Assessment and Development of Network-driven Demand-side Management Measures

Research Report No 2
Task XV of the International Energy Agency Demand Side Management Programme

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THE IEA DEMAND SIDE MANAGEMENT PROGRAMME

The International Energy Agency (IEA) was established in 1974 as an autonomous agency within the framework of the Economic Cooperation and Development (OECD) to carry out a comprehensive program of energy cooperation among its 25 Member countries and the Commission of the European Communities.

An important part of the Agency's program involves collaboration in the research, development and demonstration of new energy technologies to reduce excessive reliance on imported oil, increase long-term energy security and reduce greenhouse gas emissions. The IEA's R&D activities are headed by the Committee on Energy Research and Technology (CERT) and supported by a small Secretariat staff, headquartered in Paris. In addition, three Working Parties are charged with monitoring the various collaborative energy agreements, identifying new areas for cooperation and advising the CERT on policy matters.

Collaborative programs in the various energy technology areas are conducted under Implementing Agreements, which are signed by contracting parties (government agencies or entities designated by them). There are currently over 40 Implementing Agreements, including the IEA Demand-Side Management. Since 1993, the following 20 member countries and the European Commission have been working to clarify and promote opportunities for DSM.

Australia	France	New Zealand
Austria	Greece	Norway
Belgium	Italy	South Africa
Canada	India	Spain
Denmark	Japan	Sweden
European Commission	Korea	United Kingdom
Finland	Netherlands	United States

A total of 20 Tasks (multi-national collaborative research projects) have been initiated by the IEA DSM Programme, 13 of which have been completed. Each Task is managed by an Operating Agent (Project Director) from one of the participating countries. The Operating Agent is responsible for overall project management including project deliverables, milestones, schedule, budget and communications. Overall control of the program rests with an Executive Committee comprised of one representative from each contracting party to the Implementing Agreement. In addition, a number of special ad hoc activities–conferences and workshops–have been organized.

The actual research work for a Task is carried out by a combination of the Operating Agent and a group of Country Experts, depending on the nature of the work to be carried out. Each country which is participating in a Task nominates one or more persons as its Country Expert. Each Expert is responsible for carrying out any research work within his/her country which is required for the Task All the Experts meet regularly to review and assess the progress of the work completed by the Operating Agent and by the group of Experts. Experts meetings are usually held between two and four times a year.

The IEA DSM Programme has undertaken the following Tasks to date:

Task I	International Database on Demand-Side Management
Task II*	Communications Technologies for Demand-Side Management
Task III*	Cooperative Procurement of Innovative Technologies for Demand-Side Management
Task IV*	Development of Improved Methods for Integrating Demand-Side Management
Task V*	Investigation of Techniques for Implementation of Demand-Side Management Technology in the Marketplace
Task VI*	Mechanisms for Promoting DSM and Energy Efficiency in Changing Electricity Businesses
Task VII*	International Collaboration on Market Transformation
Task VIII*	Demand Side Bidding in a Competitive Electricity Market
Task IX*	The Role of Municipalities in a Liberalized System
Task X*	Performance Contracting
Task XI*	Time of Use Pricing and Energy Use for Demand Management Delivery
Task XII	Cooperation on Energy Standards (not proceeded with)
Task XIII*	Demand Response Resources
Task XIV*	Market Mechanisms for White Certificates Trading
Task XV	Network-Driven Demand Side Management
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Task XVII	Integration of Demand Side Management, Energy Efficiency, Distributed Generation and Renewable Energy Sources
Task XVIII	Demand Side Management and Climate Change
Task XIX	Micro Demand Response and Energy Saving
Task XX	Branding of Energy Efficiency

* Completed Task

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FOREWORD

This report is a result of work which was completed within Task XV of the International Energy Agency Demand-Side Management Programme. The title of Task XV is "Network-Driven Demand Side Management." Task XV is a multinational collaborative research project which is investigating demand-side management (DSM) measures which may provide viable alternatives to augmentation of electricity networks and also provide network operational services.

Task XV is organised into five subtasks as follows:

- **Subtask 1:** Worldwide Survey of Network-Driven DSM Projects.
- **Subtask 2:** Assessment and Development of Network-Driven DSM Measures.
- **Subtask 3:** Incorporation of DSM Measures into Network Planning.
- **Subtask 4:** Evaluation and Acquisition of Network-Driven DSM Resources.
- **Subtask 5:** Communication of Information About Network-Driven DSM.

This report summarises the results from Subtask 2.

The Operating Agent (Project Director) for Task XV is Energy Futures Australia Pty Ltd, based in Sydney, Australia.

The work of Task XV is supported (through cost and task sharing) by the seven participating countries: Australia, France, India, New Zealand, South Africa, Spain and the United States. Participants provided one or more Country Experts who were responsible for contributing to the work of the Task and for reviewing work as it was completed. Some countries also nominated representatives who also contributed to the work of Task XV.

Information for this report was collected, and the document was reviewed by, Country Experts and representatives from the organisations listed in the Table on page v.

The Principal Investigator for, and main author of, this report is Dr David Crossley of Energy Futures Australia Pty Ltd. Any errors and omissions are the sole responsibility of the Principal Investigator.

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EXECUTIVE SUMMARY

In the electricity industry, the term 'demand-side management' (DSM) is used to refer to actions which change the electrical demand on the system. Task XV of the IEA DSM Programme, and consequently this report, are concerned with a particular type of DSM – "network-driven DSM". Network-driven DSM comprises demand-side measures used to relieve network constraints and/or to provide services for electricity network system operators.

This report has three objectives:

- to identify the value proposition for network-driven DSM measures, including the specific network problems which these measures can successfully address;
- to determine the factors which result in a network-driven DSM measure being successful in cost-effectively achieving network-related objectives; and
- to further develop network-driven DSM measures to improve their effectiveness in achieving network-related objectives.

The report concludes that the value of a network-driven DSM project varies among categories of stakeholders and may even vary among individual stakeholders (eg customers located in network-constrained areas vs customers located outside these areas). The distribution of the benefits from network-driven DSM projects among many different stakeholders means that the project proponent is unlikely to capture all the benefits from such a project; other parties who have not contributed to the cost of implementing the project may well receive some of the benefits. To provide significant value to the project proponent, the total benefits from a network-driven DSM project must be quite large and the proponent must be able capture a significant proportion of these benefits.

The report identifies a number of external and internal factors that may contribute to the success of network-driven DSM projects. Network-driven DSM projects containing the same DSM measures (such as energy efficiency, load shifting, direct load control or pricing initiatives) tend to have a common set of factors which contribute to their success and to this extent it is possible to identify sets of success factors that apply to each category of DSM measure. The challenge in designing a network-driven DSM project that will ultimately be successful in achieving its objectives is to clearly identify the success factors for each of the DSM measures included in the project and then concentrate on optimising each of these factors.

The final section of the report identifies the network problems that each category of network DSM measures can address; characterises the success factors which apply to each category; and examines how the DSM measures in each category should be implemented for them to be most effective in achieving network-related objectives.

1. INTRODUCTION

1.1 Network-driven DSM

In the electricity industry, the term 'demand-side management' (DSM) is used to refer to actions which change the electrical demand on the system. Task XV of the IEA DSM Programme, and consequently this report, are concerned with a particular type of DSM – "network-driven DSM"[1].

Network-driven DSM comprises demand-side measures used to relieve network constraints and/or to provide services for electricity network system operators. In Task XV, network-driven DSM is defined as follows:

> *Network-driven demand-side management is concerned with reducing demand on the electricity network in specific ways which maintain system reliability in the immediate term and over the longer term defer the need for network augmentation.*

Under this definition, network-driven DSM measures include:
- direct load control;
- distributed generation, including standby generation and cogeneration;
- demand response;
- energy efficiency;
- fuel substitution;
- interruptible loads;
- integrated DSM projects;
- load shifting;
- power factor correction;
- pricing initiatives, including time of use and demand-based tariffs; and
- smart metering..

1.2 Focus of this Report

This is the second report from Task XV and it is intended to achieve the objective of Subtask 2 which is "to further develop the identified network-driven DSM measures [from Subtask 1] so that they will be successful in cost effectively achieving network-related objectives."[2]

This report has three objectives:

- to identify the value proposition for network-driven DSM measures, including the specific network problems which these measures can successfully address;

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[1] For a more comprehensive discussion of network-driven DSM see the first report from Task XV: Crossley, D.J. (2008). *Worldwide Survey of Network-driven Demand-side Management Projects*. Second edition. International Energy Agency Demand Side Management Programme, Task XV Research Report No 1. Hornsby Heights, NSW, Australia, Energy Futures Australia Pty Ltd.

[2] Energy Futures Australia (2004). *Prospectus: Research Project on Network-driven DSM*. Hornsby Heights, NSW Australia, EFA, p 4.

- to determine the factors which result in a network-driven DSM measure being successful in cost-effectively achieving network-related objectives; and
- to further develop network-driven DSM measures to improve their effectiveness in achieving network-related objectives.

2. VALUE PROPOSITIONS FOR NETWORK-DRIVEN DSM

In Subtask 2 of Task XV, the objective of Activity 2-1 is to identify the value propositions for network-driven DSM measures, including the specific network problems which these measures can successfully address[3]. This section of the report summarises the results from Activity 2-1.

This section also draws on work undertaken in another Task of the IEA DSM Programme: Task XIII on Demand Response Resources.

2.1 Network Problems Addressed By DSM

Network-driven DSM projects aim to achieve peak load reductions with various response times:

- to relieve network constraints; and/or
- to provide network operational services.

2.1.1 Characteristics of Network Constraints

To be effective in relieving network constraints, DSM measures must be capable of addressing the particular characteristics of these constraints. Network constraints have both timing and spatial dimensions.

In relation to timing, network constraints may be:

- **narrow peak related** – occurring strongly at the time of the system peak and lasting seconds, minutes or a couple of hours; or
- **broad peak related** – less strongly related to the absolute system peak, occurring generally across the electrical load curve and lasting several hours, days, months, years or indefinitely (eg where the network is close to capacity).

In relation to the spatial dimension, network constraints can:

- occur generally across the network in a particular geographical area; or
- be associated with one or more specific network elements such as certain lines or substations.

[3] Energy Futures Australia (2004). *op cit*.

2.1.2 Characteristics of Network Operational Services

DSM measures have the potential to contribute to a range of network operational services, including:

- voltage regulation;
- load following;
- active/reactive power balancing;
- frequency response;
- supplemental reserve; and
- spinning reserve.

In addition, power factor correction may be regarded as a DSM measure.

With the exception of power factor correction, network operational services provided by DSM are required for relatively short periods of up to a couple of hours. They may also have a strong spatial component, with some services (such a voltage regulation) often being required in a specific location. Other network services (such as frequency control) are usually required generally across the network. The required response times also vary from minutes to almost instantaneous.

2.2 Benefits of Network-driven DSM

There are two types of possible benefits that may be provided by network-driven DSM:

- benefits that accrue to a particular stakeholder; and
- market-wide benefits, ie market operation improvements that provide significant economic and reliability benefits to all participants.

2.2.1 Benefits Accruing to a Particular Stakeholder

Typically, electricity network service providers[4] or independent system operators[5] are the proponents of network-driven DSM projects that are implemented to achieve network-related benefits that accrue specifically to the project proponent.

For **network service providers (NSPs)**, there are two main benefits:

- reduced network operating and maintenance costs; and
- deferred or reduced capital costs for network augmentation.

For **independent system operators (ISOs)**, the main benefit from implementing network-driven DSM measures is improved system reliability at a lower cost than other measures (such as increasing the level of generation over the short term or augmenting the network over the long term).

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[4] Network service providers manage electricity networks and provide transport services for electrical energy through these networks. In addition, they may or may not carry out the technical operation of the electricity system and/or own network assets.

[5] Independent system operators carry out the technical operation of electricity systems. They usually do not manage and provide transport services for electrical energy through electricity networks or own network assets.

In addition, there are two other types of stakeholder that may directly receive benefits from network-driven DSM.

Third party aggregators, who manage and aggregate the provision of load reductions and demand response by individual end-users, receive direct payments from NSPs or ISOs.

End-users of electricity, particularly those located in network-constrained areas, may benefit from:

- increased network reliability;
- lower network use of system charges than would be the case without network-driven DSM, resulting in reduced electricity bills;
- increased choice about how their energy services needs are met;
- a possible increase in the variety and number of customer services available; and
- payments from NSPs, ISOs or third party aggregators[6].

2.2.2 Market-wide Benefits

In addition to the benefits accruing to particular stakeholders, there are market-wide benefits from network-driven DSM that accrue to all participants in the market, even though the DSM measures may have been implemented by one stakeholder to achieve network-related benefits that accrue specifically to that stakeholder.

Market-wide benefits from implementing demand response measures have been identified by IEA DSM Task XIII[7]. The market-wide benefits from implementing network-driven DSM measures are very similar and the following classification is based on the work of IEA DSM Task XIII.

Economic Benefits

While network-driven DSM measures are usually implemented for reasons other than high prices in the electricity market, the load reductions achieved may lead to reduced market prices. Therefore, market-wide economic benefits from network-driven DSM may include:

- reduction in the average price of electricity in the spot market;
- reduced costs of electricity in bilateral transactions (over a 5 to 10 year period); and
- reduced hedging costs, eg reduced cost of financial options.

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6 In some network-driven DSM programs, end-use customers can receive payments for reducing their load at specific times and/or in particular locations.

7 Violette D., Freeman, R. and Neil, C. (2005). *DRR Valuation and Market Analysis: Assessing the DRR Benefits and Costs*. *Volume 1: Overview.* Prepared for International Energy Agency Demand Side Management Programme, Task XIII. Boulder, CO, Summit Blue Consulting.

Reliability Benefits

Network-driven DSM measures are often implemented to improve network reliability. Market-wide reliability benefits include:

- increase in overall system reliability;
- insurance value – lowered costs of extreme events, (ie low-probability/high-consequence events);
- real option values – added flexibility to address future events; and
- portfolio benefits – increase in resource diversity.

Market Operation Benefits

DSM measures implemented to achieve network-related objectives, may also impact on the operation of the electricity market. Market operation benefits may include:

- reduced market power (situational and behavioural); and
- improved overall market efficiency from better interaction of demand and supply.

Environmental Benefits

Implementation of network-driven DSM measures may lead to more efficient use of resources across the whole market.

2.2.3 Distribution of Benefits

As shown in the previous section, benefits from network-driven DSM may be received by one or more of a number of different stakeholders, including: independent system operators; electricity network service providers (ie network owners and/or operators); third party load reduction and demand response aggregators; end-users of electricity; and generally, all electricity market participants.

The distribution of the benefits from network-driven DSM among many different stakeholders means that an individual proponent of a network-driven DSM project is unlikely to capture all the benefits from the project. Other parties who have not contributed to the cost of implementing the project may well receive some of the benefits. This makes it difficult to develop a value proposition for particular network-driven DSM project that will be attractive for a prospective proponent. To provide significant value to the project proponent, the total benefits from the project must be quite large and the proponent must be able capture a significant proportion of these benefits.

2.3 Costs of Network-driven DSM

The actual costs of a network-driven DSM project will depend on the specific DSM measures included in the project and the circumstances in which it is implemented. However, it is possible to identify general categories of costs that apply to all network-driven DSM projects. The costs of these projects may be borne by a number of different stakeholders, including:

- the proponent of the network-driven DSM project;
- end-user participants in the project;

- electricity retailers; and
- generally, electricity market participants.

2.3.1 Costs Borne by the Project Proponent

The proponent of a network-driven DSM project usually bears all the direct costs of project implementation, comprising:

- costs of setting up the project; and
- annual operating costs.

Costs of Setting Up the Project

These are one-time expenditures that may include:

- project design and testing costs;
- marketing costs;
- costs of purchasing and installing equipment in the project proponent's facilities (eg direct load control equipment);
- costs of purchasing and installing equipment in the participants' facilities (if paid for by the project proponent);
- software costs; and
- initial year O&M costs.

Annual Operating Costs

These are ongoing costs that may include:

- payments to project participants, including any incentive payments and subsidies;
- overhead and management costs; and
- any annual licence or other fee.

2.3.2 Costs Borne by End-user Participants

End-user participants may bear a range of direct costs associated with participating in a network-driven DSM project. Such costs may include:

- O&M costs involved in reducing load at specific times and/or in particular locations;
- costs of reducing or altering the timing of production (including lost production, penalty shift rates etc);
- costs of installing and/or operating on-site generation;
- costs of purchasing and installing direct load control equipment (if not paid for by the project proponent);
- costs of installing power factor correction equipment (if not paid for by the project proponent);
- costs of installing energy efficient equipment (if not paid for by the project proponent).

The benefits a particular stakeholder gains from participating in a network-driven DSM project must be greater than the costs, otherwise the stakeholder is unlikely to participate in the project.

2.3.3 Costs Borne by Electricity Retailers

An electricity retailer bears the cost of any reduction in the consumption of electricity supplied by the retailer resulting from the implementation of network-driven DSM projects.

There has been a substantial debate over many years about whether electricity retailers should be compensated for so-called "foregone revenue" resulting from DSM activities[8]. This debate has been complicated by difficulties in estimating the level of foregone revenue resulting from a DSM project or even questions about whether "foregone revenue" is a valid concept. The problem is less acute for entities in which an electricity retailing business is combined with a network service provider business because the NSP business will derive benefits from network-driven DSM activities. However, the issue of foregone revenue can be acute in entities which comprise only an electricity retailing business.

2.3.4 Costs and Savings Borne Generally by Electricity Market Participants

Proponents of network-driven DSM projects need to recover the direct costs of implementing these projects. In most cases, the projects should also lead to cost savings for the project proponents. However, both the implementation costs and the resulting cost savings have to be allocated among the project proponent's customers, ie electricity market participants.

There are various ways in which the implementation costs and cost savings can be allocated among market participants. The simplest way is for the project proponent to make across-the-board adjustments in the prices of the services it provides. In the case of network service providers, these would be adjustments in network use of system charges. In the case of an independent system operator, these would be adjustments in the charges for the services it provides to market participants.

However, across-the-board adjustments in charges may be regarded as inequitable if some market participants do not receive any benefits from network-driven DSM projects. This may well be the case if the projects are targeted to relieve network constraints in specific, clearly-delineated geographical areas. In such a situation, there may be a strong economic argument to adjust charges only for market participants who are located in the constrained areas - in other words to impose a form of network congestion pricing. Network congestion pricing has been trialled in a few locations around the world, particularly in the South Island of New Zealand. However, in many countries congestion pricing is a highly contentious, and governments and regulators are reluctant to introduce it.

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8 Foregone revenue may also be an issue for NSPs whose revenue is dependent on the quantity of electricity transported through their networks.

The equitable allocation among electricity market participants of the implementation costs and cost savings relating to network-driven DSM projects has the potential to be as highly contentious as the allocation of the costs of utility-implemented DSM programs in the United States in the 1980s and early 1990s.

2.4 Measuring the Value of Network-driven DSM

Sections 2.2 and 2.3 demonstrated that the benefits and costs of network-driven DSM projects are distributed across a large number of different stakeholders. Also, the value to a stakeholder of a particular network-driven DSM project may vary among different categories of stakeholders. For example, a DSM project implemented to relieve a network constraint in a specific geographical area will have a very different value for customers located within that area as compared with customers located elsewhere. The same DSM project may have a high positive value for the local network service provider, whereas the project may have a high negative value for a retailer selling electricity in the network constrained area, unless the retailer is compensated for foregone revenue resulting from the project.

Therefore, measuring the value of a network-driven DSM project is not a simple proposition.

IEA DSM Task XIII[9] has defined three types of methodologies that have been used to assess the benefits and costs of demand response projects. These methodologies can equally well be applied to measuring the value of network-driven DSM projects. The methodologies are:

- benchmark assessments;
- benefit-cost framework methodologies; and
- cost-effectiveness framework methodologies based on reliability benefits.

2.4.1 Benchmark Assessments

Benchmark assessments typically examine price bid stacks in electricity markets and estimate how much prices would have dropped in a given market following a given reduction in demand achieved through a DSM project. Some assessments then go further and impute a dollar value for a DSM project by multiplying the volume of sales in the electricity market by the reduction in price.

Benchmark assessments are a very rough and ready methodology for measuring the value of a network-driven DSM project. Benchmark assessments are essentially static and retrospective. They apply to a given time period (usually a day) in the past, in a particular electricity market, under the conditions prevailing at the time. For example, if demand was reduced by (say) 5 to 10 percent on days where prices spiked, it is likely that there was also a substantial reduction in prices. It is also likely that, if generation was increased on the same days, prices would also have been lower. Going forward, these general statements do not provide a framework against which different DSM activities and system options can be assessed[10].

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[9] Violette D., Freeman, R. and Neil, C. (2005). *op cit*.

[10] Violette D., Freeman, R. and Neil, C. (2005). *op cit*.

Benchmark assessments are often used with an assumed level of demand reduction from a DSM project yet to be implemented. However the methodology can also be applied to actual demand reductions achieved after a DSM project has been implemented. However, even with data from actual achieved demand reductions, the value estimates only apply to the particular time period and electricity market studied.

Benchmark assessments applied carefully in full awareness of their limitations can provide a rough rule of thumb for the value of a network-driven DSM project. However, this is an overall economic value that provides no indication of the different values of the project to different types of stakeholders.

2.4.2 Benefit-Cost Framework Methodologies

In contrast to benchmark assessments, benefit-cost framework methodologies can be used to provide indications of the different values of a network-driven DSM project to different types of stakeholders. These methodologies are particularly useful in situations where network-driven DSM projects are being used as alternatives to network augmentation.

The vast majority of benefit-cost framework methodologies are based on the "Standard Practice Manual" (SPM)[11] which was originally developed in California for evaluating utility-sponsored DSM programs. Since it was originally published in 1983, the SPM has been updated a few times, with the 2001 version being the most recent. Some version of the SPM is in use in most regions in the United States, and it has been adapted to apply in other OECD countries as well[12].

The first step in utilising a benefit-cost framework methodology involves defining the stakeholder perspective from which the measurement is being made. The SPM sets out five tests for evaluating DSM programs and each test examines the program from a different stakeholder perspective. Following are descriptions, modified from the SPM, of the five tests and their stakeholder perspectives.

Participant Test

The Participant Test provides a measure of the quantifiable benefits and costs to a customer from participating in a DSM program. However, since many customers do not base their decision to participate in a program entirely on quantifiable variables, this test cannot be a complete measure of the benefits and costs of a program to a customer.

In the Participant Test, the benefits of participating in a DSM program include the reduction in the customer's electricity bill(s)[13], any incentive paid by the program proponent or other third parties, and any federal, state, or local tax credit received. The costs to a customer of program participation are all out-of-pocket expenses incurred as a result of participating in a program, plus any increases in the customer's electricity bill(s).

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11 California Public Utilities Commission (2001). *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects.* San Francisco, CPUC. Available at: www.cpuc.ca.gov/static/energy/electric/energy+efficiency/rulemaking/resource5.doc

12 Violette D., Freeman, R. and Neil, C. (2005). *op cit*.

13 In the case of network-driven DSM programs implemented by ISOs, these bills will include network use of system charges.

The results of this test can be expressed in four ways: through an average net present value per participant; a net present value for the total program; a benefit-cost ratio; or a discounted payback period. The primary unit of measurement is net present value for the total program.

The Participant Test gives a good "first cut" measure of the benefit or desirability of a DSM program to customers.

Ratepayer Impact Measure (RIM) Test

The Ratepayer Impact Measure (RIM) test measures what happens to customer bills or rates (tariffs) due to changes in the program proponent’s revenues and operating costs caused by a DSM program. Rates will go down if revenues collected after program implementation are greater than the total costs incurred by the program proponent. Conversely, rates or bills will go up if revenues are less than the program proponent’s costs. This test indicates the direction and magnitude of the expected change in customer bills or rate levels.

The benefits calculated in the RIM test are the savings from avoided supply costs. These avoided costs include the reduction in transmission, distribution, generation, and capacity costs for periods when load has been reduced and the increase in revenues for any periods in which load has been increased. The costs for this test are the program costs incurred by the program proponent and any other stakeholders that incur costs in creating or administering the program; the incentives paid to the program participants; decreased revenues for any periods in which load has been decreased; and increased supply costs for any periods when load has been increased.

The results of the RIM Test can be presented in several forms: the lifecycle, annual or first-year revenue impacts (cents per kWh or dollars per customer); benefit-cost ratio; and net present value. The primary units of measurement are the lifecycle revenue impact[14] and the net present value.

In contrast to most supply-side options, DSM programs cause a direct shift in revenues. Under many conditions, revenues lost from DSM programs have to be made up by customers. The RIM test is the only test that reflects this revenue shift along with the other costs and benefits associated with the program.

Total Resource Cost (TRC) Test

The Total Resource Cost Test measures the net costs of a DSM program as a resource option based on the total costs of the program, including both the participants' and the program proponent's costs.

This test represents the combination of the effects of a DSM program on both the participating customers and those not participating in the program. In a sense, it is the summation of the benefit and cost terms in the Participant and the Ratepayer Impact Measure tests, where the revenue (bill) change and the incentive terms intuitively cancel (except for the differences in net and gross savings).

[14] Usually expressed as the change in rates (cents per kWh).

The benefits calculated in the TRC Test are the avoided supply costs – the reduction in transmission, distribution, generation, and capacity costs valued at marginal cost – for the periods when there is a load reduction. The costs in this test are the program costs paid by both the program proponent and the program participants plus the increase in supply costs for the periods in which load is increased.

The results of the TRC Test can be expressed in several forms: as a net present value; a benefit-cost ratio; or as a levelised cost. The net present value is the primary unit of measurement for this test.

The primary strength of the Total Resource Cost Test is its scope. The test includes total costs (participant plus program proponent) and also has the potential for capturing total benefits (avoided supply costs). To the extent supply-side project evaluations also include total costs of generation and/or transmission, the TRC test provides a useful basis for comparing demand- and supply-side options.

Societal Test

The Societal Test is a variant on the TRC Test. The Societal Test differs from the TRC Test in that it includes the effects of externalities, excludes tax credit benefits, and uses a different (societal) discount rate.

The Societal Test is structurally similar to the Total Resource Cost Test. However, it goes beyond the TRC test in that it attempts to quantify the change in the total resource costs to society as a whole rather than to only the program proponent and its customers.

In taking a societal perspective, the Societal Test utilises essentially the same input variables as the TRC Test, but they are defined from a broader societal point of view. First, the Societal Test may use higher marginal costs than the TRC test; marginal costs used in the Societal Test should reflect the cost to society if alternatives to a DSM program are more expensive. Second, tax credits are treated as a transfer payment in the Societal Test, and thus are left out. Third, in the case of capital expenditures, interest payments are considered a transfer payment since society actually expends the resources in the first year; therefore, capital costs enter the calculations in the year in which they occur. Fourth, a societal discount rate should be used. Finally, marginal costs used in the Societal Test should also contain externality costs of power generation not captured by the market system.

Program Administrator Cost Test

The Program Administrator Cost Test measures the net costs of a DSM program as a resource option based on the costs incurred by the program proponent (including incentive costs) and excluding any net costs incurred by the participant.

The benefits for the Program Administrator Cost Test are the avoided supply costs of energy and demand, ie the reduction in transmission, distribution, generation and capacity valued at marginal costs for the periods when there is a load reduction. The costs for the test are the program costs incurred by the program proponent; the incentives paid to the participants; and the increased supply costs for the periods in which load is increased.

The results of this test can be expressed either as a net present value, benefit-cost ratio, or levelised costs. The net present value is the primary unit of measurement for this test.

As with the TRC Test, the Program Administrator Cost Test treats revenue shifts as transfer payments, meaning that test results are not complicated by the uncertainties associated with long-term rate projections and associated rate design assumptions. In contrast to the TRC Test, the Program Administrator Test includes only the portion of the participant's equipment costs that is paid for by the program proponent in the form of an incentive. Therefore, for purposes of comparison, costs in the Program Administrator Cost Test are defined similarly to those supply-side projects which also do not include direct customer costs.

Example of the Use of SPM Tests to Value Network-driven DSM Projects

A study commissioned by the Essential Services Commission of South Australia applied SPM tests to five proposed network-driven DSM programs[15]. The study assessed the net benefits and costs of using DSM initiatives and/or pricing signals in combination with interval metering, to defer augmentation of constrained network elements on the South Australian distribution system.

Constraints on the South Australian distribution system are the result of short-term peak loadings on extremely hot summer weather weekdays. Using DSM and/or innovative pricing strategies to delay the need to build or acquire additional network capacity to meet these short-term peaks, will result in reduced capital expenditure for network augmentation, and ultimately lower prices to customers.

The proposed network-driven DSM programs examined in the study were:

- **standby generation in large business facilities** – backup generators would be operated when called upon by the network operator, ETSA Utilities;
- **power factor correction** – large and medium businesses would install capacitor banks to reduce reactive power;
- **thermal energy storage –** large businesses would shift air-conditioning or industrial refrigeration loads entirely out of the peak period;
- **voluntary load control** – medium businesses would reduce their site load during peak periods in response to a request from ETSA Utilities; and
- **direct load control –** air conditioners in small business facilities and residential premises would be automatically cycled on and off, or totally interrupted, under the control of ETSA Utilities.

The cost-effectiveness of each of these proposed network-driven DSM programs was assessed from three perspectives using SPM tests:

- **Participant Benefit-Cost Ratio** (derived from the Participant Test) – measured the quantifiable benefits and costs of a DSM program to a participating customer;

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15 Charles River Associates (2004). *Assessment of Demand Management and Metering Strategy Options.* Prepared for the Essential Services Commission of South Australia. Available at: www.escosa.sa.gov.au/webdata/resources/files/040831-R-CRADemandManagement.pdf

- **Utility Benefit-Cost Ratio** (derived from the Program Administrator Cost Test) – measured the change in total costs to ETSA Utilities resulting from implementation of a DSM program; and
- **Total Resource Cost –** measured the change in the average cost of energy services across all ETSA Utilities customers.

The SPM analysis was carried out on the basis that the proposed network-driven DSM programs were implemented in the area supplied by the North Adelaide zone substation, because previous studies had shown that it was likely that the DSM programs could achieve sufficient load reductions to defer network augmentation in this geographical area. Benefits and costs were estimated over the regulatory period 2005 to 2010 using standard discounted cash flow analysis to estimate the present value of future benefits, costs, and net benefits.

The proposed network-driven DSM programs were developed to provide least-cost solutions to capacity constraints. However, they could also deliver additional benefits to the network service provider, such as the ability to bid short-term load reductions into the spot price market in response to high wholesale prices. This resource could be sold to electricity retailers who require physical hedges to offset market price spikes resulting from reduced generation or network capacity. Therefore, in the analysis, benefits to ETSA Utilities were calculated by estimating both the cost savings compared with network augmentation, and the revenue income for ETSA Utilities from selling physical hedges to retailers, at a 50% sharing ratio.

Based on the SPM analysis, if the standby generation, power factor correction and residential/small business direct load control programs were implemented in North Adelaide, they would each have benefit-cost ratios of 1.0 or greater for all three tests, and would therefore be cost-effective. However, the thermal energy storage and voluntary load control programs would not be cost-effective in North Adelaide.

2.4.3 Cost-Effectiveness Framework Methodologies Based on Reliability Benefits

Cost-effectiveness framework methodologies based on reliability benefits have been developed mainly to enable independent system operators to measure the value of network-driven demand response programs that reduce demand on the network to maintain system reliability over relatively short time periods (up to a couple of hours). In practice, most applications of these methodologies have been in assessments of the value of demand response programs carried out by the New York ISO and ISO New England in the United States[16].

Network-driven demand response programs provide demand-side resources, typically curtailable loads, that can be dispatched to maintain system reliability at acceptable levels. However, treating curtailable loads as supplemental reserves necessitates development of a method for quantifying the value of such reserves. The valuation philosophy adopted by New York ISO and ISO New England focuses on the marginal value of the additional reliability provided by the curtailment capability.

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[16] This section is drawn almost entirely (and slightly modified) from: Violette D., Freeman, R. and Neil, C. (2005). *op cit*.

This marginal value is realised from reductions in the probability and the severity of forced outages. The more likely a system is to experience outages, the greater the value of curtailable load will be. The severity of an outage can be measured by its impact on customers. The number of consumers and the collective load affected are important; the more widespread the outage, the greater the costs to customers. If conditions warrant disconnecting a single feeder, the impact on customers is smaller than if a large portion of the system load must be disconnected.

Establishing the value of curtailable loads to the system therefore involves determining the following:

1. The expected reduction in the occurrence and duration of outages, resulting from the demand response program.
2. The expected magnitude of load that would be disconnected during outages if they were triggered by system conditions.
3. The impact of disconnections on customers, in terms of the value of losses sustained as a result of the disconnection.

The first two items, taken together, can be used to estimate the reduction in expected "unserved energy" (in MWh per year), defined as:

Expected Unserved Energy (MWh per year) = Expected Outages (hours per year) x Expected Disconnected Load (MW) **(Eqn 1)**

The term Expected Unserved Energy normalises the impacts of changes in system reliability by converting any situation into an equivalent level of energy.

To those customers who lose service, outages result in monetary losses in the form of reduced production, lost sales, spoiled goods, and any other losses associated with a business activity or the value of services received by non-business customers. The lost value to customers from outages is described as the value of lost load (VOLL), expressed in dollars per unit of unserved energy ($/MWh). The expected value of curtailable load in avoiding or mitigating outages can then be expressed as the product of the Expected Outages times the Expected Disconnected Load (the consequences in physical terms) times the VOLL (the monetary measure of those consequences).

Value of Curtailable Load ($ per year) = Expected Outages (hours per year) x Expected Disconnected Load (MW) x VOLL ($ per MWh) **(Eqn 2)**

Substituting the formula for Expected Unserved Energy (Eqn. 1) yields the following equation:

Value of Curtailable Load ($ per year) = Expected Unserved Energy (MWh per year) x VOLL ($ per MWh) **(Eqn 3)**

According to this formula (Eqn 3), the value of curtailable load, and by association the value of the demand response program that creates it, is based on the expectations of future outages, not on a retrospective analysis of how many times the curtailable load was called upon. This reflects the fact that demand response programs have value as a hedge against generation outages and higher-than-expected demand, regardless of whether they are ultimately needed, or how much they are actually used in any given year. Outage history may affect future expectations, and therefore value, but it is the expectations upon which value is estimated.

In order to estimate the value of demand response programs, estimates must be derived for the three inputs to the Value of Curtailable Load formula (Eqn 3). These estimates can be based on information available to most NSPs and ISOs and on appropriate use of the body of knowledge on the value of lost load.

2.5 Value Proposition Conclusions

The major conclusion from this section 2 is that the value of a network-driven DSM project varies among categories of stakeholders and may even vary among individual stakeholders (eg customers located in network-constrained areas vs customers located outside these areas). Therefore, the value proposition for a network-driven DSM project will also vary depending on the particular stakeholder being considered.

There are several consequences arising from this situation:

- the distribution of the benefits from network-driven DSM projects among many different stakeholders means that the project proponent is unlikely to capture all the benefits from such a project; other parties who have not contributed to the cost of implementing the project may well receive some of the benefits;
- to provide significant value to the project proponent, the total benefits from a network-driven DSM project must be quite large and the proponent must be able capture a significant proportion of these benefits;
- both the implementation costs for, and the cost savings resulting from, a network-driven DSM project have to be allocated among the project proponent's customers, ie electricity market participants;
- if the implementation costs and cost savings are allocated among market participants through across-the-board adjustments in the prices of the services the project proponent provides, this may be regarded as inequitable, particularly if some market participants do not receive any benefits from the network-driven DSM projects;
- inequities may particularly arise if a network-driven DSM project is targeted to relieve network constraints in a specific geographical area;
- in such a situation, there may be a strong economic argument to adjust charges only for market participants who are located in the constrained area - in other words to impose a form of network congestion pricing; however, in many countries congestion pricing is a highly contentious, and governments and regulators are reluctant to introduce it;
- because of the distribution of benefits and costs among a large number of stakeholders, measuring the value of a network-driven DSM project is not a simple proposition; in addition, the value of a particular project will vary among individual stakeholders;
- however, methodologies have been developed that enable the measurement of the value of different types of network-driven DSM projects, both for individual stakeholders and in broader contexts, including for society as a whole.

3. EFFECTIVENESS OF NETWORK-DRIVEN DSM MEASURES

The objective of Activity 2-2 in Subtask 2 is to determine the factors which result in a DSM measure being successful in cost-effectively achieving network-related objectives[17]. These success factors are identified by analysing the information contained in the Task XV case study database of network-driven DSM projects. This section of the report summarises the results from Activity 2-2. The case study database is accessible on-line on the Task XV website at: http://www.ieadsm.org/CaseStudies.aspx.

3.1 Success Factors for Network-Driven DSM Projects

Examination of the 64 case studies of network-driven DSM projects in the Task XV database[18] identifies two types of factors that may contribute to the success of the projects:

- external factors that establish the context within which a network-driven DSM project operates; and
- internal factors that are specific to each individual project and determine how the project is implemented.

3.2 External Success Factors

The context within which a network-driven DSM project operates is shaped and governed by a number of factors external to the project itself. Some of these comprise broad geographic and socio-economic factors such as climate change, economic conditions and the political situation. While such broad external factors can affect the outcome of a project, their influence on the project occurs indirectly and cannot easily be taken into account when the project is being designed. Therefore, such factors will not be considered further here.

A second group of external factors exert more direct influences on whether a network-driven DSM project is successful. These factors can be taken into account when a project is being designed. From the Task XV case study database, it is possible to identify seven types of external success factors that may directly contribute to the success of network-driven DSM projects:

- government policies;
- regulatory regime;
- market structure;
- commitment by project proponent;
- technology availability;
- commercial considerations; and
- public relations benefits.

Table 1 (pages 17 to 22) shows the distribution of these external success factors across the 64 network-driven DSM projects in the Task XV case study database.

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17 Energy Futures Australia (2004). *Prospectus: Research Project on Network-driven DSM*. Hornsby Heights, NSW Australia, EFA.

18 Crossley, D.J. (2008). *Worldwide Survey of Network-driven Demand-side Management Projects*. Second edition. International Energy Agency Demand Side Management Programme, Task XV Research Report No 1. Hornsby Heights, NSW, Australia, Energy Futures Australia Pty Ltd.

TABLE 1. EXTERNAL SUCCESS FACTORS FOR THE NETWORK-DRIVEN DSM PROJECTS IN THE TASK XV CASE STUDY DATABASE								
Case Study No	Project	Government Policies	Regulatory Regime	Market Structure	Commitment by Project Proponent	Technology Availability	Commercial Considerations	Public Relations Benefits
Direct Load Control								
DC01	Ethos Project Trial of Multimedia Energy Management Systems - Wales, UK				√	√		
DC02	Sydney CBD Demand Curtailment Project - Australia				√	√		
DC03	LIPAedge Direct Load Control Program - USA			√	√	√	√	
DC04	Sacramento Peak Corps - USA		√	√	√	√		√
DC05	PEF Direct Load Control and Standby Generator Programs - USA		√	√		√		
DC06	ETSA Utilities Air Conditioner Direct Load Control Program - Australia							
DC07	California Automated Demand Response System Pilot - USA							
DC08	Orion Network DSM Program - New Zealand							
DC09	Separation of Agricultural Feeders for Load Control - India							

Case Study No	Project	Government Policies	Regulatory Regime	Market Structure	Commitment by Project Proponent	Technology Availability	Commercial Considerations	Public Relations Benefits
Distributed Generation								
DG01	Nelson Bay Embedded Generation - Australia				√	√	√	
DG02	Bromelton Embedded Generation - Australia				√	√	√	
DG03	Kerman Photovoltaic Grid-Support Project - USA				√	√		√
DG04	Chicago Energy Reliability and Capacity Account - USA	√			√	√		
DG05	Mitigation of Load Shedding in Pune Urban Circle - India				√	√		
Demand Response								
DR01	ISO New England Demand Response Programs - USA			√	√	√	√	
DR02	New York ISO Demand Response Programs - USA			√	√	√	√	
DR03	PJM Load Response Programs - USA			√	√	√	√	
DR04	South Island Demand Side Participation Trial - New Zealand		√	√	√		√	

Case Study No	Project	Government Policies	Regulatory Regime	Market Structure	Commitment by Project Proponent	Technology Availability	Commercial Considerations	Public Relations Benefits
Energy Efficiency								
EE01	Efficient Lighting Project DSM Pilot - Poland				√			
EE02	Oncor Standard Offer Program for Residential and Commercial Energy Efficiency - USA		√				√	
EE03	Oncor Air Conditioning Distributor Market Transformation Program - USA		√				√	
EE04	Espanola Power Savers Project - Canada				√			√
EE05	Katoomba DSM Program - Australia	√			√		√	√
EE06	Drummoyne Demand Management Project - Australia	√	√	√	√			
EE07	Nashik CFL Pilot Project - India	√			√	√	√	
EE08	Mumbai Efficient Lighting Program - India	√			√	√	√	
EE09	Mumbai Consumer Awareness Campaign - India	√			√		√	√
EE10	Bangalore Efficient Lighting Program - India	√			√	√	√	
Fuel Substitution								
FS01	Tahmoor Fuel Substitution Project - Australia				√	√	√	
FS02	Binda-Bigga Demand Management Project - Australia				√	√	√	
FS03	Paradip Port Substitution of Cooking Fuel Project - India				√		√	√

Case Study No	Project	Government Policies	Regulatory Regime	Market Structure	Commitment by Project Proponent	Technology Availability	Commercial Considerations	Public Relations Benefits
Interruptible Loads								
IL01	Load Interruption Contract - Spain			√	√		√	
IL02	Flexible Load Interruption Contract - Spain			√	√		√	
IL03	Interruptibility Contract for Cogenerators - Spain			√	√		√	
IL04	Active / Reactive Power Exchange - Spain			√	√		√	
IL05	California Energy Cooperatives - USA			√	√		√	
Integrated DSM Projects								
IP01	Blacktown DSM Program - Australia	√	√		√			
IP02	Castle Hill Demand Management Project - Australia	√	√		√			
IP03	Parramatta DSM Program - Australia	√	√		√			
IP04	Olympic Peninsula Non-wires Solutions Pilot Projects and GridWise Demonstration - USA	√			√			√
IP05	Brookvale / DeeWhy DSM Program - Australia	√	√		√			
IP06	Maine-et-Loire DSM Project - France				√		√	
IP07	Deferring Network Investment - Finland				√	√	√	

Case Study No	Project	Government Policies	Regulatory Regime	Market Structure	Commitment by Project Proponent	Technology Availability	Commercial Considerations	Public Relations Benefits
Integrated DSM Projects (continued)								
IP08	French Riviera DSM Program -France				√	√		√
IP09	Manweb Demand Side Management Project - Wales, United Kingdom				√		√	√
IP10	Coalition of Large Distributors Conservation and Demand Management Programs - Canada	√	√	√	√		√	√
IP11	Pilot Project to Improve Agricultural Pump Set Efficiency - India	√			√	√	√	
IP12	Agricultural Pump Set Efficiency Improvement Program - India	√			√	√	√	
Load Shifting								
LS01	Winter Peak Demand Reduction Scheme - Ireland				√		√	
LS02	Eskom DSM Profitable Partnership Programme - South Africa	√			√			√
LS03	TU Electric Thermal Cool Storage Program - USA				√	√	√	
LS04	Mad River Valley Project - USA				√		√	
LS05	Baulkham Hills Substation Deferral Project - Australia	√	√		√			
Power Factor Correction								
PC01	Marayong Power Factor Correction Program - Australia				√		√	

Case Study No	Project	Government Policies	Regulatory Regime	Market Structure	Commitment by Project Proponent	Technology Availability	Commercial Considerations	Public Relations Benefits
Pricing Initiatives								
PI01	California Critical Peak Pricing Tariff for Large Customers - USA	√	√	√		√		√
PI02	Loire Time of Use Tariff Program - France			√	√		√	√
PI03	Queanbeyan Critical Peak Pricing Trial - Australia			√	√	√		√
PI04	Hourly Demand Tariff - Spain	√	√	√	√			
PI05	End User Flexibility by Efficient Use of Information and Communication Technologies - Norway			√	√	√		√
PI06	Tempo Electricity Tariff - France	√	√	√	√	√	√	
PI07	Reduced Access to Network Tariff - Spain	√	√	√	√		√	
PI08	EnergyAustralia Pricing Strategy Study - Australia	√	√	√	√	√	√	√
PI09	California Statewide Pricing Pilot for Small Customers - USA	√	√	√	√	√	√	√
Smart Metering								
SM01	Carbon Trust Advanced Metering Trial - United Kingdom	√			√	√		√

3.2.1 Government Policies

Government policies can contribute to the success of network-driven DSM projects in two ways:

- they can create a favourable context in which network-driven DSM projects are seen as viable alternatives to supply-side options; and/or
- they can impose obligations requiring the use of network-driven DSM projects instead of supply-side options.

The role of government policies in creating a favourable context for network-driven DSM projects can be seen in the Katoomba DSM Program in Australia (Case Study EE05), the Olympic Peninsula project in the United States (Case Study IP04) and the Eskom Profitable Partnership Programme in South Africa (Case Study LS02). In these projects, government policies were generally in favour of energy efficiency and DSM but the government did not specifically require the implementation of demand-side options.

Stronger government intervention through imposing a requirement for demand-side options can be seen in the more recent direct load control, energy efficiency and integrated DSM projects in Australia (Case Studies DC02, DC06, EE06, IP01 to IP03 and IP05). Most of these programs were implemented in the State of New South Wales, where the State Government has imposed a condition on the licences of electricity distributors that requires them to take demand-side options into account when planning network augmentations. In response to this requirement, the electricity industry itself developed a voluntary Code of Practice that specifies how electricity distributors could incorporate DSM into their planning of network augmentations[19]. The Code was first developed in 1999 and has been revised several times since then; each revision is authorised by the relevant government department before it is published.

The Chicago Energy Reliability and Capacity Account (Case Study DG04) and the California Critical Peak Pricing Tariff (Case Study PI01), both in the United States, are interesting examples of government actions requiring the implementation of network-driven DSM. In Chicago, the local government, the City of Chicago, sued the local utility for not providing an adequate electricity network and the court ordered the utility to establish a fund of money to be used for demand-side options. In California, the State Government, working through the electricity industry regulator and the California Energy Commission, required the local utilities to establish a range of demand-side responses to the 2001 “energy crisis”, including the development of critical peak pricing.

A somewhat unusual case of government intervention is the Separation of Agricultural Feeders for Load Control project in India (Case Study DC09). The project was initiated by the Government of Gujarat and implemented by electricity distributors in the State of Gujarat. In 2003, the Government of Gujarat announced a scheme called "Jyotigram Yojana" (JGY) to provide continuous three phase power supply to rural areas of the State to improve the quality of life of the rural population. Under the JGY scheme, the

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19 Department of Energy, Utilities and Sustainability (2004). *Demand Management for Electricity Distributors: NSW Code of Practice.* Third Edition. Sydney, DEUS.

Gujarat Government decided to separate agricultural pump set connections from domestic light and fan (DLF) connections by constructing separate 11 KV feeders for agricultural loads. This enabled electricity distributors to implement direct load control of agricultural pumps by establishing schedules specifying the times during the day when each agricultural feeder would be energised. The main objective of implementing this direct load control program was to flatten the load curve to provide sufficient network capacity for the morning and evening peaks.

3.2.2 Regulatory Regimes

Regulatory regimes act in a similar way to government policies in contributing to the success of network-driven DSM projects:

- they can create a favourable context in which network-driven DSM projects are seen as viable alternatives to supply-side options; and/or
- they can impose obligations requiring the use of network-driven DSM projects instead of supply-side options.

The role of regulatory regimes in creating a favourable context for network-driven DSM is demonstrated in a recent determination by the electricity industry regulator in the Australian State of New South Wales[20]. In 2004, the regulator introduced a D-factor into the weighted average price cap control formula that allowed distribution network service providers to recover:

- approved non-tariff-based DSM implementation costs, up to a maximum value equivalent to the expected avoided distribution costs;
- approved tariff-based DSM implementation costs;
- approved revenue foregone as a result of non-tariff-based DSM activities.

This determination provides significant incentives that enable electricity distributors to recover virtually all the costs they incur in implementing network-driven DSM projects, including the revenue foregone from lower quantities of electricity being transported through the network. The allowable cost recovery is capped at a maximum value equivalent to the expected costs of the alternative network augmentation option (eg building a new line or substation). All network-driven DSM projects recently implemented in New South Wales benefit from these incentives. This includes the following projects in the Task XV case study database: Case Studies DC02, EE06, FS02, IP01 to IP03 and IP05).

The role of regulatory regimes in imposing a requirement for demand-side options can be seen in the actions of many state-based regulators in the United States. From the 1980s to the mid-1990s, the regulators required electricity utilities to carry out energy efficiency DSM programs and also provided some financial incentives to enable them to do so. Regulators in some US states still impose similar requirements which can apply to network-driven DSM projects. This includes the following projects in the Task XV case study database: Case Studies DC04, DC05, EE02 and EE03. In California, the

[20] Independent Pricing and Regulatory Tribunal (2004). *NSW Electricity Distribution Pricing 2004/05 to 2008/09: Final Report*. Sydney, IPART.

regulator had a role in requiring the local utilities to develop critical peak pricing (Case Studies DC07, PI01 and PI09).

3.2.3 Market Structure

The structure of the electricity market can be an important factor in enabling the implementation of network-driven DSM projects. This is most evident where a network-driven DSM measure is closely linked to the market structure. Typically, such measures aim to influence the behaviour of end-users. There are two types of these measures:

- measures that provide market-linked incentives to end-users;
- measures that impose market-linked penalties on end-users.

Market-linked incentives reward end-users for behaviour that increases network reliability. In the United States, most of the independent system operators (ISOs) have developed programs that enable end-use customers to receive payments for reducing their loads at times when there are high market prices or network capacity shortages (see Case Studies DR01 to DR03). Individual utilities in the United States have developed similar measures (see Case Studies DC03 to DC05). The transmission system operator in Spain has also developed similar measures, mostly based on various forms of interruptibility contracts (see Case Studies IL01 to IL04).

California Energy Cooperatives (Case Study IL05) are an interesting example of an initiative that uses market-linked incentives. An Energy Cooperative comprises a group of end-users who have banded together to offer load reductions to an electricity utility. The load reductions can be called by the utility and the cooperative ensures that the required level of reduction is delivered by aggregating the reductions achieved by individual cooperative members. The utility pays the cooperative for both the availability of the load reduction and any reductions actually delivered. The cooperative distributes these payments to its members.

Market-linked penalties discourage end-users from behaviour that decreases network reliability. These penalties mostly take the form of time of use prices with high prices during peak periods lasting several hours (see Case Studies DC07 and PI01 to PI09). The purpose of these measures is to encourage end-users to shift their use of electricity away from the peak period. There is also increasing use of critical peak pricing in which very high electricity prices are set for short periods (one or two hours) at the time of the system peak (see Case Studies DC07, PI01, PI03, PI08 and PI09).

3.2.4 Commitment by Project Proponent

Commitment by the proponent of a network-driven DSM project may be an important factor in ensuring the success of the project. Because network-driven DSM is not the usual or generally accepted way in which network problems are resolved, strong commitment by the project proponent is usually important in most network-driven DSM projects.

Commitment by the project proponent is particularly important:

- where distributed generation is used as an alternative to network augmentation (see Case Studies DG01 to DG05);

- in integrated network-driven DSM projects (see Case Studies IP01 to IP 12); and
- in most direct load control, demand response, interruptible loads and load shifting projects (see Case Studies DC01 to DC09, DR01 to DR04, IL01 to IL05 and LS01 to LS05).

Network-driven DSM initiatives by the Bonneville Power Authority (BPA) demonstrate the importance of commitment by a project proponent. BPA operates the transmission network in much of the Pacific Northwest region of the United States. In 2001, BPA started considering measures other than building new transmission lines to address load growth, constraints and congestion on the transmission system. Currently, BPA, along with others in the region, is exploring "non-wires solutions" as a way to defer large construction projects. BPA defines non-wires solutions as a broad array of alternatives, including demand response, distributed generation, energy efficiency measures, generation siting and pricing strategies that individually or in combination delay or eliminate the need for upgrades to the transmission system. BPA and its consultants have developed a screening process and checklist to evaluate a transmission problem area to determine whether it is a candidate for a non-wires solution.

BPA has focussed particularly on the Olympic Peninsula area in north-west Washington State (Case Study IP04). The Peninsula has received particular attention because it is an environmentally sensitive area with increasing demand for electricity and limited transmission capacity. The capacity of the transmission lines on the Peninsula may become inadequate as early as December 2007, if there is a forced outage of one line during peak periods of cold weather. A significant transmission construction project, including a new 20-mile 230 kV line, is being contemplated on the Peninsula. In an attempt to defer the construction of this line, BPA is carrying out a number of non-wires solutions pilot projects on the Peninsula, including direct load control, demand response, voluntary load curtailments, networked distributed generation and energy efficiency.

3.2.5 Technology Availability

In some network-driven DSM projects, the availability of a particular type of technology is crucial to the success of the project. Indeed, some network-driven DSM projects are designed specifically to take advantage of a particular type of technology.

This is particularly the case with direct load control and demand response projects (see Case Studies DC01 to DC09 and DR01 to DR04). These types of network-driven DSM projects require specific types of technology to enable remote communication with, and control of, appliances and equipment and near real-time monitoring of the load reductions achieved.

The availability of a particular type of technology is also crucial for distributed generation projects (see Case Studies DG01 to DG04), fuel substitution projects (Case Studies FS01 to FS03), and some projects employing time of use pricing (see Case Studies PI01, PI03, PI05, PI06 and PI09).

The LIPAedge Direct Load Control Program (Case Study DC03) is an example of a network-driven DSM project built around the availability of a particular type of technology. Long Island Power Authority (LIPA) developed the LIPAedge program to use central control of residential and small commercial air-conditioning thermostats to achieve peak load reduction. The program uses the programmable ComfortChoice thermostat designed by the Carrier Corporation with associated communication infrastructure provided by Silicon Energy.

The system operator uses an internet-based system to control a demand-side resource comprising about 20,000 thermostat-controlled air conditioners. Two-way pagers are used to transmit a curtailment order to the thermostats and to receive acknowledgment and monitoring information. The thermostats take immediate action or adjust their schedules for future action, depending on what the system operator ordered. The thermostats log the order and respond via pager, enabling LIPA to monitor the response to the event.

For a summer load curtailment, the system operator might send a command at 9:00 am directing all thermostats to move their set points up 4 degrees, starting at 2:00 pm and ending at 6:00 pm. Alternatively, the system operator could send a command directing all thermostats to completely curtail immediately. The command would be received and acted upon by all loads, providing full response within about 90 seconds. This is far faster than generator response, which typically requires a 10-minute ramp time. Thermostats can be addressed individually, in groups, or in total; this provides both flexibility and speed.

End-use customers also receive benefits. The thermostat is fully programmable and remotely accessible, with all of the associated energy savings and convenience benefits. A web-based remote interface is provided for customer interaction. Customers can also override curtailment events. This feature appears to be important to gain customer acceptance and it probably increases the reliability of the response.

3.2.6 Commercial Considerations

Most network-driven DSM projects are justified on the basis that they are more cost-effective than supply-side options. For some specific projects, commercial considerations are the most important success factor.

This is particularly the case where DSM measures are used to defer proposed network augmentations (see Case Studies DC08, DG01, DG02, DR04, EE06, FS01, IP06, IP07, LS04 and PC01). In these types of projects, the main justification for implementing network-driven DSM measures is that they are more cost-effective than the network augmentation “build” option. Commercial considerations are also important in projects where DSM measures are used to target peak load reductions generally on the network (see Case Studies DC03, IL01 to IL05, LS01, PI06 and PI07) and particularly in countries such as India where there are acute shortages of both network and generation capacities (see Case Studies DC09, DG05, EE07 to EE10, FS03, IP11 and IP12).

A good example of a project where commercial considerations were important is the Mad River Valley Project in the United States (Case Study LS04). The Mad River Valley is a region in central Vermont which is home to growing ski resort developments. In 1989, the Valley was served by a 34.5kV distribution line extending in a long “U” down one valley, across a ridge and back along the other side of the ridge. Sugarbush Resort, the largest load on the line, was located at the base of the “U”, its weakest point. The resort informed the local electricity utility that it was planning to increase its load to accommodate a new hotel and conference centre and significant new snowmaking equipment. An increase in load at that location would have impaired the reliability of the line, requiring an upgrade. Under Vermont's line extension rules at the time, it was likely that a major portion of the cost of the upgrade would be charged to the customer. Neither the customer nor the utility wanted to pay for the line. Instead, a network-driven DSM project was negotiated with two major elements: a targeted utility energy efficiency program in the Mad River Valley, and a customer load management commitment under which Sugarbush committed to ensuring that load on the distribution line would not exceed the safe level.

Commercial considerations were also important in the Paradip Port Substitution of Cooking Fuel Project in India (Case Study FS03). The project was initiated and funded by the Paradip Port Trust which administers the port of Paradip. The Trust purchases electricity in bulk under a maximum demand contract and then supplies electricity directly to its employees for household use. The objective of the project was to reduce system peak demand by introducing LPG as a domestic cooking fuel through replacing electric stoves used by Trust employees. The project was targeted at cooking in the residential sector because this activity comprised approximately 60% of the electrical usage in each household. Almost 90% of the households in the residential facility provided by the Trust used electric stoves for cooking, adding 3 to 4 MW to the electricity demand. Because electric stoves were the largest contributors to the peak demand, replacing these with LPG cooking stoves resulted in considerable electricity and cost savings.

3.2.7 Public Relations Benefits

In some cases, achieving public relations benefits for the project proponent is a major success factor for a network-driven DSM project. Public relations benefits may include: increased customer loyalty, increased credibility for the project proponent, and improved relations with governments and/or regulators.

There is no particular type of project for which public relations benefits are always a success factor, though public relations issues tend to be important in projects that require participation by large numbers of end-users. In the Task XV case study database, public relations issues are important in the following projects: Case Studies DC04, DG03, EE04, EE05, EE09, FS01, IP04, IP08, LS02, LS04, PI01 to PI03 and PI05.

The California Critical Peak Pricing Tariff for Large Customers (Case Study PI01) was implemented in the aftermath of the 2001 "energy crisis" in the state in which all the major investor-owned utilities filed for bankruptcy protection and electricity prices doubled for some customers over a matter of months. It was imperative that the state government and the regulator be seen to be doing something to relieve the situation. In June 2002, the California Energy Commission adopted an Order Instituting Rulemaking on "policies and practices for advanced metering, demand response, and dynamic pricing". In June 2003, the Commission authorised a Critical Peak Pricing (CPP) tariff for large customers proposed by the three California investor-owned utilities, as well as several other demand response-related programs. A statewide demand response measurement and evaluation (M&E) effort also began in 2003, comprising a comprehensive monitoring and evaluation plan. The plan outlined M&E activities in an effort to provide information that would improve the cost-effectiveness of demand response activities going forward.

The goal underlying all of the demand response programs was to provide California with greater flexibility in responding to periods of high peak electricity demand. The objective in rolling out these specific programs relatively quickly with limited formal rate design research was to achieve a "quick win" that would:

- take advantage of the new interval meters installed in customers premises;
- give both customers and utilities experience in implementing statewide demand response programs;
- deliver significant load reductions for summer 2004; and
- make a significant contribution to achieving the California Public Utilities Commission's overall price-responsive demand response goals.

A different type of public relations benefit is evident in the French Riviera DSM Program (Case Study IP08). In this case, a very large DSM project is being implemented to defer the need to upgrade a major transmission line serving the eastern part of the Provence-Alpes-Côte d'Azure region of France. For the past 20 years, there has been very strong local opposition to the upgrading of the line because the line would pass through the classified scenic gorges of the Verdon Regional Park. In May 2006, the state court, after a complaint from an environmental group, refused planning permission for the upgrading of the line. Therefore, at present, the DSM program is the only way to secure supply to this region by keeping load growth within the capacity of the existing line.

3.3 Internal Success Factors

Internal success factors are specific to each particular network-driven DSM project and determine how the project is implemented. In general, projects that demonstrate a clear "story" and understanding of the market and have developed the right linkages and partnerships to successfully target that market are likely to be more successful than projects that lack such characteristics. Successful network-driven DSM projects require well thought-out processes and procedures. Projects that clearly articulate the steps involved in implementation as well as clearly delineate management responsibilities and structures have a higher likelihood of succeeding relative to those that do not.

Seven types of internal success factors can be identified from the Task XV case study database:

- project objectives;
- target market;
- demand-side measures used;
- market barriers addressed;
- outreach and marketing;
- participation process and customer service; and
- delivery mechanisms.

Each of these factors is a component of most network-driven DSM projects. However, depending on the specific project design, some of the factors are more important than others in contributing to the success of individual projects.

Table 2 (pages 30 to 35) shows the distribution of these internal success factors across the 64 network-driven DSM projects in the Task XV case study database.

TABLE 2. INTERNAL SUCCESS FACTORS FOR THE NETWORK-DRIVEN DSM PROJECTS IN THE TASK XV CASE STUDY DATABASE								
Case Study No	Project	Project Objectives	Target Market	Demand-side Measures Used	Barriers Addressed	Outreach and Marketing	Participation Process & Customer Service	Delivery Mechanisms
Direct Load Control								
DC01	Ethos Project Trial of Multimedia Energy Management Systems - Wales, UK	√	√	√	√	√	√	√
DC02	Sydney CBD Demand Curtailment Project - Australia	√		√	√			√
DC03	LIPAedge Direct Load Control Program - USA	√	√	√	√	√	√	√
DC04	Sacramento Peak Corps - USA	√	√	√	√	√	√	√
DC05	PEF Direct Load Control and Standby Generator Programs - USA	√	√	√	√	√	√	√
DC06	ETSA Utilities Air Conditioner Direct Load Control Program - Australia	√	√	√	√	√	√	√
DC07	California Automated Demand Response System Pilot - USA	√	√	√	√	√	√	√
DC08	Orion Network DSM Program - New Zealand	√	√	√	√	√	√	√
DC09	Separation of Agricultural Feeders for Load Control - India	√	√	√		√	√	

Case Study No	Project	Project Objectives	Target Market	Demand-side Measures Used	Barriers Addressed	Outreach and Marketing	Participation Process & Customer Service	Delivery Mechanisms
Distributed Generation								
DG01	Nelson Bay Embedded Generation - Australia	√						
DG02	Bromelton Embedded Generation - Australia	√						
DG03	Kerman Photovoltaic Grid-Support Project - USA	√						
DG04	Chicago Energy Reliability and Capacity Account - USA	√						
DG05	Mitigation of Load Shedding in Pune Urban Circle - India	√						
Demand Response								
DR01	ISO New England Demand Response Programs - USA	√	√	√	√	√	√	√
DR02	New York ISO Demand Response Programs - USA	√	√	√	√	√	√	√
DR03	PJM Load Response Programs - USA	√	√	√	√	√	√	√
DR04	South Island Demand Side Participation Trial - New Zealand	√	√	√		√	√	

Case Study No	Project	Project Objectives	Target Market	Demand-side Measures Used	Barriers Addressed	Outreach and Marketing	Participation Process & Customer Service	Delivery Mechanisms
Energy Efficiency								
EE01	Efficient Lighting Project DSM Pilot - Poland	√	√	√	√	√		√
EE02	Oncor Standard Offer Program for Residential and Commercial Energy Efficiency - USA	√	√	√	√	√		√
EE03	Oncor Air Conditioning Distributor Market Transformation Program - USA	√	√	√	√	√		√
EE04	Espanola Power Savers Project - Canada	√	√	√	√	√	√	√
EE05	Katoomba DSM Program - Australia	√	√	√	√	√		√
EE06	Drummoyne Demand Management Project - Australia	√	√	√	√	√	√	√
EE07	Nashik CFL Pilot Project - India	√	√	√	√	√	√	√
EE08	Mumbai Efficient Lighting Program - India	√	√	√	√	√	√	√
EE09	Mumbai Consumer Awareness Campaign - India	√	√			√	√	√
EE10	Bangalore Efficient Lighting Program - India	√	√	√	√	√	√	√
Fuel Substitution								
FS01	Tahmoor Fuel Substitution Project - Australia	√	√	√	√	√	√	√
FS02	Binda-Bigga Demand Management Project - Australia	√	√	√	√	√	√	√
FS03	Paradip Port Substitution of Cooking Fuel Project - India	√	√	√				√

Case Study No	Project	Project Objectives	Target Market	Demand-side Measures Used	Barriers Addressed	Outreach and Marketing	Participation Process & Customer Service	Delivery Mechanisms
Interruptible Loads								
IL01	Load Interruption Contract - Spain	√	√	√				
IL02	Flexible Load Interruption Contract - Spain	√	√	√				
IL03	Interruptibility Contract for Cogenerators - Spain	√	√	√				
IL04	Active / Reactive Power Exchange - Spain	√	√	√				
IL05	California Energy Cooperatives - USA	√	√	√	√	√	√	√
Integrated DSM Projects								
IP01	Blacktown DSM Program - Australia	√	√	√	√	√	√	√
IP02	Castle Hill Demand Management Project - Australia	√	√	√	√	√	√	√
IP03	Parramatta DSM Program - Australia	√	√	√	√	√	√	√
IP04	Olympic Peninsula Non-wires Solutions Pilot Projects and GridWise Demonstration - USA	√	√	√	√	√	√	√
IP05	Brookvale / DeeWhy DSM Program - Australia	√	√	√	√	√	√	√
IP06	Maine-et-Loire DSM Project - France	√	√	√	√	√	√	√
IP07	Deferring Network Investment - Finland	√	√	√	√	√	√	√

Case Study No	Project	Project Objectives	Target Market	Demand-side Measures Used	Barriers Addressed	Outreach and Marketing	Participation Process & Customer Service	Delivery Mechanisms
Integrated DSM Projects (continued)								
IP08	French Riviera DSM Program - France	√	√	√	√	√	√	√
IP09	Manweb Demand Side Management Project - Wales, United Kingdom	√	√	√	√	√	√	√
IP10	Coalition of Large Distributors Conservation and Demand Management Programs - Canada	√	√	√	√	√	√	√
IP11	Pilot Project to Improve Agricultural Pump Set Efficiency - India	√	√	√				
IP12	Agricultural Pump Set Efficiency Improvement Program - India	√	√	√	√	√	√	√
Load Shifting								
LS01	Winter Peak Demand Reduction Scheme - Ireland	√	√	√	√	√	√	
LS02	Eskom DSM Profitable Partnership Programme - South Africa	√	√	√	√	√	√	√
LS03	TU Electric Thermal Cool Storage Program - USA	√	√	√	√	√		√
LS04	Mad River Valley Project - USA	√	√	√	√	√	√	
LS05	Baulkham Hills Substation Deferral Project - Australia	√	√	√	√			√
Power Factor Correction								
PC01	Marayong Power Factor Correction Program - Australia	√	√	√	√			

Case Study No	Project	Project Objectives	Target Market	Demand-side Measures Used	Barriers Addressed	Outreach and Marketing	Participation Process & Customer Service	Delivery Mechanisms
Pricing Initiatives								
PI01	California Critical Peak Pricing Tariff for Large Customers - USA	√	√	√	√	√	√	√
PI02	Loire Time of Use Tariff Program - France	√	√	√	√	√	√	√
PI03	Queanbeyan Critical Peak Pricing Trial - Australia	√	√	√	√	√	√	√
PI04	Hourly Demand Tariff - Spain	√	√	√	√	√	√	
PI05	End User Flexibility by Efficient Use of Information and Communication Technologies - Norway	√	√	√	√	√	√	√
PI06	Tempo Electricity Tariff - France	√	√	√	√	√	√	√
PI07	Reduced Access to Network Tariff - Spain	√	√	√	√	√	√	
PI08	EnergyAustralia Pricing Strategy Study - Australia	√	√			√	√	
PI09	California Statewide Pricing Pilot for Small Customers - USA	√	√	√		√	√	
Smart Metering								
SM01	Carbon Trust Advanced Metering Trial - United Kingdom	√	√	√	√	√	√	√

3.3.1 Project Objectives

Defining the project objectives is a fundamental first step in designing a network-driven DSM project. Clear and well-defined objectives are an important factor in determining whether or not a project is successful. Indeed, for many projects, the clarity with which the project objectives are defined determines whether or not the project is successful. In particular, the way in which the objectives for a project are defined often drives the design of the project and the selection of the individual project components.

Project objectives are important success factors for all network-driven DSM projects, and particularly important for direct load control projects (see Case Studies DC01 to DC09), demand response projects (see Case Studies DR01 to DR04), integrated DSM projects (see Case Studies IP01 to IP08), interruptible loads projects (see Case Studies IL01 to IL05), load shifting projects (see Case Studies LS01 to LS05), and some pricing initiative projects (see Case Studies PI01 to PI03 and PI07).

The Baulkham Hills Substation Deferral project in Australia (Case Study LS05) is a good example of a network-driven DSM project where the project objective was an important success factor. The project had a very clear objective: to defer an AUD 1.7 million network augmentation project to construct the Baulkham Hills zone substation, which had become necessary as a result of the growth in summer afternoon peaks. This objective was achieved very simply by reaching an agreement with one major industrial customer who uses large furnaces and puts a substantial peak demand of 12 MVA on the network. Under the agreement, the customer is given 24 hours notice to shed load between 1 pm and 5 pm the following day. The customer is able to implement load shifting by speeding up production prior to the event and then slowing it down during the peak. The agreement with this one customer achieved peak load reductions of between 3.5 and 4.5 MVA. The project was highly cost-effective. The majority of the cost of the project was the payments made to the participating customer which totalled AUD 70,000. An additional cost of approximately AUD 10,000 was incurred in setting up and initiating the project.

3.3.2 Target Market

For a network-driven DSM project to be successful, the target market chosen for the project should be directly related to achieving the project objectives. In the Baulkham Hills Substation Deferral project (Case Study LS05) referred to in the previous section, the target was a single customer whose ability to shift peak load was all that was required to achieve the project’s objective.

However, targets will rarely be as small and well-defined as in the Baulkham Hills project. Frequently, the target market will comprise a mix of end-use customers, market intermediaries and trade allies (such as appliance and equipment suppliers), each of whom has the ability to make a small contribution to achieving the project’s objectives.

The mix of participants in a target market often plays a role in the cost-effectiveness of network-driven DSM projects. For example, at present, a project in a market comprising larger commercial customers will tend to be more cost effective than an identical project in a market of smaller commercial or residential customers. There will be higher costs involved in marketing the project to a large number of small customers as compared with a small number of larger customers.

However, this may change in the future. A large number of small loads has a greater reliability than a few large ones, and with today's communication technologies, the small loads can be easily programmed to respond to meet the requirements of both the householder and the network operator. In particular, if householders themselves can nominate the loads to be automatically switched and the circumstances which trigger switching, this provides a one-stop 'set and forget' system that is likely to produce a much more reliable load reduction response than systems that require customers to make a decision to manually switch loads during every trigger event.

The target market is an important success factor in all types of network-driven DSM projects, with the exception of distributed generation. In distributed generation projects, the target market is usually all the customers in the area served by the network to which the generator is connected.

The Castle Hill Demand Management Project in Australia (Case Study IP02) provides a good demonstration of the importance of the target market as a success factor in network-driven DSM projects. The objective of the Castle Hill project is to defer capital expenditure of AUD 3.2 million to build a new substation scheduled for 2005/06. The substation is required because of increasing penetration and use of air conditioners in the Castle Hill commercial centre and surrounding residential areas, resulting in summer peak loads that will exceed system capability by about 2008. The Castle Hill project is focussing on the commercial sector and the target market is well-defined and easily located. The majority of end-use customers approached for the project are retail tenants of one major shopping centre located in the area that would be served by the new substation. The program is targeting interruptible loads, the use of existing standby generators, the installation of high efficiency air conditioning (and the upgrading of existing air conditioning systems), and the installation of efficient lighting and power factor correction equipment in new and replacement applications.

3.3.3 Demand-side Measures Used

The specific demand-side measures used in the project is a crucial success factor for all network-driven DSM projects.

For a project to be successful, the demand-side measures must be:

- capable of achieving the objective set for the project; and
- targeted at the project target market.

Consequently, the selection of the demand-side measures to be used in a project is primarily driven by the project objective and the project target market. A third major driver is the cost of each demand-side measure, including the cost of any equipment involved and installation and maintenance costs.

Some network-driven DSM projects use only one demand-side measure. The Tahmoor Fuel Substitution Project in Australia (Case Study FS01) is an example of a project that used a single measure. The purpose of the Tahmoor project was to defer augmentation of the distribution network by controlling growth in the winter evening peak demand and combating a low load factor. The project promoted the use of bottled gas by residential customers for cooking and space heating. Customers were contacted via a letterbox drop with a personalised letter providing details of subsidies available for from the local electricity distributor and the costs of bottled gas appliances. The distributor arranged the installation of bottled gas and appliances and provided subsidies to reduce the cost of these installations.

The Tahmoor project succeeded in flattening load growth to a degree, but take-up was less than had been hoped. One reason may have been that at the time the program was underway, the state's primary gas distributor made public overtures about extending reticulated natural gas to the area. These plans never materialised, but the possibility of using mains gas may have delayed and ultimately prevented customers from making decisions in favour of the electricity distributor's bottled gas alternative. As a result, the program deferred the distribution network augmentation for a shorter period than had originally been forecast.

Other network-driven DSM projects use several different demand-side measures and integrated DSM projects use a range of measures. For example, the Maine-et-Loire DSM Project in France (Case Study IP06) used a range of DSM measures undertaken both on the network side, and on the customer side, of the electricity meter to address voltage drop problems on rural distribution feeders.

The network-related DSM measures in the Maine-et-Loire project included:

- installing voltage regulators on the feeders;
- installing voltage regulators on the network side of the meter at customers' premises;
- use of three phase/single phase transformers to distribute the single-phase current loads of customers across three phases;

and the customer-related DSM measures included:

- shifting the use of electric household appliances and water heaters to off-peak periods;
- installing inverters for lighting and data processing end-uses;
- implementing electronic "soft" starters for electric motors;
- distributing compact fluorescent lamps;
- implementing automatic controllers for domestic boilers;
- installing a wood-fired boiler;
- using portable diesel generators for intermittent generation at selected sites; and
- installing a 40 kVA diesel generator at a pig breeding farm.

3.3.4 Barriers Addressed

The underlying objective for all network-driven DSM projects (with the exception of distributed generation projects) is to change the ways in which end-use customers use electricity or purchase electrical appliances and equipment. This change can usually be achieved most effectively if the specific factors preventing the change ("barriers") can be identified and action taken to overcome these barriers. Frequently, this will involve providing incentives to encourage the desired behaviour change or disincentives to discourage undesirable behaviour.

To a greater or lesser extent, most network-driven DSM projects are explicitly or implicitly designed to overcome barriers[21]. Table 2 (pages 30 to 35) shows that barriers addressed is an important success factor in all the projects in the Task XV case study database, with the exception of distributed generation projects. Usually, the most successful network-driven DSM projects are those that clearly identify the relevant barriers and implement actions that are targeted to directly overcome those barriers.

The Texas Utilities Electric Cool Storage Program (Case Study LS03) is a good example of a network-driven DSM program that identified specific barriers and provided incentives targeted at removing these barriers. During the late 1970s, TU recognised the need to address the increasing air conditioning load of commercial buildings. Thermal cool storage was seen as a promising means of flattening commercial air conditioning load shapes. In 1981, TU realised that offering financial incentives would eliminate many barriers to installation of thermal cool storage systems. These barriers included a high initial system cost, a long payback period and the large physical size of a thermal cool storage system compared to a standard system.

TU's Thermal Cool Storage program was the first non-residential DSM program offered by TU Electric, beginning full-scale in 1982. The program provided cash incentives to customers who installed thermal storage systems to provide space and/or process cooling during TU's on-peak periods. The incentives were based on the load shifted from on-peak to off-peak hours.

TU focused on marketing the concept and benefits of thermal cool storage and did not sell any thermal cool storage equipment. For customers who were interested in thermal cool storage, equipment manufacturers presented formal proposals that included costs and equipment options. The final decision on choice of equipment was up to the customer.

TU's marketing efforts for the Thermal Cool Storage program were geared toward the three predominant parties in the decision making process: the developers/owners of commercial buildings, engineers, and architects. TU field representatives marketed the program to customers and to trade allies (architects, engineers, equipment manufacturers and distributors) by explaining the benefits of thermal cool storage and the customer incentives that TU offered. TU also provided customer building audits which included an analysis of various HVAC system types and system estimated operating costs.

3.3.5 Outreach and Marketing

For certain types of network-driven DSM projects, outreach and marketing are critical to the success of the project. This is a success factor particularly in those projects where achieving the project objectives involves encouraging a large number of small end-use customers, typically in the commercial and/or residential sectors, to change the

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[21] The term "barrier" is employed here in its common usage to mean something that is preventing end-use customers from changing the ways in which they use electricity or purchase electrical appliances and equipment. Economists have a stricter definition that describes barriers in terms of "market failures". Under this stricter definition, many of the factors that are commonly identified as barriers to DSM and energy efficiency would be excluded.

ways in which they use electricity or purchase electrical appliances and equipment. Most energy efficiency projects, integrated DSM projects and pricing initiatives fall into this category (see Case Studies EE01 to EE10, IP01 to IP12 and PI01 to PI09), as do most direct load control, demand response and load shifting projects (see Case Studies DC01 to DC09, DR01 to DR04 and LS01 to LS05).

The Espanola Power Savers Project in Canada (Case Study EE04) is an example of a DSM project where outreach and marketing was an important success factor. The Espanola project was a community-based energy efficiency project which mounted a full-scale effort to extract the maximum possible reduction in electricity consumption from a geographically concentrated area.

The Espanola project used a two-pronged approach. First an extensive, cost effective list of energy conservation measures and installation specifications was established to maximise energy savings. Second, the project used a market saturation approach to elicit attitudinal and behavioural change that optimised energy savings and then maintained the energy efficiency built into the community.

A community assessment was carried out in the spring of 1991 to obtain a comprehensive understanding of the environment in which the program was to be launched. Besides collecting and analysing traditional demographic data, the assessment attempted to discover the formal and informal networks/power structure within the community.

A detailed marketing/communication plan was developed and implemented. It emphasised cultivation of community interest and support to achieve a maximum participation rate and uptake of recommended energy efficiency measures and to achieve a community "culture shift" to wise electricity use over the long term. A cornerstone of the plan involved the formation of a Community Advisory Committee at the outset of the project which consisted of over 30 representatives from organisations within the town. The committee had two primary functions:

- to provide advice and guidance to the project on ways to promote the wise use of electricity; and
- to provide direct community feedback to the project on existing and potential project-related issues.

Additional community involvement/communication mechanisms included: project newsletters, open house/information nights, presentations to community organisations, an energy conservation week, radio/newspaper advertising, municipal council presentations, a curriculum based energy conservation educational package, a spring writing contest, high school presentations, Energy Conservation Comer in the Public Library, logo/slogan contest, opening ceremonies, picnics and displays, energy saving tips contest, electricity bill inserts, direct mail, and cable TV community service announcements.

3.3.6 Participation Process and Customer Service

The participation process and customer service component of a network-driven DSM project comprises the procedures, forms, communications, and other interactions that occur among prospective and ultimate participants in the project and the project proponent and project implementers. The ease or difficulty of a project's participation process, and the effectiveness of the associated customer service support, can both be critically important success factors for some types of projects, particularly those projects involving interactions with a large number of electricity end-users. This includes most direct load control projects (see Case Studies DC01 to DC09), demand response projects (see Case Studies DR01 to DR04), fuel substitution projects (see Case Studies FS01 to FS03), integrated DSM projects (see Case Studies IP01 to IP12) and pricing initiative projects (see Case Studies PI01 to PI09).

The Queanbeyan Critical Peak Pricing Trial in Australia (Case Study PI03) is a pricing initiative in which the participation process and customer service is crucial for the success of the project. The project is investigating the feasibility of promoting peak load reductions by residential sector customers to relieve distribution network constraints in a particular geographical area.

The Queanbeyan project involves applying seasonal time of use and critical peak pricing tariffs to about 200 households. Two seasonal tariff schedules are applied – for summer and winter. Critical peak periods are called by the electricity retailer when the load on the local network is reaching maximum capacity or when high price events occur in the competitive wholesale electricity market. Critical peak periods may be called for a maximum of 12 times per year; customers are given a minimum two hours notice.

In the Queanbeyan project, implementation of time of use and critical peak pricing tariffs requires the installation of interval meters and in-home information display units in participants' dwellings. The installation of this new technology is paid for by the local electricity retailer. The interval meters measure energy use in half hour blocks. Each meter is directly connected to a two-way communications unit using mobile phone technology that enables the retailer to send and receive messages to and from the meter. This technology is used both for automatic meter reading and to signal an upcoming critical peak period and instruct the meter to adjust its tariff.

The in-home information display unit, the Home Energy Monitor, communicates with the interval meter through power line carrier technology. It plugs into any power socket and is about the size of a regular wall phone. The Monitor comprises a LED alphanumeric display which provides customers with specific information about the amount of electricity they are using, and how much it is costing. It also includes green, amber, and red LED lights which show customers whether they are using electricity at low, medium, or high prices, corresponding to off peak/shoulder, peak and critical peak tariffs. A beeping sounds alerts customers to the start of a critical peak period.

Customers who participate in the trial are instructed to keep an eye on the Home Energy Monitor and adjust their electricity usage to avoid high tariff periods and capitalise on the lower tariffs. Some tips are provided about how to reduce electricity usage during high price periods. Customers are also provided with a Participant Gift Pack that includes compact fluorescent lamps, energy timers, an energy efficiency thermometer, an energy wise calculator, CD-ROM, and an energy wise brochure.

3.3.7 Delivery Mechanisms

The delivery mechanism of a network-driven DSM project picks up the implementation process at its finale and comprises the actual mechanism whereby the end-users' electricity-related behaviour is changed. Delivery mechanisms are very varied and may include, for example, the provision of targeted information and/or financial incentives, and the physical installation of hardware such as energy efficient appliances, and metering, communications and direct load control equipment.

The effectiveness of delivery mechanisms is an important success factor for many network-driven DSM projects. Delivery mechanisms are crucial for projects involving direct load control, demand response and smart metering (see Case Studies DC01 to DC09, DR01 to DR03, IP04, PI01, PI03, PI05, PI06, PI09 and SM01). The effectiveness of the delivery mechanism is also an important success factor in projects that involve the payment of a financial incentive to reward changed end-user behaviour, (see Case Studies DC05, EE01 to EE03, FS02, IL05, IP01 to IP05, LS02, LS03, and LS05). Finally, the delivery mechanism is also an important success factor in projects that involve the provision of information (see Case Studies EE04, EE05, EE09, IP06 to IP08).

The Efficient Lighting Project DSM Pilot in Poland (Case Study EE01) used a highly targeted delivery mechanism. The project provided financial incentives for residents of network-constrained areas in three cities to install compact fluorescent lamps (CFLs). The cost of CFLs sold through the project was subsidised. The subsidies were directed at participating CFL manufacturers in exchange for their agreement to certain negotiated wholesale prices and delivery arrangements. The subsidised lamps were made available to the residents of the three cities using discount coupons. There were three types of coupons, labelled A, B, and C. The A and B coupons, which offered the highest price discounts (about 55% and 45% respectively), were delivered only to those residents living in the target network-constrained areas. The C coupons (about 35% discount) were delivered to the remaining residents of the participating cities. In all three cities, the A and B coupons were valid only for the first two weeks of the project's operation. This timeframe was established to encourage residents in the target areas to make their CFL purchases quickly so that it would be easier to measure the effect of a massive CFL installation on the electricity networks in the target areas (where measurements of electricity use were focused). The C coupons were valid for six weeks, after which the CFL sales by the project ceased.

The delivery mechanism was also important in the Carbon Trust Advanced Metering Trial in the United Kingdom (Case Study SM01). The trial aimed to demonstrate the potential benefits of advanced metering and understand the business case for encouraging widespread adoption of the technology by small and medium enterprises (SMEs). In addition to installing advanced meters at sites, a variety of different types of energy saving advice were provided to sites during the trial. These services ranged from basic data provision to detailed advice on energy saving communicated through emails, phone calls and site visits. The trial found that the level of energy savings achieved was highly correlated with the delivery mechanism.

3.4 Conclusions on the Effectiveness of DSM Measures

This section 3 has identified a number of external and internal factors that may contribute to the success of network-driven DSM projects. External factors establish the context within which a network-driven DSM project operates, while internal factors are specific to each individual project and determine how the project is implemented.

The success or otherwise of the DSM measures that are components of network-driven DSM projects is intimately bound up with the success of the projects themselves. Projects containing the same DSM measures (such as energy efficiency, load shifting, direct load control or pricing initiatives) tend to have a common set of factors which contribute to their success and to this extent it is possible to identify sets of success factors that apply to each category of DSM measure. These are shown in Table 3 (page 44).

The challenge in designing a network-driven DSM project that will ultimately be successful in achieving its objectives is to clearly identify the success factors for each of the DSM measures included in the project and then concentrate on optimising each of these factors. For example, if the delivery mechanism is a success factor for a DSM measure included in the project, the project designer should choose an appropriate delivery mechanism and then concentrate on optimising the effectiveness of that mechanism.

TABLE 3. SUCCESS FACTORS FOR NETWORK-DRIVEN DSM MEASURES											
Success Factors	**Network-driven DSM Measures**										
	Direct Load Control	Distributed Generation	Demand Response	Energy Efficiency	Fuel Substitution	Interruptible Loads	Integrated DSM	Load Shifting	Power Factor Correction	Pricing Initiatives	Smart Metering
External Success Factors											
Government policies							√	√		√	√
Regulatory regime	√			√			√	√		√	√
Market structure	√		√			√				√	
Commitment by project proponent	√	√	√	√	√	√	√	√	√	√	√
Technology availability	√	√	√		√					√	√
Commercial considerations		√	√	√	√	√	√	√	√	√	√
Public relations benefits				√						√	
Internal Success Factors											
Project objectives	√	√	√	√	√	√	√	√	√	√	√
Target market	√		√	√	√	√	√	√	√	√	√
Demand-side measures used	√		√	√	√	√	√	√	√	√	√
Market barriers addressed	√		√	√	√	√	√	√	√	√	
Outreach and marketing	√		√	√	√		√	√	√	√	√
Participation process and customer service	√		√		√		√	√	√	√	√
Delivery mechanisms	√		√	√	√		√	√	√	√	√

4. FURTHER DEVELOPMENT OF NETWORK-DRIVEN DSM MEASURES

The objective of Activity 2-3 in Subtask 2 is to further develop network-driven DSM measures to improve their effectiveness in achieving network-related objectives[22]. This section of the report summarises the results from Activity 2-3.

4.1 Identification of Network-driven DSM Measures

The following 11 categories of network-driven DSM measures are identified in the 64 case studies of network-driven DSM projects in the Task XV database[23]:

- direct load control;
- distributed generation, including standby generation and cogeneration;
- demand response;
- energy efficiency;
- fuel substitution;
- interruptible loads;
- integrated DSM;
- load shifting;
- power factor correction;
- pricing initiatives, including time of use and demand-based tariffs; and
- smart metering.

These categories are also listed in Table 3 (page 44).

Each of these categories of DSM measures will now be reviewed to: identify the network problems that each category can address; characterise the success factors which apply to each category; and examine how the DSM measures in each category should be implemented for them to be most effective in achieving network-related objectives.

4.2 Direct Load Control

With direct load control, customers pay reduced tariffs and/or receive other incentives in return for allowing the network operator to remotely shut down or cycle selected electrical equipment owned by the customer (eg air conditioners, water heaters). Direct communication links are connected between the network operator and the customers' electrical equipment. These links enable the network operator to remotely switch the customer's loads at short notice in response to particular problems on the electricity network.

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[22] Energy Futures Australia (2004). *Prospectus: Research Project on Network-driven DSM*. Hornsby Heights, NSW Australia, EFA.

[23] Crossley, D.J. (2008). *Worldwide Survey of Network-driven Demand-side Management Projects*. Second edition. International Energy Agency Demand Side Management Programme, Task XV Research Report No 1. Hornsby Heights, NSW, Australia, Energy Futures Australia Pty Ltd.

4.2.1 Network Problems Addressed

Direct load control applied during peak periods on a network can be used both to relieve network constraints and to provide most network operational services.

Direct load control can address all types of network constraints. It can be deployed strategically in geographical areas where network constraints occur and can also be implemented in particular localities to reduce demand on a specific network element.

Network Constraints	
Narrow peak related	√
Broad peak related	√
Specific network element(s)	√
Generally across the network	√

Network Operational Services	
Voltage regulation	√
Load following	√
Active/reactive power balancing	√
Frequency response	√
Supplemental reserve	√
Spinning reserve	√
Power factor correction	

Direct load control can also provide most types of network operational services. The effectiveness with which direct load control provides some network operational services, such as frequency response and spinning reserve, depends critically on the speed with which remote switching of customer loads can be implemented in response to an event. Because the network operator has direct control of customer loads, the response to an event is usually more reliable than with load management measures that must be implemented by customers.

4.2.2 Applicable Success Factors

External Success Factors		Internal Success Factors	
Government policies		Project objectives	√
Regulatory regime	√	Target market	√
Market structure	√	Demand-side measures used	√
Commitment by project proponent	√	Market barriers addressed	√
Technology availability	√	Outreach and marketing	√
Commercial considerations		Participation process and customer service	√
Public relations benefits		Delivery mechanisms	√

As with load shifting, commercial considerations on the part of the end-use customer are a major success factor for direct load control. However, once a customer is happy with the proposed arrangements and the rewards provided by the project proponent, the actual switching of loads is controlled remotely by the network operator without any involvement by the customer. Therefore direct load control may be less disruptive and therefore more attractive to the customer than load shifting without remote switching.

Commitment by the project proponent (the network owner or operator) and supportive government policies and regulatory regime are also important external success factors for direct load control. In addition, most of the identified internal success factors come into play when direct load control is used for network support.

4.2.3 Effective Implementation

Direct load control, like all load management measures, is best suited to achieving short-term load reductions (up to a couple of hours) to relieve network constraints and to provide network operational services at peak times.

An effective direct communication system between the network operator and the controlled loads located in the customer's premises is essential for direct load control. Ideally, the communication system should be two-way so that the network operator can receive information in real-time or near real-time about the load reductions actually achieved. However, the response to an event is usually quite reliable because the load switching is controlled remotely by the network operator.

4.3 Distributed Generation

Distributed generators are relatively small and modular and are usually connected directly to the local distribution network, rather than to the transmission network. Distributed generation can inject energy into the electricity network close to the load it serves and in this situation reduces demand on the portion of the network which would otherwise supply the load.

4.3.1 Network Problems Addressed

Network Constraints	
Narrow peak related	√
Broad peak related	√
Specific network element(s)	√
Generally across the network	√

Network Operational Services	
Voltage regulation	√
Load following	√
Active/reactive power balancing	√
Frequency response	√
Supplemental reserve	√
Spinning reserve	√
Power factor correction	

Some types of distributed generation which operate continuously can be used to reduce overall demand across the whole electrical load curve. Other types which operate intermittently, such as standby generators, can be used to reduce demand at the time of the system peak. Distributed generation facilities installed to provide network support can be deployed strategically in geographical areas where network constraints occur or can be installed in particular localities to reduce demand on a specific network element. Distributed generation can also reduce network losses, improve utilisation (load factor) of existing transmission and generation assets, provide voltage support on long rural lines and also, with appropriate technology fitted to larger distributed generation plant, provide automatic frequency response.

4.3.2 Applicable Success Factors

External Success Factors		Internal Success Factors	
Government policies		Project objectives	√
Regulatory regime		Target market	
Market structure		Demand-side measures used	
Commitment by project proponent	√	Market barriers addressed	
Technology availability	√	Outreach and marketing	
Commercial considerations	√	Participation process and customer service	
Public relations benefits		Delivery mechanisms	

The major success factor for the use of distributed generation for network support is commitment by the project proponent (in this case the network owner and/or operator). The network owner/operator must be prepared to accept that distributed generation can be used to achieve network-related objectives as an alternative to traditional network augmentation solutions.

Once this position has been reached, other relevant success factor include: the availability of suitable generation technology; commercial considerations (ie is there a business case for the use of distributed generation?); and clear definition of the network-related objectives to be achieved by installing distributed generation.

4.3.3 Effective Implementation

Using distributed generation for network support can be achieved in two ways:

- by implementing a new distributed generation installation at an appropriate location; or
- by making use of existing distributed generation installations (eg standby generators).

Implementing a new installation is likely to be capital expensive and relatively inflexible, particularly if the generator is installed at a particular location to relieve a network constraint. If the constraint is subsequently relieved by other means (eg when load growth justifies building a network augmentation), the generator may become a stranded asset. This can be overcome by implementing installations where the generator can be subsequently removed and relocated. This was done in the Nelson Bay Embedded Generation project (Case Study DG01).

Making use of existing distributed generation installations can be a cheaper and more flexible option. However, there can be significant costs involved in carrying out the technical modifications required to enable an existing generator to synchronise to the system and to enable the generator to be dispatched. In addition, because the generator is not owned by the network owner/operator, changes in the business requirements of the generator owner can adversely affect the availability of the generator for network support. For example, in the Brookvale / DeeWhy DSM Program (Case Study IP05), the network owner spent considerable time investigating the use of a standby generator only to discover that the generator was inadequate to supply the existing load at the owner's premises and that the site containing both the generator and the related substation was planned for redevelopment.

4.4 Demand Response

Demand response comprises actions taken by end-use customers to change (usually reduce) their electricity use in response to problems on the electricity network and/or high prices in the electricity market.

4.4.1 Network Problems Addressed

Network Constraints	
Narrow peak related	√
Broad peak related	√
Specific network element(s)	√
Generally across the network	√

Network Operational Services	
Voltage regulation	√
Load following	√
Active/reactive power balancing	√
Frequency response	√
Supplemental reserve	√
Spinning reserve	√
Power factor correction	

Demand response is typically used by network operators to provide targeted load reductions on their networks. Applied during peak periods, demand response can be used both to relieve network constraints and to provide most network operational services.

Demand response can address all types of network constraints. It can be deployed strategically in geographical areas where network constraints occur and can also be implemented in particular localities to reduce demand on a specific network element.

Demand response can also provide most types of network operational services. The effectiveness with which demand response provides some network operational services, such as frequency response and spinning reserve, depends critically on the speed with which demand response can be implemented in response to an event. Where the network operator has direct control of demand response, the response to an event is usually more reliable than with load management measures that must be implemented by customers.

4.4.2 Applicable Success Factors

As with the other types of load management measures, commercial considerations on the part of the end-use customer are a major success factor for demand response. However, because the customer usually has the ability to opt out of demand response events, they are usually less disruptive and therefore more attractive to the customer than the other types of load management measures.

External Success Factors		Internal Success Factors	
Government policies		Project objectives	√
Regulatory regime		Target market	√
Market structure	√	Demand-side measures used	√
Commitment by project proponent	√	Market barriers addressed	√
Technology availability	√	Outreach and marketing	√
Commercial considerations	√	Participation process and customer service	√
Public relations benefits		Delivery mechanisms	√

Commitment by the project proponent (the network owner or operator) and supportive government policies and regulatory regime are also important external success factors for demand response. In addition, most of the identified internal success factors come into play when demand response is used for network support.

4.4.3 Effective Implementation

Demand response, like all load management measures, is best suited to achieving short-term load reductions (up to a couple of hours) to relieve network constraints and to provide network operational services at peak times.

Demand response, can be implemented in one of three ways:

- the network operator implements time of use electricity pricing and customers may voluntarily respond to changes in prices with significant changes in their electricity usage (usually load reductions at times of high prices);
- the network operator gives notice of a demand response event to the customer, then relies on the customer to reduce their electricity usage; or
- the network operator carried out remote switching of controlled loads at the customer's premises with or without giving notice to the customer.

Remote switching by the network operator produces the most reliable response while the response from the first two methods can be quite variable. In particular, where demand response relies on the customer to change behaviour or to carry out load switching, the level of response tends to decay over time as the novelty of the situation wears off and/or the customers lose interest.

An effective communication and notification system between the network operator and end-use customers is essential for all types of demand response except for voluntary response by customers to time of use pricing. Ideally, the communication system should be two-way so that the network operator can receive information in real-time or near real-time about the load reductions actually achieved.

4.5 Energy Efficiency

The objective of energy efficiency projects is to reduce the quantity of energy used per unit of output or delivered service. As a DSM measure, energy efficiency leads to reduced load levels on the electricity network.

4.5.1 Network Problems Addressed

Most energy efficiency projects reduce overall demand across the whole electrical load curve and can be used to combat the effect of general load growth on the network. It may also be possible to use energy efficiency to reduce demand at the time of the system peak if loads which contribute to that peak can be identified and energy efficiency measures applied specifically to those loads.

Network Constraints	
Narrow peak related	
Broad peak related	√
Specific network element(s)	√
Generally across the network	√

Network Operational Services
Voltage regulation
Load following
Active/reactive power balancing
Frequency response
Supplemental reserve
Spinning reserve
Power factor correction

Energy efficiency projects can be deployed strategically in geographical areas where network constraints occur or can be implemented in particular localities to reduce demand on a specific network element. However, energy efficiency projects are difficult to target accurately enough to provide network operational services.

4.5.2 Applicable Success Factors

External Success Factors		Internal Success Factors	
Government policies		Project objectives	√
Regulatory regime	√	Target market	√
Market structure		Demand-side measures used	√
Commitment by project proponent		Market barriers addressed	√
Technology availability		Outreach and marketing	√
Commercial considerations	√	Participation process and customer service	
Public relations benefits	√	Delivery mechanisms	√

Because they are difficult to target accurately, energy efficiency projects are not often implemented specifically to achieve network-related objectives. Energy efficiency may be implemented primarily to achieve another purpose, such as to meet regulatory requirements or to achieve public relations benefits. The use of energy efficiency for network support is then incidental to this primary purpose.

One important consideration is whether there is a business case for the use of energy efficiency to achieve network-related objectives. Energy efficiency projects result in reduced electricity usage by customers and this will adversely impact the financial position of network businesses whose revenue is dependent on the volume of electricity transported through the network.

If an energy efficiency project is used for network support, most of the identified internal success factors come into play.

4.5.3 Effective Implementation

Establishing clear objectives and effective targeting is the key to successfully using energy efficiency projects to achieve network-related objectives. The objectives to be achieved must be within the capability of the project and the project must target specific loads, end-uses and customers that will contribute to achieving these objectives.

For example, if the objective is to defer the augmentation of a particular network element (eg a line or substation), the loads targeted by the project must be physically located on that element, the end-uses must be occurring during peak times on the element, and the customers must be willing and able to increase the energy efficiency of those particular end-uses.

Once the objectives and targeting of an energy efficiency project have been determined, overcoming any barriers to increasing energy efficiency, and developing effective outreach and marketing and delivery mechanism all become important.

4.6 Fuel Substitution

As a DSM measure, fuel substitution from electricity to other fuels operates in a similar way to energy efficiency. However, fuel substitution results in loads being lost to electricity, probably permanently, whereas with energy efficiency the end uses continue to be served by electricity but at a reduced load level.

4.6.1 Network Problems Addressed

Network Constraints	
Narrow peak related	
Broad peak related	√
Specific network element(s)	√
Generally across the network	√

Network Operational Services
Voltage regulation
Load following
Active/reactive power balancing
Frequency response
Supplemental reserve
Spinning reserve
Power factor correction

Most fuel substitution projects reduce overall demand across the whole electrical load curve and can be used to combat the effect of general load growth on the network. It may also be possible to use fuel substitution to reduce demand at the time of the system peak, if loads which contribute to that peak can be identified and fuel substitution applied specifically to those loads. Fuel substitution projects can be deployed strategically in geographical areas where network constraints occur or can be implemented in particular localities to reduce demand on a specific network element. As with energy efficiency, fuel substitution projects are difficult to target accurately enough to provide network operational services.

4.6.2 Applicable Success Factors

External Success Factors		Internal Success Factors	
Government policies		Project objectives	√
Regulatory regime		Target market	√
Market structure		Demand-side measures used	√
Commitment by project proponent	√	Market barriers addressed	√
Technology availability	√	Outreach and marketing	√
Commercial considerations	√	Participation process and customer service	√
Public relations benefits		Delivery mechanisms	√

The major success factor in using fuel substitution to achieve network-related objectives is commitment by the project proponent (in this case the network owner and/or operator). The network owner/operator must be prepared to accept that fuel substitution can be used to achieve network-related objectives as an alternative to traditional network augmentation solutions.

Once this position has been reached, other relevant success factor include: the availability of suitable technology that uses an alternative fuel for the targeted end-uses; commercial considerations (ie is there a business case for the use of fuel substitution, including the probable permanent loss of the load?); clearly defining the network-related objectives to be achieved through fuel substitution; identifying the target market; outreach and marketing to targeted customers; the participation process and customer service; and the delivery mechanisms.

4.6.3 Effective Implementation

Similarly to energy efficiency, establishing clear objectives and effective targeting is the key to successfully using fuel substitution to achieve network-related objectives. The objectives to be achieved must be within the capability of the fuel substitution project and the project must target specific loads, end-uses and customers that will contribute to achieving these objectives.

For example, if the objective is to defer the augmentation of a particular network element (eg a line or substation), the loads targeted by the fuel substitution project must be physically located on that element, the end-uses must be occurring during peak times on the element, and the customers must be willing and able to purchase new appliances or equipment and switch to an alternative fuel for those particular end-uses.

Once the objectives and targeting of a fuel substitution project have been determined, overcoming any barriers to fuel substitution, and developing effective outreach and marketing, participation processes and customer service, and delivery mechanisms (especially the purchase and installation of new appliances or equipment) all become important.

4.7 Interruptible Loads

Interruptible loads confer the right on a network operator to interrupt supply to a customer based on an existing contract, tariff, or agreement, typically during a system emergency.

4.7.1 Network Problems Addressed

Network Constraints	
Narrow peak related	√
Broad peak related	√
Specific network element(s)	√
Generally across the network	√

Network Operational Services	
Voltage regulation	√
Load following	√
Active/reactive power balancing	√
Frequency response	√
Supplemental reserve	√
Spinning reserve	√
Power factor correction	

During peak periods on a network, interruptible loads can be used both to relieve network constraints and to provide most network operational services.

Interruptible loads can address all types of network constraints. They can be deployed strategically in geographical areas where network constraints occur and can also be implemented in particular localities to reduce demand on a specific network element. They can also provide most types of network operational services. The effectiveness with which interruptible loads provide some network operational services, such as frequency response and spinning reserve, depends critically on the speed with which customer loads can be interrupted in response to an event. Where the network operator has direct control of interruptible loads, the response to an event is usually more reliable than with load management measures that must be implemented by customers.

4.7.2 Applicable Success Factors

External Success Factors		Internal Success Factors	
Government policies		Project objectives	√
Regulatory regime		Target market	√
Market structure	√	Demand-side measures used	√
Commitment by project proponent	√	Market barriers addressed	√
Technology availability		Outreach and marketing	
Commercial considerations	√	Participation process and customer service	
Public relations benefits		Delivery mechanisms	

In common with direct load control and load shifting, commercial considerations on the part of the end-use customer are a major success factor for the deployment of interruptible loads. By definition, interruptible loads require a change in the customer's pattern of electricity use. Because interruptible load events often occur at very short notice they are inherently more disruptive and inconvenient to customers than other types of load management measures. Therefore, interruptible loads will only be attractive to customers if appropriate rewards (eg incentive payments and/or lower tariffs) are available to compensate for the time, effort and costs involved.

Commitment by the project proponent (the network owner or operator) and supportive government policies and regulatory regime are also important external success factors. In addition, many of the identified internal success factors come into play when interruptible loads are used for network support. However, outreach and marketing, participation and customer service, and delivery mechanisms may be less important because customers will only accept the inherent disruption and inconvenience of interruptible loads if they are happy with the rewards offered.

4.7.3 Effective Implementation

Interruptible loads, like all load management measures, are best suited to achieving short-term load reductions (up to a couple of hours) to relieve network constraints and to provide network operational services at peak times.

Interruptible loads can be deployed in one of two ways:

- the network operator gives notice of an interruptible load event to the customer, then relies on the customer to reduce their electricity usage; or
- the network operator gives notice to the customer, then unilaterally interrupts supply to the customer.

The former method may have a less severe impact on the customer's operations, but can provide a less reliable response, particularly if no sanctions are applied to customers who fail to reduce their electricity usage. This is the situation with some of the interruptible load arrangements applied by the transmission network operator in Spain (Case Studies IL01 and IL02).

An effective direct communication system between the network operator and the customer is essential for the deployment of interruptible loads. At a minimum, the communication system will be used to provide notification to the customer of upcoming interruptible load events. Ideally, the communication system should be two-way so that the network operator can receive information in real-time or near real-time about the load reductions actually achieved.

4.8 Integrated DSM Projects

Integrated DSM projects employ a range of individual DSM measures appropriate to the objectives they are aiming to achieve.

4.8.1 Network Problems Addressed

Network Constraints	
Narrow peak related	√
Broad peak related	√
Specific network element(s)	√
Generally across the network	√

Network Operational Services	
Voltage regulation	√
Load following	√
Active/reactive power balancing	√
Frequency response	√
Supplemental reserve	√
Spinning reserve	√
Power factor correction	√

Integrated DSM projects are used both to reduce overall demand across the whole electrical load curve and to reduce demand at the time of the system peak. Typically, such projects are deployed strategically in geographical areas where network constraints occur but can also be implemented in particular localities to reduce demand on a specific network element. Depending on the specific individual DSM measures employed, integrated DSM projects may also be used to provide network operational services.

4.8.2 Applicable Success Factors

External Success Factors		Internal Success Factors	
Government policies	√	Project objectives	√
Regulatory regime	√	Target market	√
Market structure	√	Demand-side measures used	√
Commitment by project proponent	√	Market barriers addressed	√
Technology availability	√	Outreach and marketing	√
Commercial considerations	√	Participation process and customer service	√
Public relations benefits	√	Delivery mechanisms	√

The range of possible integrated DSM projects is very diverse. Consequently, while some success factors did not apply to the particular integrated DSM projects included in the Task XV database, potentially any of the success factors can apply to such a project. However, the particular mix of applicable success factors will vary from project to project, depending on the specific individual DSM measures employed.

4.8.3 Effective Implementation

Because an integrated DSM project can include a diverse range of individual DSM measures, establishing clear objectives for the project is essential. Without a clear objective, such projects can lose focus and individual DSM measures may be poorly targeted. On the other hand, the strength of integrated DSM projects lies in the ability to deploy a range of DSM measures to achieve particular network-related objectives.

4.9 Load Shifting

Load shifting involves altering electricity use patterns so that on-peak electricity use is shifted to off-peak periods. To achieve network-related objectives, load must be shifted away from the peak period on the whole network or on the relevant network element. The timing of the peak period on a network element may be different from the timing of the peak on the network as a whole.

4.9.1 Network Problems Addressed

Network Constraints	
Narrow peak related	√
Broad peak related	√
Specific network element(s)	√
Generally across the network	√

Network Operational Services	
Voltage regulation	√
Load following	√
Active/reactive power balancing	√
Frequency response	√
Supplemental reserve	√
Spinning reserve	√
Power factor correction	

Load shifting applied during peak periods on a network can be used both to relieve network constraints and to provide most network operational services.

Load shifting can address all types of network constraints. It can be deployed strategically in geographical areas where network constraints occur and can also be implemented in particular localities to reduce demand on a specific network element.

Load shifting can also provide most types of network operational services. The effectiveness with which load shifting provides some network operational services, such as frequency response and spinning reserve, depends critically on the speed with which load shifting measures can be implemented in response to an event.

4.9.2 Applicable Success Factors

Commercial considerations are a major success factor for load shifting, particularly from the perspective of the end-use customer. Load shifting, by definition, requires a change in the customer's pattern of electricity use and this will only be attractive to the customer if appropriate rewards (eg incentive payments and/or lower tariffs) are available to compensate for the time, effort and costs involved.

External Success Factors		Internal Success Factors	
Government policies	√	Project objectives	√
Regulatory regime	√	Target market	√
Market structure		Demand-side measures used	√
Commitment by project proponent	√	Market barriers addressed	√
Technology availability		Outreach and marketing	√
Commercial considerations	√	Participation process and customer service	√
Public relations benefits		Delivery mechanisms	√

Commitment by the project proponent (the network owner or operator) and supportive government policies and regulatory regime are also important external success factors. In addition, most of the identified internal success factors come into play when load shifting is used for network support.

4.9.3 Effective Implementation

Load shifting, like all load management measures, is best suited to achieving short-term load reductions (up to a couple of hours) to relieve network constraints and to provide network operational services at peak times.

An effective communication and notification system between the network operator and end-use customers is required so that customers can receive notifications from the network operator and make the necessary arrangements to implement load shifting. Ideally, the communication system should be two-way so that the network operator can receive information in real-time or near real-time about the load reductions actually achieved.

4.10 Power Factor Correction

Power factor in alternating current circuits is the ratio of actual energy consumed (watts) versus the apparent power (volt-amps). In other words, power factor is the percentage of energy used compared to the energy flowing through the wires. Power factor correction aims to reduce the difference between the energy consumed and the apparent power so as to reduce energy wastage.

4.10.1 Network Problems Addressed

Network Constraints	
Narrow peak related	
Broad peak related	√
Specific network element(s)	√
Generally across the network	√

Network Operational Services	
Voltage regulation	
Load following	
Active/reactive power balancing	
Frequency response	
Supplemental reserve	
Spinning reserve	
Power factor correction	√

Most power factor correction projects reduce overall demand across the whole electrical load curve. It may also be possible to use power factor correction to reduce demand at the time of the system peak if loads which contribute to that peak can be identified and power factor correction applied specifically to those loads. Power factor correction can be deployed strategically in geographical areas where network constraints occur or can be implemented in particular localities to reduce demand on a specific network element.

4.10.2 Applicable Success Factors

External Success Factors		Internal Success Factors	
Government policies		Project objectives	√
Regulatory regime		Target market	√
Market structure		Demand-side measures used	√
Commitment by project proponent	√	Market barriers addressed	√
Technology availability		Outreach and marketing	√
Commercial considerations	√	Participation process and customer service	√
Public relations benefits		Delivery mechanisms	√

The major success factor in using power factor correction to achieve network-related objectives is commitment by the project proponent (in this case the network owner and/or operator). The network owner/operator must be prepared to accept that power factor correction can be used to relieve network constraints.

Once this position has been reached, other relevant success factor include: commercial considerations (ie is there a business case for the use of power factor correction?); clearly defining the network-related objectives to be achieved through fuel substitution; identifying the target market; outreach and marketing to targeted customers, participation process and customer service and delivery mechanisms.

4.10.3 Effective Implementation

As a DSM measure, power factor correction usually involves improving power factors at customer premises by installing capacitors. Distributed generation, synchronous motors, or adjustable speed drives with controllable front ends can also be used to correct power factor at customer premises. However, as Case Study PC01 shows, it is possible to achieve network-related objectives by installing power factor correction equipment outside customer premises on the network side of the customer's electricity meter.

Where power factor correction is required at customer premises, customer outreach and marketing are crucial. Power factor is a highly technical subject which is hard to explain and the marketing of a power factor correction program is correspondingly difficult. As Case Study IP05 shows, a successful approach may involve drawing customers' attention to their obligation to maintain an acceptable power factor and then providing a packaged solution that they can easily implement.

4.11 Pricing Initiatives

As a DSM measure, pricing initiatives aim to change customers' energy-using behaviour, particularly to alter the times at which electricity is used.

4.11.1 Network Problems Addressed

Network Constraints	
Narrow peak related	√
Broad peak related	√
Specific network element(s)	√
Generally across the network	√

Network Operational Services
Voltage regulation
Load following
Active/reactive power balancing
Frequency response
Supplemental reserve
Spinning reserve
Power factor correction

Pricing initiatives are typically used to support electricity networks by changing customers' energy-using behaviour to reduce demand at the time of the system peak. Typically, pricing initiatives are applied to particular customer classes across a whole electrical system and are therefore usually not targeted to geographical areas where network constraints occur. However, some work is now being carried out on congestion pricing in which electricity prices are increased in constrained network areas.

Because of the inherent difficulty in targeting pricing initiatives, they are not used to provide network operational services.

4.11.2 Applicable Success Factors

External Success Factors		Internal Success Factors	
Government policies	√	Project objectives	√
Regulatory regime	√	Target market	√
Market structure	√	Demand-side measures used	√
Commitment by project proponent	√	Market barriers addressed	√
Technology availability	√	Outreach and marketing	√
Commercial considerations	√	Participation process and customer service	√
Public relations benefits	√	Delivery mechanisms	√

Many success factors are applicable to pricing initiatives. Such initiatives can only be implemented if they conform with government policies and regulatory regimes. Pricing initiatives must also be closely linked to the structure of the electricity market. Acceptance by the network owner/operator that pricing initiatives will be effective in achieving network-related objectives is also required and the business case for implementing particular pricing initiatives must be sound. In addition, technology that enables customers to take advantage of time-related electricity pricing can greatly increase the effectiveness of pricing initiatives in achieving network-related objectives; such technology may vary from simple time clocks to complex load control equipment.

Important internal success factors include: specifically-defined objectives to be achieved through pricing initiatives; a clearly-identified target market; and effective outreach and marketing to targeted customers.

4.11.3 Effective Implementation

There are three main price structures used to encourage end-use customers to alter the times at which they use electricity:

- **Time-of-Use (TOU):** Comprises different unit prices for electricity during different blocks of time, usually defined for a 24 hour day. TOU tariffs reflect the average cost of generating and delivering electricity during those time periods.
- **Real-time Pricing (RTP):** The electricity price fluctuates throughout the day reflecting changes in the wholesale price of electricity. Customers receive day-ahead or hour-ahead notification of RTP prices.
- **Critical Peak Pricing (CPP):** This is a hybrid of TOU and RTP. The basic rate structure is TOU and provision is made for replacing the normal peak price with a much higher CPP price under specified trigger conditions (eg when system reliability is compromised or wholesale prices are very high).

If implemented by themselves, the effectiveness of these pricing structures in achieving network-related objectives can be highly variable because customers change their behaviour on a voluntary basis, in response to the pricing signals. The level of customer response may be increased by establishing a very high multiple (between 10 and 20 times) for the electricity price during critical peak periods as compared with the price during shoulder periods. Such a 'shock' critical peak price provides a strong stimulus for customers to manage or reduce electricity consumption during critical peak events.

The effectiveness of pricing initiatives can also be increased by installing enabling technology that automatically switches customer loads in response to pre-set price levels. If customers themselves can nominate the loads to be automatically switched and the price levels at which switching will occur, this provides a one-stop 'set and forget' system that is likely to produce a much more reliable load reduction response than systems that require customers to make a decision to manually switch loads during every high price event.

4.12 Smart Metering

Currently, recording the quantities of energy consumed by end-users is mostly carried out by using ***accumulation meters*** which simply record energy consumption progressively over time. However, more advanced meters are increasingly being used. ***Interval meters*** record the quantities of energy consumed over set, frequent time intervals. ***Smart meters*** include, in addition to the interval metering capability, one-way or two-way communications between the energy supplier and the meter.

4.12.1 Network Problems Addressed

Network Constraints	
Narrow peak related	√
Broad peak related	√
Specific network element(s)	
Generally across the network	√

Network Operational Services
Voltage regulation
Load following
Active/reactive power balancing
Frequency response
Supplemental reserve
Spinning reserve
Power factor correction

There are two ways in which ways in which smart metering can be used to support electricity networks

First, smart meters enable the implementation of time-varying pricing which sends price signals to customers that reflect the underlying costs of generating, transporting and supplying electricity. Price-based demand response programs can reduce or shape customer demand and particularly can reduce peak loads on the electricity network and therefore reduce the amount of investment required in network infrastructure.

Second, analysing data from smart meters provides end-users with detailed information about the ways in which they use electricity and can enable businesses to identify and implement energy, cost and carbon savings. Energy savings reduce the overall load on the network, therefore contributing to supporting the network.

4.12.2 Applicable Success Factors

External Success Factors		Internal Success Factors	
Government policies	√	Project objectives	√
Regulatory regime	√	Target market	√
Market structure		Demand-side measures used	√
Commitment by project proponent	√	Market barriers addressed	
Technology availability	√	Outreach and marketing	√
Commercial considerations	√	Participation process and customer service	√
Public relations benefits		Delivery mechanisms	√

In many jurisdictions around the world, governments and/or regulators have mandated the mass roll-out of smart meters. In jurisdictions where this has not occurred, the effective use of smart meters to reduce loads on electricity networks is assisted by supportive governments and regulators. In the absence of a government mandate, there must be a strong business case for electricity distributors to implement a mass roll-out of smart meters. The business case may include other benefits to the distributor unrelated to network support, such as automated meter reading. Effective deployment of smart meters is also dependent on active commitment by project proponents (usually electricity distributors) and on appropriate smart metering technology being available.

Clear project objectives and a well-defined target market must be established if network-related objectives are to be achieved through deployment of smart meters. Accompanying demand side measures, particularly time-varying pricing must also be developed and implemented. Outreach and marketing, participation processes and delivery mechanisms are also crucial internal success factors for smart metering network-driven DSM programs.

4.12.3 Effective Implementation

Installing smart meters will, by itself, do nothing to achieve load reductions for network support purposes. To achieve network-related objectives, any roll-out of smart meters must be accompanied by the introduction of time-varying electricity prices and the provision of appropriate information and education programs for end-use customers. Implementing remote switching of customer loads linked to changing electricity prices will also improve the effectiveness of network-driven DSM projects involving smart meters.

5. CONCLUSION

This report has three objectives:

- to identify the value proposition for network-driven DSM measures, including the specific network problems which these measures can successfully address;
- to determine the factors which result in a network-driven DSM measure being successful in cost-effectively achieving network-related objectives; and
- to further develop network-driven DSM measures to improve their effectiveness in achieving network-related objectives.

The report concludes that the value of a network-driven DSM project varies among categories of stakeholders and may even vary among individual stakeholders (eg customers located in network-constrained areas vs customers located outside these areas). The distribution of the benefits from network-driven DSM projects among many different stakeholders means that the project proponent is unlikely to capture all the benefits from such a project; other parties who have not contributed to the cost of implementing the project may well receive some of the benefits. To provide significant value to the project proponent, the total benefits from a network-driven DSM project must be quite large and the proponent must be able capture a significant proportion of these benefits.

The report identifies a number of external and internal factors that may contribute to the success of network-driven DSM projects. Network-driven DSM projects containing the same DSM measures (such as energy efficiency, load shifting, direct load control or pricing initiatives) tend to have a common set of factors which contribute to their success and to this extent it is possible to identify sets of success factors that apply to each category of DSM measure. The challenge in designing a network-driven DSM project that will ultimately be successful in achieving its objectives is to clearly identify the success factors for each of the DSM measures included in the project and then concentrate on optimising each of these factors.

The final section of the report identifies the network problems that each category of network DSM measures can address; characterises the success factors which apply to each category; and examines how the DSM measures in each category should be implemented for them to be most effective in achieving network-related objectives.