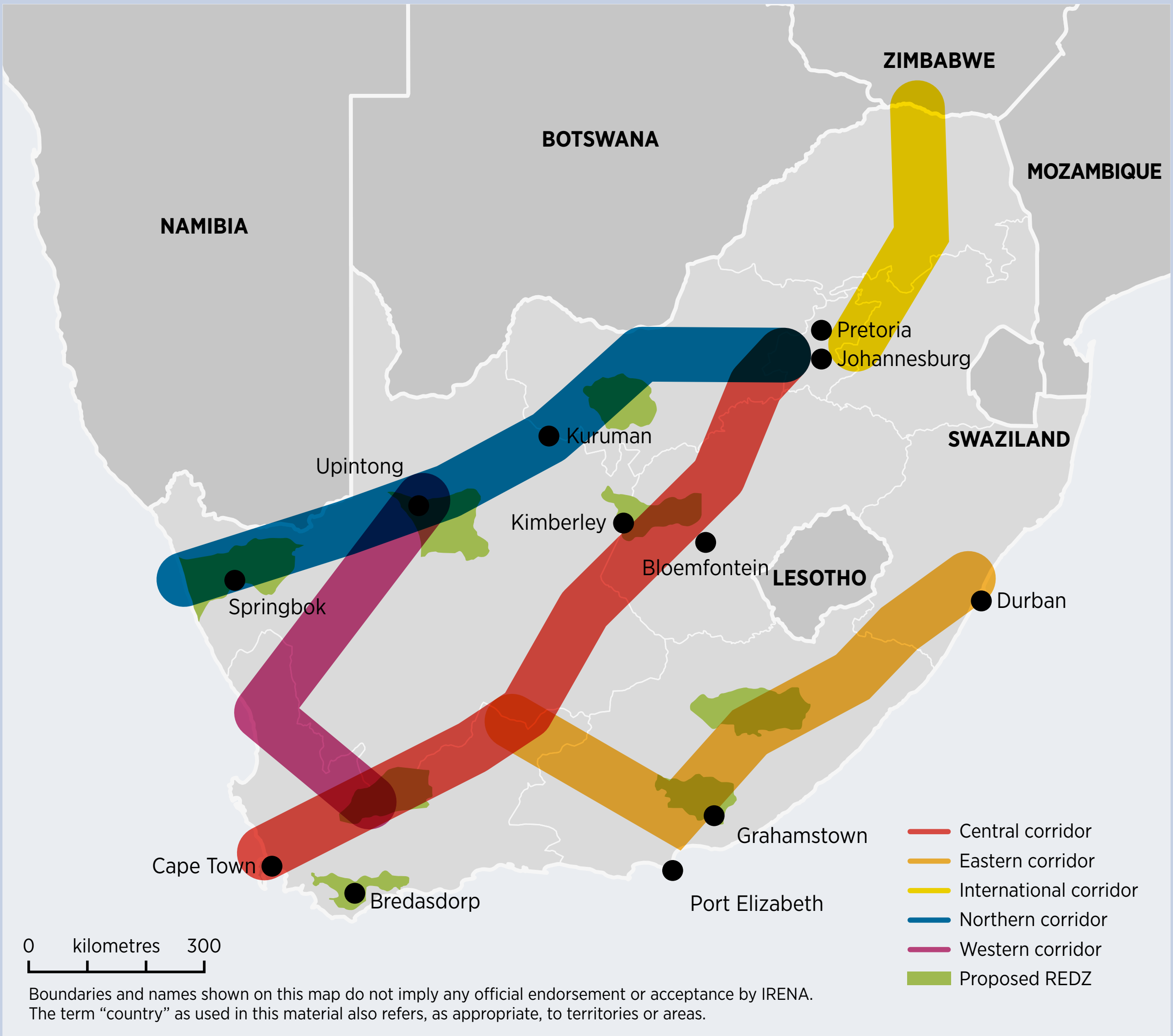
- The variability of wind and solar power is a principal driver for new approaches to planning. With these resources, planners must consider capacity factors and generating characteristics, not just rated capacity. They need to consider diurnal and seasonal variability in the wind and solar resources. They also need to select adequate resource portfolios, and plan to operate dispatchable generation based on net loads (gross load minus non-dispatchable renewable generation, including behind-the-meter generation). Long-term models and modelling tools need to be updated or applied differently in order to capture the specific characteristics of variable renewables. Updates of this kind are discussed extensively in IRENA, 2017.
- Planning for system stability during contingency events will also need to evolve as wind and solar grow to high penetration levels. Because wind turbines and solar PV are asynchronous generators, they generally lack the inertial qualities of synchronous generation technologies, which involve large rotating masses. When a disturbance occurs on the grid (for example, the unplanned outage of a large generator or transmission line), the inertia of synchronous generators enhances the stability of the grid by mitigating frequency deviations and buying enough time for system operators to dispatch contingency reserves. As renewable energy deployment grows, the need for fast response contingency reserves may increase compared to systems that are more dependent on the inertia of synchronous generators, whilst the supply with these reserves may decrease at the same time.

Box 9 **REZ initiatives**

Transmission expansion planning can either be proactive or reactive, with the application of a variety of approaches widely discussed (for example, see IEA, 2013). In a proactive approach, the transmission plan takes into account information on all possible generation scenarios, including location, technology, and corresponding network expansion costs. Uncertainty about the evolution of generation capacities, coupled with the long lead times of transmission projects, therefore requires robust and flexible transmission plans that are suitable for a range of possible generation scenarios. Reactive planning happens in response to a new, unanticipated system need that cannot be ignored, or when a long-anticipated problem has not been adequately addressed. In these cases, long-lead times for transmission development can result in (temporary) transmission capacity inadequacy. Proactive transmission planning, as used within the context of REZs, seems particularly suited to the integration of renewables such as wind and solar, as these resources' lead times are much shorter compared to the lead times of conventional generation assets. Reactive planning is less effective than the proactive approach because the urgency of finding a solution forestalls some of the options that require more time to develop.

The co-ordination between generation and transmission becomes increasingly difficult with growing shares of renewables and distributed generation. Although planning efforts designed specifically to accommodate or promote the growth of renewable generating resources are a much more recent development, examples of such efforts in various stages of implementation can also be found throughout the world. These planning efforts, which are commonly referred to as REZ initiatives, refer to situations in which transmission system development is tied to the delivery of renewable energy from areas with large amounts of renewable potential (typically, wind or solar resources). To date, REZ initiatives have been successfully employed or are currently under way in several regions, including in India, South Africa, the State of Texas (United States), and the State of Queensland (Australia). For example, South Africa has developed eight "Renewable Energy Development Zones" (REDZ) and five Power Corridors, which aim to better synchronise renewable generation and transmission system development by streamlining and accelerating regulatory processes (see figure below).

Figure 10 Zones and corridors to boost renewable power in South Africa



Source: McEwan (2017)

South Africa's Renewable Energy Development Zones (REDZ) and Power Corridors define priority geographical areas where wind and solar PV technologies can be incentivised and where major grid expansion can be directed (DoEA SA, 2016). Key incentives are provided by accelerated Environmental Impact Assessment (EIA) processes for both renewables and transmission projects. South Africa pursues a strategy of Strategic Environmental Assessments to pre-assess environmental sensitivities within the proposed REDZ and Power Corridors at a regional scale. This is in order to simplify and speed up the site-specific assessments. As a result, projects within these areas will only be subject to a basic assessment and not a full EIA process. It is expected that this results in more than halving the environmental authorisation process time (147 days to completion, instead of 300 days).

GLOSSARY

Action plan

A component of a long-term resource plan or transmission plan that describes in detail some of the specific activities that will be implemented in the near-term. For example, a 20-year IRP might include an action plan with detailed information about resources that will be procured in the first three years. Those details might specify the type of resource to be procured, its capacity and capabilities, its location, and the schedule for construction and commissioning. Similar details are generally not included for resources to be procured in the latter years of the plan.

Formal plan (or formal planning process)

A plan or planning process that is authorised or mandated via a legal requirement imposed on the utility or another planning entity.

Integrated Resource Planning (IRP)

A planning mechanism in which the costs and benefits of both demand- and supply-side resources are evaluated to develop the least total cost mix of resource options under a given set of technical, economic, and environmental constraints. Despite the fact that the definition for a "resource" also includes demand-side resources, only the IRP typically consider the cost-effective demand-side, including energy efficiency, distributed generation and storage. IRPs may also consider environmental and social impacts of different resource options.

While the term "IRP" generally refers to the process of integrated resource planning, in some cases, as per industry parlance, it can also refer to an integrated resource plan ("an IRP", or "the IRP"), *i.e.*, the plan emerging from the IRP process. The distinction is normally clear from the context.

Jurisdiction

The political or territorial boundaries over which a public policy applies, or over which a government or regulatory entity has authority.

Operating reliability

Refers to the ability of the bulk power system to withstand sudden disturbances, such as electricity short circuits or unanticipated loss of system elements from credible contingencies, while avoiding uncontrolled cascading blackouts or damage to equipment.

Power sector

This term refers broadly to the collection of utilities, IPPs, and other organisations that are involved in the development and operation of the power system.

Power system planning

The process of determining the development plan with the lowest economic cost that can expand the generation, transmission and distribution systems while reliably (adequately and securely) supplying the load forecast within a set of technical, economic and environmental constraints.[35] The two main categories of power system planning are resource planning and transmission planning.

Renewable Energy Zones (REZs)

Areas that have been identified as having considerable potential for large scale development of renewable generation, or that have been given priority for renewable generation development. Most REZ initiatives also focus on developing the transmission needed to deliver that power to load centres.

Region

A geographical area encompassing more than one jurisdiction.

Regional planning

A planning mechanism that addresses the combined requirements of more than one political jurisdiction.

35 Although the word "constraint" has a negative connotation, the term is routinely used by planners to describe any condition (expressed as a mathematical formula) that the plan must satisfy in order to be acceptable.

Regional resource plans/Regional IRPs

A planning mechanism that is similar to single-jurisdictional resource planning or IRP, except that the plan extends to more than one jurisdiction. The regional resource plan can represent an amalgamation of state or country IRPs. It can also represent a least-cost IRP for an entire region (referred to as a Regional IRP). Alternatively, it can represent a combination of these two, with the addition of large regional projects that may serve more than one state or country. This may be due to the project's size and the likely mismatch of capacity and loads within a single jurisdiction, or to the competing resource requirements and environmental impacts of a given resource (especially hydro). Regional resource plans require co-ordination with regional transmission plans. Ideally, there are close linkages between regional resource plans, where they exist, and state- or country-specific resource planning efforts.

Regional power system plan

Regional power system plans are similar to regional transmission plans, but take a step further to address issues related to system adequacy (whether there are adequate generation resources to meet system requirements under periods of stress). A regional power system plan will, however, not include a detailed plan for procuring specific types of generation or demand-side resources on a specific schedule, as would be the case in an IRP.

Regional transmission plan

Regional transmission plans are developed to identify the transmission infrastructure required to serve the power needs of multiple jurisdictions operating within a synchronous, interconnected grid. The emphasis in these plans is on minimising costs while ensuring reliability and open access to transmission for utilities and independent power producers (IPPs). In recent years, regional transmission plans have frequently focused on the build-out of transmission needed to facilitate the development of large renewable energy sites and the delivery of power from these often-remote sites to load centres.

Resource

Any asset or programme that is used to satisfy customer demand for electricity services. This includes both supply-side resources (*i.e.*, the physical machinery and assets that generate, transmit, and distribute electricity) and demand-side resources (*i.e.*, distributed generation, and programmes or equipment that control or modify load – for example, through energy efficiency or demand response). Electricity storage may be considered either a supply-side or a demand-side resource, depending on how it is deployed.

Resource adequacy

Refers to the ability of the electricity system to supply the aggregate electrical demand and energy requirements of the end-use customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.

Resource planning

The process of determining future requirements for power system resources and of ensuring that those requirements are met. It is a type of power system planning that focuses almost exclusively on ensuring adequate generation resources will be available to meet anticipated load, with little or no attention given to transmission and distribution resource needs. Until somewhat recently, most resource planning efforts around the world only considered supply-side resources. These plans are often referred to as "master plans", "power development plans", or "generation expansion plans".

Resource portfolio

A collection of resources that may be deployed together in an integrated manner.

Transmission planning

Another type of power system planning that usually focuses exclusively on identifying the transmission assets needed to deliver electricity reliably and at least cost from anticipated future generation to anticipated future load. On rare occasions, an alternative, non-transmission means of serving load may be considered as part of a transmission planning process.

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