Cost effectiveness of Utility driven DSM programmes: Issues and challenges

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SHAKTI
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FOUNDATION

Abstract

This paper is the fifth in the series of background papers developed for the participants of the Utility CEO Forum on demand side management (DSM).

Demand side resources constitute energy and demand savings resulting from the actions of a utility, beyond the customer's meter. Defining cost-effectiveness helps DSM compete with the conventional supply options in order to receive the attention and funding necessary to succeed. In India, the model DSM regulations, notified by the Forum of Regulators, in May 2010, and the subsequent DSM regulations, notified by the Electricity Regulatory Commissions in many states, have consistently emphasized the importance of establishing the cost effectiveness of DSM programmes for obtaining regulatory approvals.

Standardisation of the fundamental methods to evaluate cost effectiveness can provide consistency and transparency to the regulatory process of DSM programme's appraisal and approval.

This paper provides a review of the current regulatory framework guiding the establishment of cost effectiveness for utility driven DSM programmes in India. Standardised methods & tests adopted in India and abroad have been outlined. Further, a case study of the evaluation of cost effectiveness of DSM programmes in State has been illustrated.

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1. Introduction

Demand side resources constitute energy and demand savings resulting from the actions of a utility, beyond the customer's meter. These actions, when undertaken in a programmatic framework are referred to as 'utility driven demand side management (DSM) programmes'. Evaluating the cost effectiveness of DSM programmes is essential to recognise and quantify the potential of the utility's demand side resources. Defining cost-effectiveness also helps DSM compete with other resource/supply options so as to receive the attention and funding necessary to succeed.

In India, the Model DSM regulations, published by the Forum of Regulators in 2010, as well as the subsequent DSM regulations, notified by the electricity regulatory commissions in many states, have consistently stressed the importance of establishing cost effectiveness of DSM programmes for obtaining regulatory approvals. These regulations also recognise the establishment of cost effectiveness as a critical milestone, in the overall DSM programme implementation framework.

Illustrative steps in the DSM planning process by utilities

1.1. Evolution of standard cost effectiveness tests and Indian experience

The 'California Standard Practice Manual', published in 2001, established standard procedures for deriving the cost effectiveness indicators of utility sponsored DSM programmes, administered by the investor owned electric utilities in California. This manual, published by the California Public Utilities Commission (CPUC), marks the beginning of the standardisation of cost effectiveness evaluation by defining five key cost-effectiveness tests, which together provide a comprehensive approach for screening utility driven DSM programmes. The investor owned electric utilities in California and several other states in America have been adopting these tests for over a decade now and have been very successful.

In April 2010, the Maharashtra Electricity Regulatory Commission (MERC) adopted the five tests and published the 'Regulations on DSM Measures' and Programme's Cost Effectiveness Assessment'. The commission also published a detailed guide titled 'MERC Cost Effectiveness Assessment Guide', for establishing the cost-effectiveness indicators of the DSM measures and programmes driven by utilities in Maharashtra. The guide explains various elements of cost and benefit in each of the five tests and further provides the derivation formulae for calculating these elements. These regulations and guidelines provide a consistent set of methods to be followed by the licensees in the state and there by provide transparency to the regulatory process of DSM programme appraisal and approval.

Basic approach for computing and representing cost effectiveness tests

The basic structure of each cost-effectiveness test involves a calculation of the total benefits as well as costs from a certain vantage point to determine whether or not the overall benefits exceed the costs. A test is positive if the benefit-to-cost ratio is greater than one, and negative if it is less than one. Results can be reported either in net present value (NPV) INR (method by difference) or as a ratio (i.e., benefits/costs).

$$Benefit\ cost\ ratio = \frac{NPV\ \sum Benefits}{NPV\ \sum Costs}$$

Or

$$Net\ present\ value = NPV\ \sum Benefits - NPV\ \sum Costs$$

Significance of standard cost effectiveness tests for DSM programmes

The five tests adopted in the 'California Standard Practice Manual' and the *'MERC DSM regulations on cost-effectiveness'* are as follows:

- The participant cost test (PCT),
- The programme administrator cost test (PACT),
- The ratepayer impact measure test (RIM),
- The total resource cost test (TRC), and
- The societal cost test (SCT)

PCT provides a measure of the quantifiable benefits and costs to an “average” consumer for participating in a DSM programme. However, many consumers do not base their decision to participate in a DSM programme entirely on quantifiable variables (many times consumer decision to buy an appliance/device/equipment are based on factors such as brand value etc.).

PACT calculates the costs and benefits of the DSM programme from the perspective of the utility (or a programme administrator), which is sponsoring the incentives and implementing the programme.

RIM test measures the difference between the change in total revenues earned by the utility and the change in the total costs incurred by the utility as a result of the DSM programme. The test in effect determines what happens to the consumer bills or tariff rates due to changes in utility’s revenues and costs caused by the DSM measure/programme. However, to assess the tariff impact in per unit (per kWh) terms, the life cycle revenue impact of the DSM programme (LRIRIM) per unit of energy (kWh) can be calculated by dividing the difference of NPV (costs) and NPV (benefits) over the annual energy sales of the Utility.

TRC measures the net cost of a DSM programme as a resource option based on the total cost of the programme, including both the participant’s and the licensee’s costs.

The SCT test is structurally similar to the TRC Test. However, the SCT 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 service territory (the licensee and its consumers). In taking society's perspective, the SCT utilizes essentially the same cost variables as the TRC Test, but the benefits are defined with a broader societal point of view (Eg: carbon emission reductions).

The following table summarizes the five tests in terms of the vantage point and the various elements of cost and benefit they consider for evaluation.

Test	Acronym	Vantage point	Components of cost	Components of benefits
Participant cost test	PCT	Comparison of costs and benefits of the customer installing the measure	• Purchase costs of energy efficient equipment; • Installation costs of energy efficient equipment	• Avoided costs of conventional equipment; • Incentive payments; • Utility bill savings

Programme administrator cost test	PACT	Comparison of programme administrator costs to supply-side resource costs	• Direct incentive costs; • Administrative, marketing and outreach costs; • Annual Monitoring & Verification (M&V) costs	• Energy related costs avoided by the Utility; • Generation capacity costs avoided by the Utility; • T&D capacity costs avoided by the Utility
Ratepayer impact measure	RIM	Comparison of administrator costs and utility bill reductions to supply-side resource costs	• Direct incentive costs; • Administrative, marketing and outreach costs; • Annual M&V costs; • Annual loss of revenue from reduced sales	• Energy related costs avoided by the Utility; • Generation capacity costs avoided by the Utility; • T&D capacity costs avoided by the Utility
Total resource cost test	TRC	Comparison of programme administrator and customer costs to utility resource savings	• Purchase costs of energy efficient equipment; • Installation costs of energy efficient equipment • Administrative, marketing and outreach costs • Annual M&V costs	• Energy related costs avoided by the Utility; • Generation capacity costs avoided by the Utility; • T&D capacity costs avoided by the Utility
Societal cost test	SCT	Comparison of society's costs of energy efficiency to resource savings and non-cash costs and benefits	• Purchase costs of energy efficient equipment; • Installation costs of energy efficient equipment • Administrative, marketing and outreach costs • Annual M&V costs	• Energy related costs avoided by the Utility; • Generation capacity costs avoided by the Utility; • T&D capacity costs avoided by the Utility; • Carbon emission reductions

Cost-effectiveness decision criteria

There is no single best test for evaluating the cost-effectiveness of utility driven DSM programmes. Each of the five tests provides different sets of information on the impact of DSM programmes from distinct vantage points within the energy ecosystem. The regulatory commissions across the world adopt different tests for screening the DSM programmes. For example, in USA, a majority of the states adopt TRC or SCT as the primary tests for screening DSM programmes. The decision criteria adopted by MERC in India is highlighted below.

Eliminate all programmes that do not pass the TRC test; Implement all such DSM programmes that pass the TRC as well as the RIM test.

This would mean that the DSM programme would not only be economical option as compared to the supply side option that the licensee has, but it would also result in lower tariffs for all the licensee consumers, whether they are programme participants or programme non-participants. The programme participants would of course gain more than non-participants, however, here the non-participants will be better off than before as their tariffs and hence their bills will go down.

DSM programmes that pass the TRC but fail the RIM test, will be evaluated on a case to case basis by the Commission. Here, the Commission's decision will essentially be guided by the extent of impact on the non-participants. If the impact in absolute or percentage is negligible (less than Rs.0.01 per kWh sold by the licensee or less than 0.1 % of the present tariff level of non-participants) the Commission may approve the DSM programme. To lessen or minimize the impact on non-participants, the Commission may ask the licensees to try out alternate programme designs for the DSM programmes.

Although PCT and SCT are not hurdle tests, the licensees should present the results of these tests.

Key factors driving the cost effectiveness of DSM programmes

From the table that describes the various elements of costs and benefits in the five cost effectiveness tests, it is evident that the purchase costs of energy efficient equipment and the avoided costs (both energy and capacity related) of power play a critical role in driving the cost effectiveness indicators for DSM programmes.

The purchase costs of energy efficient equipment generally vary with the incremental costs incurred by the target consumers in the licensee area. In this regard, there are three basic types of DSM measures that can be driven by the utilities.

- ***Replacement measures*** involve normal replacement of conventional equipment at the end of its useful life. The incremental costs in such measures are usually the differential cost between energy efficient equipment and the conventional ones. The salvage value of the old equipment is almost negligible.
- ***Retrofit measures*** are early replacement measures, which promote replacement of conventional equipment before the completion of its useful life. The incremental costs in such measures are usually equal to the difference in capital costs of energy efficient equipment and the salvage value of conventional ones. However to avoid the complexity of computing the salvage value of different equipment at varied life, this tool does not consider any salvage value for retrofit measures.
- ***New construction measures*** target the newly built facilities for installing energy efficient technologies the time of construction. The incremental costs in such measures are usually the differential cost between energy efficient equipment and the conventional ones.

The avoided cost of power is a derivative of the treatment of conserved electricity resulting from the implementation of DSM programmes. Different demand-supply scenarios, the cost of power supply, short-term electricity prices and many other factors drive the treatment of conserved electricity by utilities. Some of the possible treatments under different scenario are described below for illustration.

Illustrative Scenario	Treatment of conserved electricity	Proxy for avoided cost calculations
Power surplus and high cost of supply	Avoiding the purchase of energy due to savings resulting from the DSM programmes	Costs of energy charges of ***marginal source*** for meeting the demand
Power deficit and high cost of short term electricity	Selling the energy savings to the consumers within licensee area	Weighted average tariff of consumers benefiting from increased supply
Power surplus and high cost of short term electricity	Selling the energy savings through short term route	Difference of prices in short term route expected in the market and cost of purchase of electricity from the source

The table describes that the marginal costs of power can be a reasonable proxy for the avoided costs in one of the scenarios of power supply. Therefore, computation of the marginal costs of power is essential in the process of establishing the cost effectiveness indicators for DSM programmes.

The marginal cost (MC) of power is defined as the price of electricity to meet the incremental kW of demand and kWh of energy. The marginal cost of power is dependent upon multiple factors such as time of the day, season, supply mix, demands fulfilled, etc. The cost of supply to meet the demand varies based on these factors, and there is a consequential impact on the MC of supply.

MC can be estimated in either the long-run or short-run perspective. In the long-run approach, the contracted capacity of supply is not fixed, and changes in demand influence the timing as well as the choice of adding future resources (that is, generation capacity). State has tied-up its power supplies for FY 15-17 through long-term contracts. The long-term contract has a lead time of at least three to four years (between execution of the contract and delivery of supply). In the short-run approach, the contracted capacity of supply is assumed to be fixed, so that changes in demand only affect the dispatch of the existing generating units.

1.2. Issues and challenges for establishing cost effectiveness of DSM programmes in India

The nature of DSM programmes makes it very difficult for utilities to establish cost effectiveness in the traditional manner. The definition of appropriate cost effectiveness indicators and their representation of the interests of various stakeholders is the fundamental challenge. Apart from this, there is a great degree of uncertainty prevailing on the expected impact of DSM programmes on consumer tariffs.

Some of the critical questions that have remained unanswered are as follows:

i. What are the indicators for representing the cost effectiveness of DSM measures and programmes?

ii. What are the marginal costs of power for utilities in India? and How do these costs vary with time and geography?

iii. What are the avoided costs of power that can be expected from large scale implementation of DSM programmes under different power supply scenarios in the states?

iv. What are the indicators for screening DSM programmes based on cost effectiveness?

In this scenario, the process of regulatory appraisal of the cost effectiveness of DSM programmes becomes complex and difficult in the absence of clear regulations and guidelines. In the states that have already notified DSM regulations, the lack of clear guidelines on how to establish cost effectiveness is impeding the utilities' efforts in identifying the cost effective potential for demand side resources.

Therefore, there is a need to standardise methods, tests and procedures that can provide value to the utilities' efforts in identifying the cost effective potential for demand side resources in the country. The specific actions in this regard are as follows:

- The State Electricity Regulatory Commissions (SERCs) in the country should notify relevant regulations and guidelines for the establishment of cost effectiveness indicators and screening of DSM programmes based on the results of the cost effectiveness tests. The Forum of Regulators (FOR) can develop model regulations and guidelines focusing on the establishment of cost effectiveness indicators and screening of DSM programmes based on the results of the cost effectiveness tests. Or, the 'MERC Regulations on DSM Measures' and Programme's Cost Effectiveness Assessment', the 'MERC Cost Effectiveness Assessment Guide' and the 'California Standard Practise Manual' can be referred by the SERCs while developing such regulations and guidelines.

- Computation of the marginal costs of power (both variable and capacity costs) procured by the electric utilities should be standardised and relevant guidelines should be notified. The methods for assessment of the variability in marginal costs with respect to time of day, calendar month, year in future and geography should also be standardised in order to mitigate uncertainties in the variability of marginal costs.

- Computation of avoided costs of power (both energy and capacity) should be standardised for different scenarios that may arise from the power supply status expected in various parts of the country.

2. Case study: Evaluating cost effectiveness of DSM programmes in a sample State

Background

State's power sector has recently transformed from being marginally deficit to surplus. The supply from various sources has outstripped the electric demand in the near future, making State a power surplus state. In a surplus scenario, the biggest challenge for the state is to minimise energy costs through efficient utilisation of resources. DSM has proven to provide cost-effective energy as well as demand savings thereby improving resource efficiency and energy security in a sustainable manner. Utilities worldwide have acquired DSM resources to minimise power resource costs.

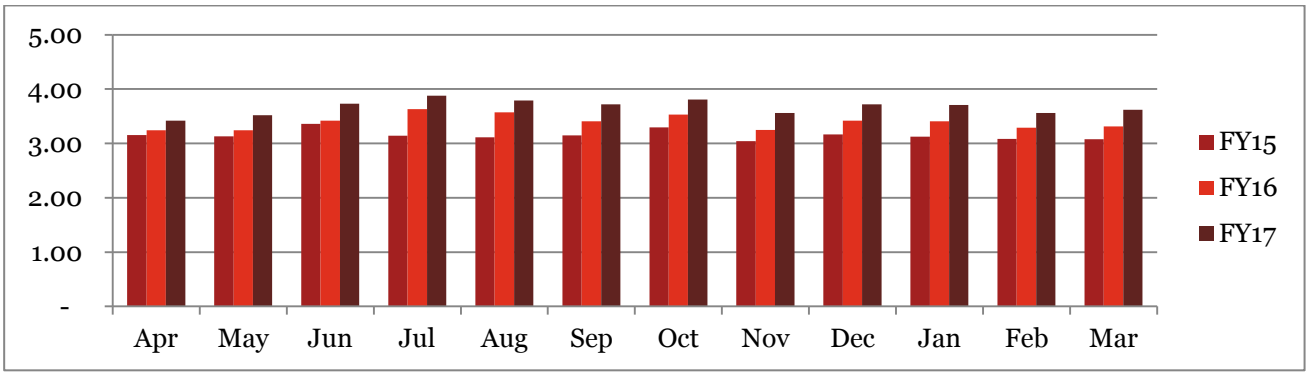
Despite the proven benefits of DSM, there is a great degree of uncertainty prevailing with regard to the cost effectiveness of DSM measures as compared to the conventional supply resources (e.g: thermal, hydro and nuclear generators) in State. This uncertainty is derailing the progress of megawatt scale DSM investments. Standardisation of the fundamental methods, used to evaluate cost effectiveness of DSM measures, will enable State utilities (electricity distribution licensees) to make informed investment decisions in favour of megawatt scale DSM programmes.

In an effort to promote this objective, Shakti Sustainable Energy Foundation initiated a study to design and develop a tool that can evaluate the cost-effectiveness of utility driven DSM programmes in State. The envisaged tool is expected to provide transparency to the regulatory process of DSM programme appraisal and approval, in State, and also serve as a model for the utilities and commissions in other states.

Methodology

As first step towards building this tool, PwC sought to quantify the marginal costs of power supply in State. The objective was to benchmark the avoided costs of energy and capacity that are critical in determining the cost effectiveness of DSM programmes. In this regard, rigorous data collection and analysis of power demand and supply sources led to the development of hourly load (state wide electric demand) forecasts and supply stack of planned resources (generators) in 2015-17. Further analysis performed by mapping the hourly demand forecasts to the supply stacks revealed the marginal resources, which are essentially highest variable cost generators serving the demand at different time blocks in State.

Avoided cost of power (energy charges): Forecast

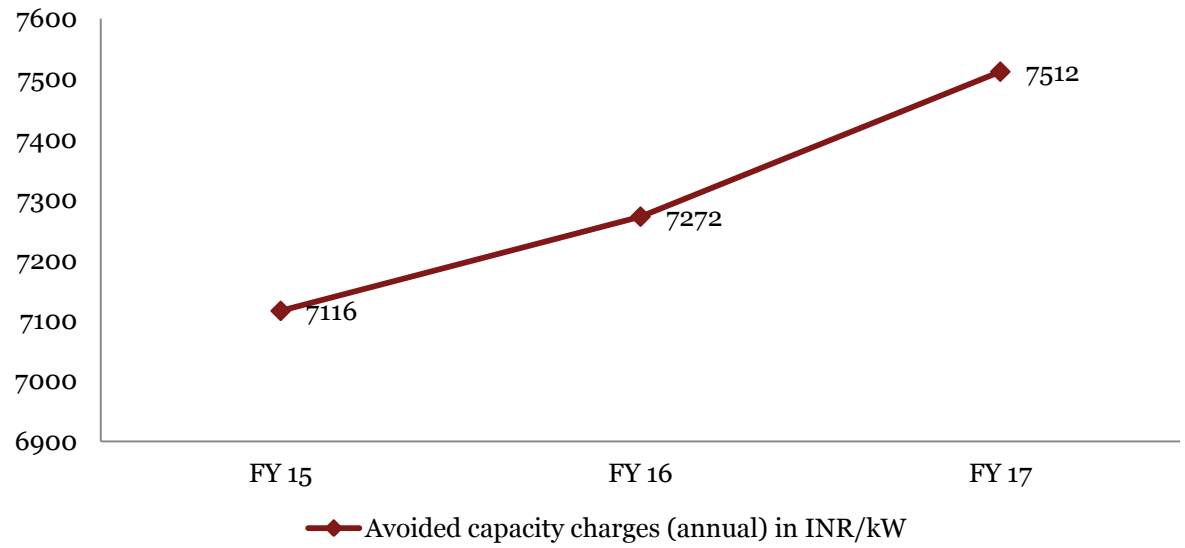


Source: PwC Analysis

Variability in avoided cost of power (energy charges)

- Hourly avoided cost forecasts varies from INR 3.03 – 4.11 per unit
- The least avoided cost (3.03) is expected in the off peak hours during April'14 to March'15
- The highest avoided cost (4.11) is expected in the July'16

Avoided cost of generation capacity INR/kW/annum



Source: PwC analysis

In the current surplus scenario, energy savings and peak demand reduction, derived from large scale DSM interventions in the State, can best translate to avoided purchase of power resulting from the box-down of highest variable cost generators. The tangible avoided costs for State's utilities, in such treatment of conserved electricity, will be the variable costs of the boxed down generators. Apart from this, the State utilities may continue to pay the fixed costs of the boxed down generators and may not derive any benefits with regard to avoided generation capacity. However, this study considers both the scenarios (with and without the avoided capacity benefits) in order to evaluate the cost effectiveness of DSM programmes in State.

In the next step towards building the DSM cost effectiveness tool, PwC sought to identify the key cost effectiveness tests that can compare the benefits of DSM programmes with the costs incurred by various stakeholders. The objective was to standardize the computation of various components of costs and benefits within the envisaged tool.

The five cost-effectiveness tests adopted for building the DSM cost effectiveness tool are as follows:

- The participant cost test (PCT),
- The programme administrator cost test (PACT),
- The ratepayer impact measure test (RIM),
- The total resource cost test (TRC), and
- The societal cost test (SCT)

Finally, the DSM cost effectiveness tool was built on the MS Excel platform and six DSM measures were selected based on the load research study undertaken by the Shakti Sustainable Energy Foundation in 2012.

- M 1: - Incentives for the purchase and installation of energy- efficient luminaires;
- M 2: - Incentives for the purchase and installation of energy- efficient ceiling fans;
- M 3: - Incentives for the purchase and installation of energy- efficient air conditioners;
- M 4: - Incentives for the purchase and installation of energy- efficient refrigerators;
- M 5: - Incentives for the purchase and installation of energy- efficient electric Geysers;
- M 6: - Incentives for the purchase and installation of energy- efficient agriculture pumping system

2.1. Results of the cost effectiveness evaluation of DSM programmes[1]

In the scenario that considers both avoided energy costs and avoided capacity costs as benefit components in the cost- effectiveness tests,

- M 1 is cost effective in the residential category with T5 tubular lamp retrofits up to 100% rebate under the rebate design and INR 4/unit under the standard offer design; For the same T5 lamps, M 1 is not cost effective in the non domestic category even with 25% rebate and INR 0.5/unit standard offer
- M 2 is cost effective in the residential category when the State utilities offer incentives up to 42% under rebate design and INR 1.95/unit under standard offer design
- M 3 is cost effective for replacement and new construction measures, in the residential category, as long as State utilities limit the incentives up to 38% under rebate design and INR 3.95/unit under standard offer design; In the non domestic category, the programme is cost effective up to 17% under rebate design and INR 1.00/unit under standard offer design
- M 4 is cost effective for replacement and new construction measures, in the residential category, as long as State utilities limit the incentives up to 4.5% under rebate design and INR 0.68/unit under standard offer design
- M 5 is cost effective for replacement and new construction measures, in the residential category, as long as State utilities limit the incentives up to 5% under rebate design and INR 0.7/unit under standard offer design
- M 6 is cost effective up to 100% rebates

In the scenario that considers only avoided energy costs as benefit component in the cost- effectiveness tests,

- M 1 is cost effective in the residential category as long as State utilities limit the incentives up to 18% under rebate design and INR 0.65/unit under standard offer design
- M 2 is cost effective in the residential category as long as State utilities limit the incentives up to 16% under rebate design and INR 0.75/unit under standard offer design
- M 3 is cost effective for replacement and new construction measures, in the residential category, as long as State utilities limit the incentives up to 6.5% under rebate design and INR 0.7/unit under standard offer design
- M 4 and M 5 are cost effective at the same incentive levels in the earlier scenario
- M 6 is cost effective up to 100% rebates and INR 3.28/unit of standard offer

[1] Refer Appendix 1A to understand the meaning and outcomes in detail

Timing of DSM resource acquisition is a critical factor driving the cost effectiveness of DSM programmes; DSM programmes should be considered as one of the resources during the planning stage and the distribution licensees in State should evaluate DSM programmes along with other resources for electricity supply.

Appendix 1 A - Application of DSM cost effectiveness tool

The following table shows the input information/parameters, used by the DSM cost effectiveness tool, in order to evaluate the cost effectiveness of DSM programmes in State.

Input parameters for evaluating the cost effectiveness of DSM programmes[2] in State

		M 1	M 2	M 3	M 4	M 5	M 6
Programme design Parameters	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**
Target end use sector		Residential	Residential	Residential	Residential	Residential	Agriculture
Eligible population of appliance		1000000	13000000	700000	500000	1000000	600000
Annual participation rate	%	50%	50%	50%	50%	50%	25%
Measure type[3]		Retrofit	Retrofit	Retrofit	Retrofit	Retrofit	Retrofit
Programme start date (Start date of any financial year)	Date	4/1/2014	4/1/2014	4/1/2014	4/1/2014	4/1/2014	4/1/2014
Programme end date (End date of any financial year)	Date	3/31/2015	3/31/2015	3/31/2015	3/31/2015	3/31/2015	3/31/2015
Incentive Design[4]		Rebate	Rebate	Rebate	Standard Offer	Rebate	Rebate
Rebate level of capital cost	%	75%	30%	30%	25%	20%	70%
Rebate level of installation cost	%	0%	0%	0%	0%	0%	0%
Standard offer	INR/kWh	3.00	1.50	3.50	1.00	1.50	3.00
Administrative, marketing and outreach costs	Percentage of overall programme cost	15%	15%	15%	15%	15%	15%
Annual M&V cost	Percentage of overall programme cost	5%	5%	5%	5%	5%	5%
NTG ratio		0.95	0.95	0.95	0.95	0.95	0.95

[2] The DSM measures are coded for easy reference as below.
M 1 - Incentives for purchase and installation of energy efficient luminaires; M 2 - Incentives for purchase and installation of energy efficient ceiling fans; M 3 - Incentives for purchase and installation of energy efficient air conditioners; M 4 - Incentives for purchase and installation of energy efficient refrigerators; M 5 - Incentives for purchase and installation of energy efficient electric geysers; M 6 - Incentives for purchase and installation of energy efficient agriculture pumping system

[3] Replacement measures involve replacement of conventional equipment at the end of its useful life. The incremental costs in such measures are usually the differential cost between energy efficient equipment and the conventional ones. The salvage value of the old equipment is almost negligible.
Retrofit measures are early replacement measures, which promote replacement of conventional equipment before the completion of its useful life. The incremental costs in such measures are usually equal to the difference in capital costs of energy efficient equipment and the salvage value of conventional ones. However to avoid the complexity of computing the salvage value of different equipment at varied life, this tool does not consider any salvage value for retrofit measures.
New construction measures target the newly built facilities for installing energy efficient technologies the time of construction. The incremental costs in such measures are usually the differential cost between energy efficient equipment and the conventional ones.
[4] Rebate programmemes offer capital rebates to offset the differential cost involved in purchase of high efficiency electric appliances.
Standard offer programmeme is a mechanism to acquire demand-side resources (energy and demand savings) based on a predetermined rate (e.g. INR/kWh). These rates are reflective of the feed-in-tariffs for energy efficient technologies.

Measure level parameters	Unit	Value	Value	Value	Value	Value	Value
Conventional appliance wattage	Watt	52	75	1955	-	-	5592.75
Energy efficient appliance wattage	Watt	30	35	1325	-	-	3728.5
Energy consumption of conventional appliance	kWh/unit/year	-	-	-	501	906	-
Energy consumption of energy efficient appliance	kWh/unit/year	-	-	-	205	723	-
Peak coincidence factor	Percentage	50%	50%	70%	70%	10%	30%
Useful life of energy efficient appliance	Years	5	8	8	8	6	5
Annual average operational hours	Hours	1560	3030	1230	2040	210	2040
Installation cost of energy efficient appliance	INR	100	200	500	500	500	1000
Capital cost of energy efficient appliance	INR	400	2500	35000	20000	10000	40000
Capital cost of conventional appliance	INR	100	1700	25000	15000	7000	30000
Utility parameters	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**
Distribution Losses	Percentage	25%	25%	25%	25%	25%	25%
Annual fuel cost escalation of marginal resources	Percentage	5%	5%	5%	5%	5%	5%
Plant load factor of marginal resources	Percentage	78%	78%	78%	78%	78%	78%
Revenue realisation rate / Average retail tariff	INR/kWh	4	4	4	4	4	6.28
Retail tariff (paid by consumer)	INR/kWh	4	4	4	4	4	0.25
State sponsored subsidy	INR/kWh	-	-	-	-	-	6.03
Annual retail tariff escalation	Percentage	5%	5%	5%	5%	5%	5%
Grid emission factor	tCO2 / MWh	0.79	0.79	0.79	0.79	0.79	0.79
Value of carbon emission reductions	INR / tCO2	50.00	50.00	50.00	50.00	50.00	50.00
Financial parameters	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**
Discount rate for participant benefits	Percentage	12%	12%	12%	12%	12%	12%
Discount rate for utility benefits	Percentage	12%	12%	12%	12%	12%	12%
Discount rate for participant costs	Percentage	10%	10%	10%	10%	10%	10%
Discount rate for utility costs	Percentage	10%	10%	10%	10%	10%	10%

Time of use of tubular lamps in State's residential households (M1) (YES / NO)

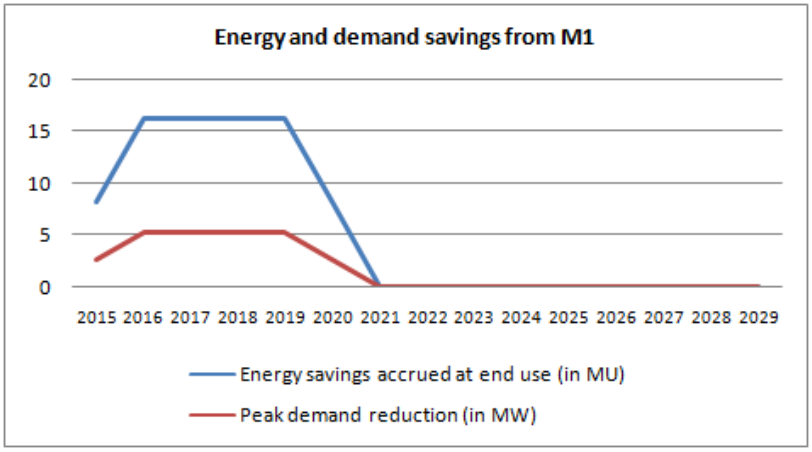
Month / Time block	April-14	May-14	June-14	July-14	August-14	September-14	October-14	November-14	December-14	January-15	February-15	March-15
1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	NO
8	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
9	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
11	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
12	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
13	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
14	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
15	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
16	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
17	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
18	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
19	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
20	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
21	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
22	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
23	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
24	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

M 1: Incentives for purchase and installation of Energy efficient luminaires

This measure considers utility sponsored incentives for purchase and installation of energy efficient luminaires by consumers in the licensee area. The input table indicates the intent of the user to evaluate this measure by considering T5 tubular lamp retrofits for residential consumers. Considering 50 lakh T5 tubular lamps participating in this programme, it is expected to deliver 16.3 MU of annual energy savings and 5.225 MW of peak demand reduction in the state of State.

Energy and demand savings from M1 in residential category



Results for residential category in State (75% rebate and INR 3/unit standard offer)

Scenario with avoided capacity benefits

Test	Ratio (Benefit / cost)	NPV in lakhs (Benefit - cost)
PCT	4.12	3122.78
PACT	2.70	3788.84
RIM	1.25	1193.35
TRC	1.86	2788.84
SCT	1.87	2821.65

Test	Rebate			Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	4.12	4.62	4.62	1.84	2.04	2.04
PACT ratio	2.70	2.70	2.70	2.35	2.35	2.35
RIM ratio	1.25	1.25	1.25	1.17	1.17	1.17
TRC ratio	1.86	2.20	2.20	2.00	2.39	2.39
SCT ratio	1.87	2.21	2.21	2.01	2.41	2.41

Both TRC and RIM test indicators (i.e. ratio and NPV), which are critical for screening, have cleared the hurdle. RIM ratio greater than one (or positive NPV) indicates that the cost of this DSM measure is less compared to the existing supply sources in State. This may also result in overall electricity tariff reduction if the utilities choose to pass on the benefits of enhanced resource efficiency to the consumers.

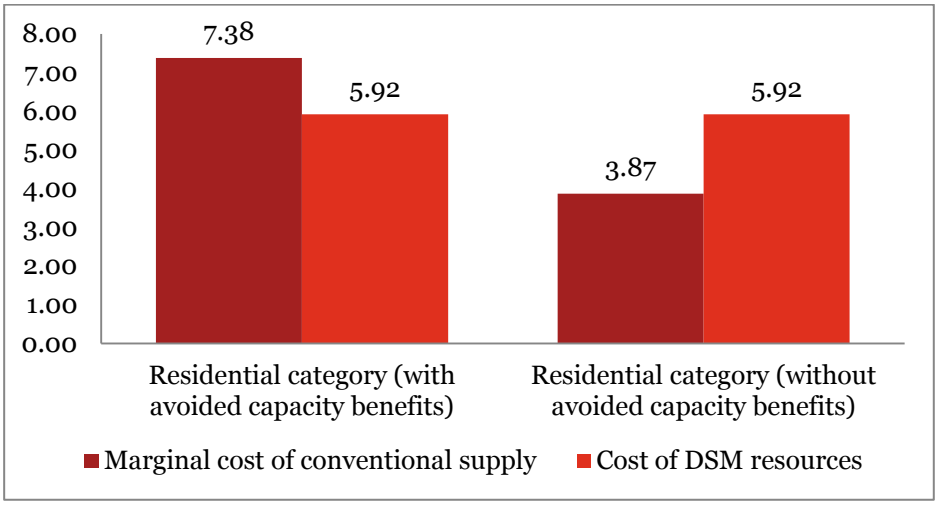
In case of replacement and new construction measures the costs are only incremental in nature after considering the conventional equipment costs. Therefore the TRC ratios are higher for such measures as compared to retrofit. However, the RIM ratios are independent of the type of measure. One can also estimate the impact of this programme on consumer tariffs by dividing the NPV (benefits - costs) from RIM test on the overall annual electricity sales in State.

Scenario without avoided capacity benefits

Test	Rebate			Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	4.12	4.62	4.62	1.84	2.04	2.04
PACT ratio	1.42	1.42	1.42	1.23	1.23	1.23
RIM ratio	0.65	0.65	0.65	0.61	0.61	0.61
TRC ratio	0.98	1.16	1.16	1.05	1.26	1.26
SCT ratio	0.99	1.17	1.17	1.06	1.27	1.27

Clearly the RIM test ratios in this scenario have failed to clear the hurdle. This indicates that the cost of this DSM measure is higher as compared to the existing supply sources in State.

Comparison of costs between DSM and conventional supply (75% rebate and INR 3/unit standard offer)

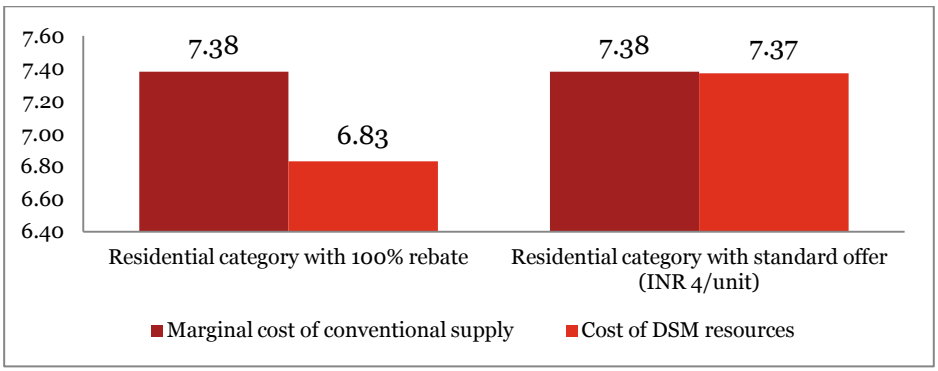


Incentive cap (max.) to remain cost effective in residential category

The most important application of the 'DSM cost effectiveness tool' is that it allows the users to quantify the hurdle rate of incentive for different programme designs to remain cost effective. For example, if one considers avoided capacity benefits, the tool indicates that the State utilities can offer up to 100% rebate under the rebate design and INR 4/unit under the standard offer design to remain cost effective in promoting T5 lamp retrofits in the residential consumers. In other words, the RIM ratios would reach its hurdle value (one) at these incentive levels. However, if one does not consider avoided capacity benefits, the tool indicates that this DSM programme becomes cost effective, even without avoided capacity benefits, at rebate levels not more than 18% and standard offer not more than INR 0.65/unit.

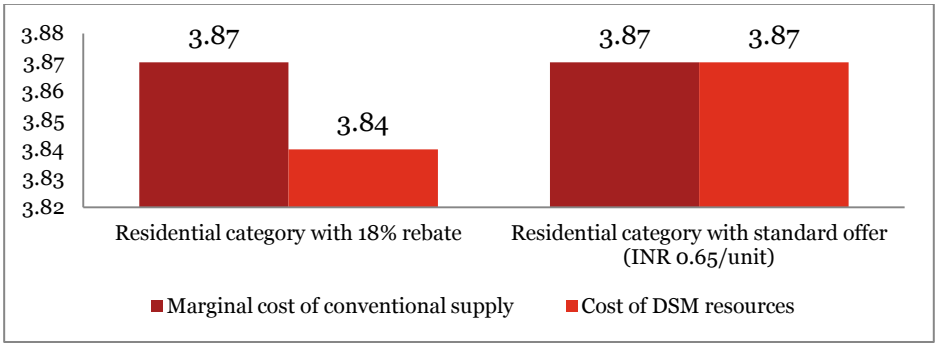
Scenario with avoided capacity benefits

	100% Rebate - retrofit		**Standard offer (INR 4/unit) - retrofit**	
Test	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)
PCT	9.25	4122.78	2.10	2745.55
PACT	2.02	3038.24	1.76	2596.97
RIM	1.08	442.75	1.00	1.47
TRC	1.73	2538.24	1.89	2829.06
SCT	1.74	2571.04	1.90	2861.87



Scenario without avoided capacity benefits

	18% Rebate - retrofit		Standard offer (INR 0.65/unit) - retrofit	
Test	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)
PCT	1.39	842.78	1.22	548.98
PACT	5.90	2620.73	5.69	2601.06
RIM	1.01	25.24	1.00	5.57
TRC	1.18	480.73	1.21	545.03
SCT	1.19	513.53	1.22	577.84



Results in Non domestic category (NDS) Scenario with avoided capacity benefits

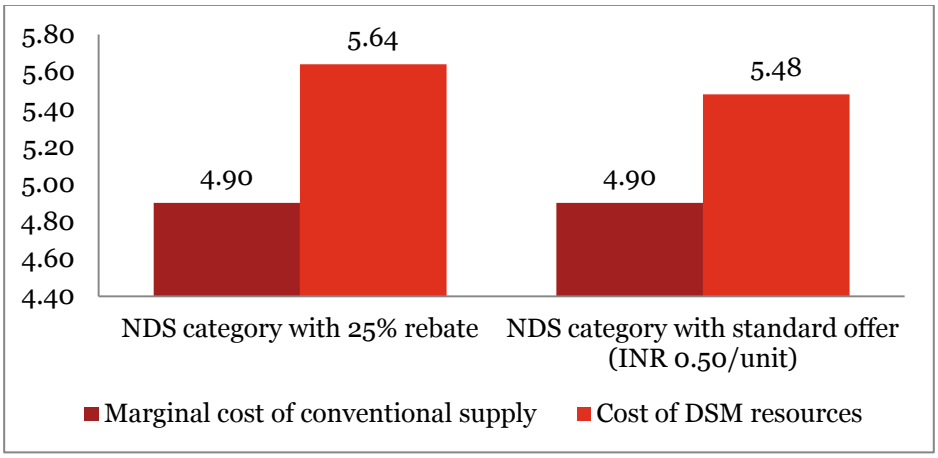
Now, we will examine the cost effectiveness of M1 in the Non domestic category (NDS). By changing some of the key input parameters such as the time of use of appliance, peak coincidence factor (30%), useful life of energy efficient luminaire (2 years), revenue realisation rate (INR 5.36/kWh), the annual average operational hours (4320 hours), and keeping everything else same, we can derive the cost effectiveness of M1 in NDS category.

Cost effectiveness ratios for M1 in NDS category

	25% Rebate - retrofit		Standard offer (INR 0.5/unit) - retrofit	
Test	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)
PCT	2.53	3062.96	2.00	2488.61
PACT	6.52	3748.99	8.18	3887.00
RIM	0.87	-660.50	0.89	-522.49
TRC	1.65	1748.99	1.70	1819.98
SCT	1.67	1791.58	1.71	1862.57

Even at 25% rebate level the RIM test indicators (i.e. ratio and NPV) have failed to clear the hurdle. RIM ratio less than one (or negative NPV) indicates that the cost of this DSM measure is higher as compared to the existing supply sources in State. The tool indicates the same outcome for standard offer design at INR 0.5/kWh.

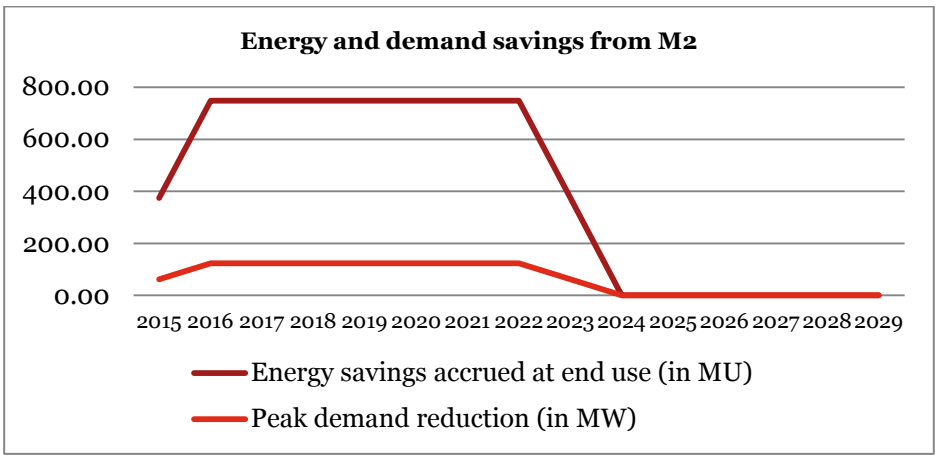
Comparison of costs in NDS category



M 2: Incentives for purchase and installation of Energy efficient ceiling fans

This measure considers utility sponsored incentives for purchase and installation of energy efficient ceiling fans by residential consumers in State.

Results for residential category in State (30% rebate and INR 1.5/unit standard offer)



Scenario with avoided capacity benefits

Test	Rebate			Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	1.69	2.57	2.57	1.30	1.93	1.93
PACT ratio	3.57	3.57	3.57	3.33	3.33	3.33
RIM ratio	1.13	1.13	1.13	1.10	1.10	1.10
TRC ratio	1.35	2.95	2.95	1.44	3.38	3.38
SCT ratio	1.36	2.97	2.97	1.45	3.41	3.41

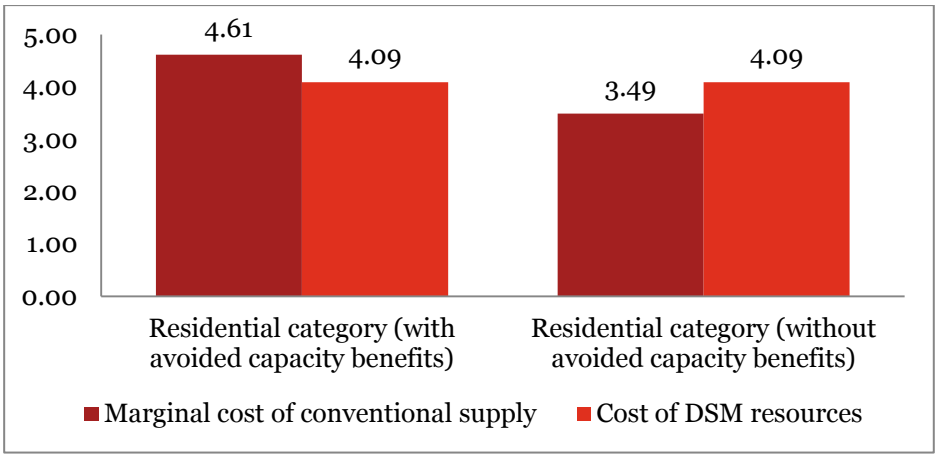
Both TRC and RIM test indicators (i.e. ratio and NPV), which are critical for screening, have cleared the hurdle. RIM ratio greater than one (or positive NPV) indicates that the cost of this DSM measure is less compared to the existing supply sources in State. This may also result in overall electricity tariff reduction if the utilities choose to pass on the benefits of enhanced resource efficiency to the consumers.

Scenario without avoided capacity benefits

Test	Rebate			Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	1.69	2.57	2.57	1.30	1.93	1.93
PACT ratio	2.71	2.71	2.71	2.53	2.53	2.53
RIM ratio	0.85	0.85	0.85	0.84	0.84	0.84
TRC ratio	1.03	2.24	2.24	1.09	2.56	2.56
SCT ratio	1.04	2.26	2.26	1.10	2.59	2.59

Clearly the RIM test ratios in this scenario have failed to clear the hurdle. This indicates that the cost of this DSM measure is higher as compared to the existing supply sources in State.

Comparison of costs for M2

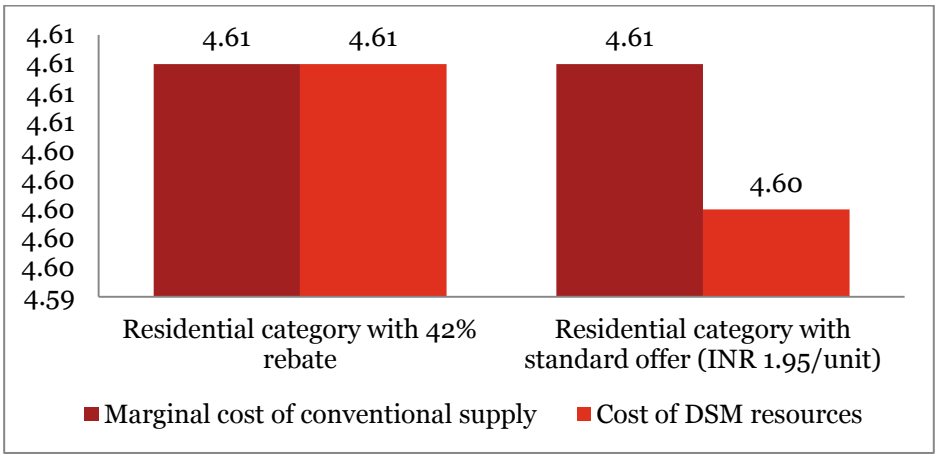


Incentive cap (max.) to remain cost effective in residential category

Scenario with avoided capacity benefits

	42% Rebate - retrofit		**Standard offer (INR 1.95/unit) - retrofit**	
Test	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)
PCT	2.18	126932.68	1.41	71324.86
PACT	2.55	167766.53	2.56	168269.01
RIM	1.00	72.62	1.00	575.10
TRC	1.28	60516.53	1.40	78822.46
SCT	1.29	62592.07	1.41	80898.00

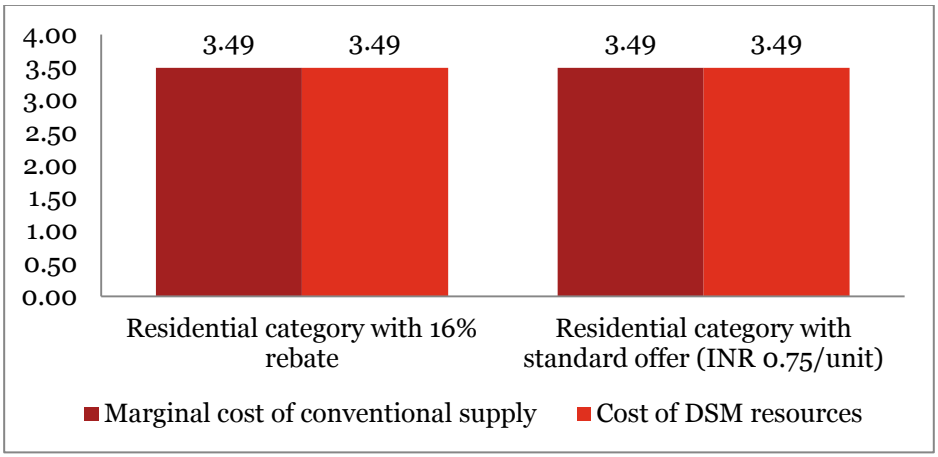
If one considers avoided capacity benefits, the tool also indicates that State utilities can offer up to INR 1.95/unit under standard offer design and up to 42% rebates under the rebate design to remain cost effective under the retrofit measures.



Scenario without avoided capacity benefits

	16% Rebate - retrofit		**Standard offer (INR 0.75/unit) - retrofit**	
Test	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)
PCT	1.28	42432.68	1.12	21545.06
PACT	5.08	167966.83	5.06	167764.23
RIM	1.00	272.92	1.00	70.32
TRC	1.10	18466.83	1.14	25361.71
SCT	1.11	20542.37	1.15	27437.26

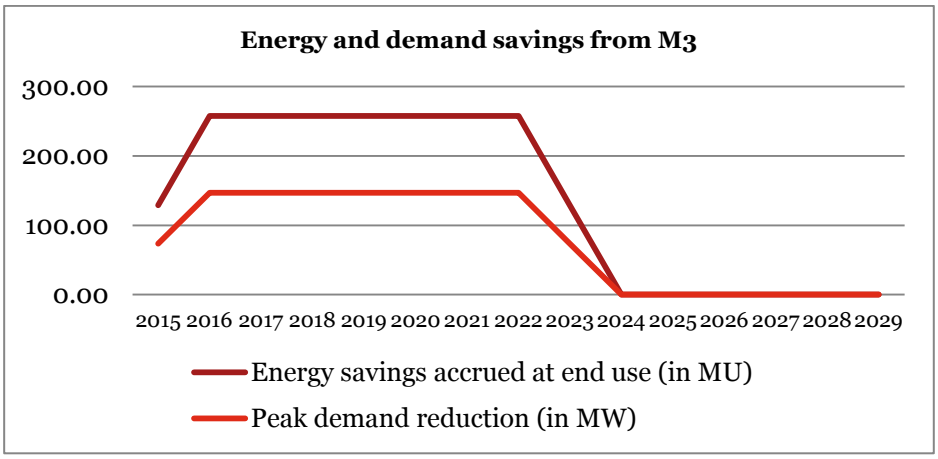
If one does not consider avoided capacity benefits, the tool indicates that this DSM programme becomes cost effective, even without avoided capacity benefits, at rebate levels not more than 15% and standard offer not more than INR 0.75/unit.



M 3: Incentives for purchase and installation of Energy efficient air conditioners

This measure considers utility sponsored incentives for purchase and installation of energy efficient room air conditioners by residential and non domestic categories in State.

Results for residential category in State (30% rebate and INR 3.5/unit standard offer)



Scenario with avoided capacity benefits

Test	Rebate			Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	1.07	2.07	2.07	0.86	1.57	1.57
PACT ratio	2.29	2.29	2.29	2.00	2.00	2.00
RIM ratio	1.15	1.15	1.15	1.07	1.07	1.07
TRC ratio	0.91	2.29	2.29	0.97	2.66	2.66
SCT ratio	0.92	2.30	2.30	0.97	2.67	2.67

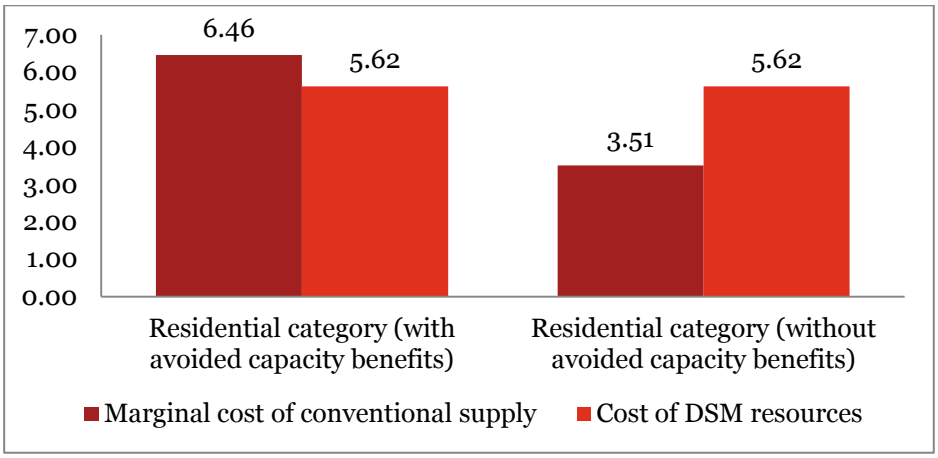
TRC test indicators (i.e. ratio and NPV) have failed to clear the hurdle under retrofit measures. However this is not true in case of replacement and new construction measures. The RIM ratios are greater than one (or positive NPV) indicating that the cost of this DSM measure is less compared to the existing supply sources in State.

Scenario without avoided capacity benefits

Test	Rebate			Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	1.07	2.07	2.07	0.86	1.57	1.57
PACT ratio	1.24	1.24	1.24	1.09	1.09	1.09
RIM ratio	0.62	0.62	0.62	0.58	0.58	0.58
TRC ratio	0.50	1.24	1.24	0.53	1.44	1.44
SCT ratio	0.50	1.25	1.25	0.53	1.46	1.46

Clearly the RIM test ratios in this scenario have failed to clear the hurdle. This indicates that the cost of this DSM measure is higher as compared to the existing supply sources in State.

Comparison of M3 costs in residential category

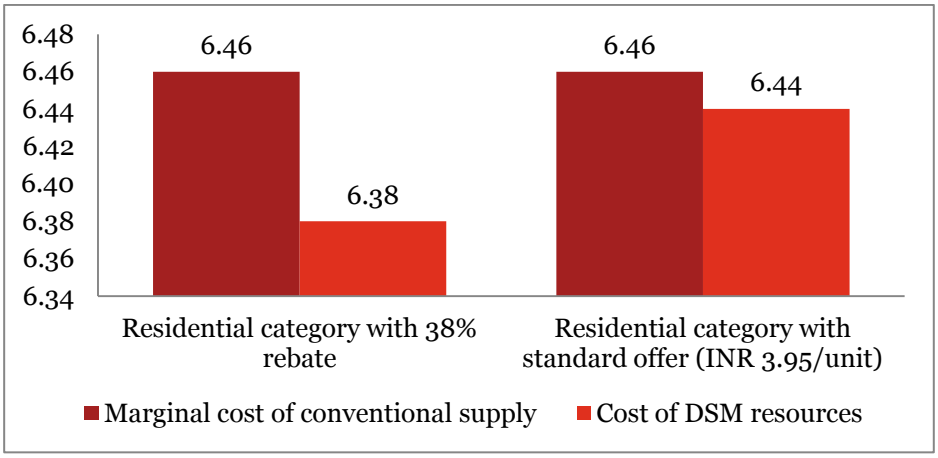


Incentive cap (max.) to remain cost effective in residential category

Scenario with avoided capacity benefits

	38% Rebate - replacement		**Standard offer (INR 3.95/unit) – replacement**	
Test	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)
PCT	2.46	113475.45	1.62	76786.84
PACT	1.81	59412.30	1.77	58107.76
RIM	1.01	1680.51	1.00	375.97
TRC	2.08	69212.30	2.57	81368.44
SCT	2.09	69926.85	2.59	82082.98

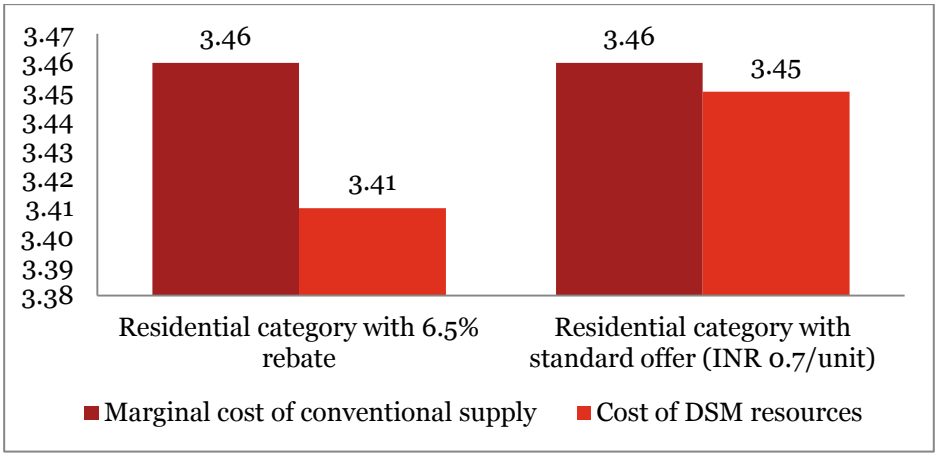
If one considers avoided capacity benefits, the tool also indicates that State utilities can offer up to INR 3.95/unit under standard offer design and up to 38% rebates under the rebate design to remain cost effective under the replacement and new construction measures.



Scenario without avoided capacity benefits

	6.5% Rebate - replacement		Standard offer (INR 0.7/unit) - replacement	
Test	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)	Ratio (Benefit / cost)	NPV in Lakhs (Benefit - cost)
PCT	1.31	36300.45	1.24	30372.41
PACT	5.65	58678.99	5.36	57993.57
RIM	1.01	947.20	1.00	261.78
TRC	1.72	29891.49	1.81	31878.37
SCT	1.74	30606.04	1.83	32592.92

If one does not consider avoided capacity benefits, , the tool also indicates that State utilities can offer up to INR 0.7/unit under standard offer design and up to 6.5% rebates under the rebate design to remain cost effective under the replacement and new construction measures.



Results in Non domestic category (NDS)
Scenario with avoided capacity benefits

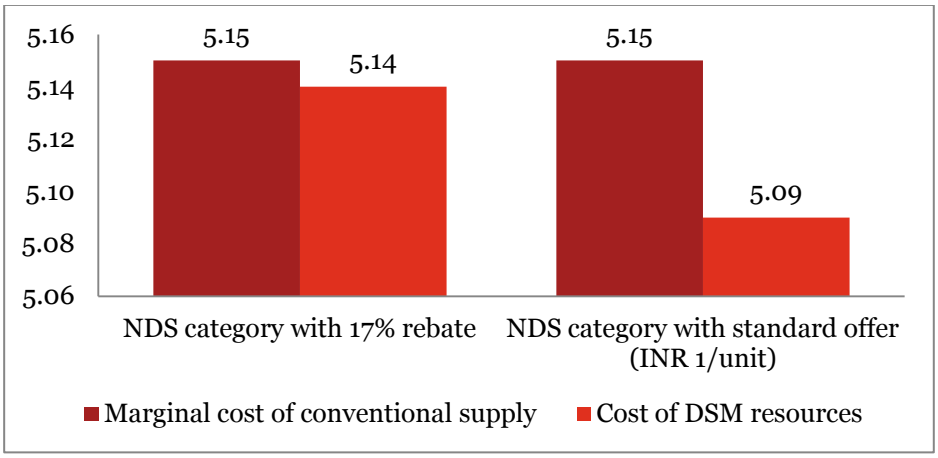
Now, we will examine the cost effectiveness of M3 in the Non domestic category (NDS). By changing some of the key input parameters such as the time of use of appliance, useful life of energy efficient AC (6 years), revenue realization rate (INR 5.36/kWh), the annual average operational hours (2400 hours), peak coincidence factor (50%), rebate (17%), standard offer (INR 1/unit), we can derive the cost effectiveness of M3 in NDS category.

Cost effectiveness ratios for M3 in NDS category

Test	17% Rebate			INR 1/unit Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	1.40	2.24	2.24	1.18	1.88	1.88
PACT ratio	4.90	4.90	4.90	5.13	5.13	5.13
RIM ratio	1.00	1.00	1.00	1.01	1.01	1.01
TRC ratio	1.15	3.26	3.26	1.19	3.63	3.63
SCT ratio	1.16	3.28	3.28	1.20	3.65	3.65

If one considers avoided capacity benefits, the tool also indicates that State utilities can offer up to INR 1/unit under standard offer design and up to 17% rebates under the rebate design to remain cost effective in the NDS category.

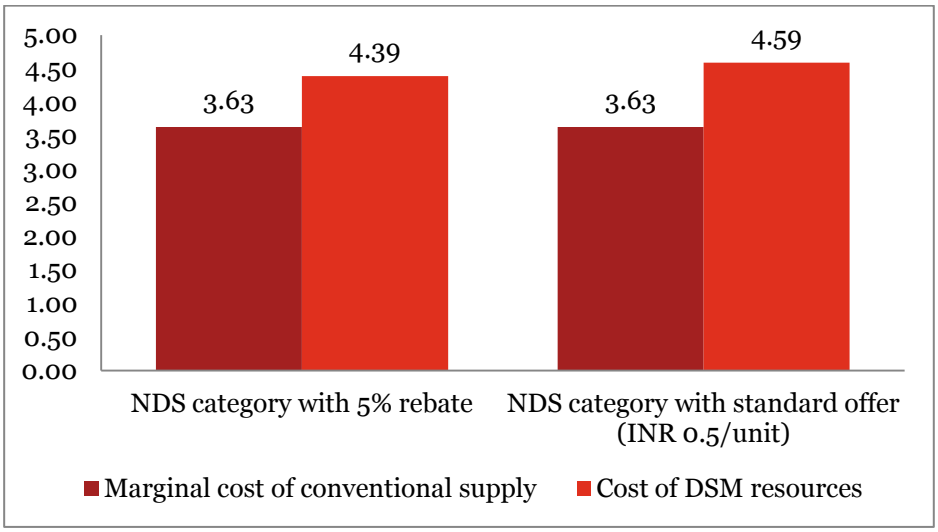
Comparison of costs in NDS category



Scenario without avoided capacity benefits

Test	5% Rebate			INR 0.5/unit Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	1.10	1.84	1.84	1.09	1.79	1.79
PACT ratio	11.73	11.73	11.73	7.23	7.23	7.23
RIM ratio	0.82	0.82	0.82	0.79	0.79	0.79
TRC ratio	0.86	2.74	2.74	0.86	2.75	2.75
SCT ratio	0.87	2.77	2.77	0.87	2.78	2.78

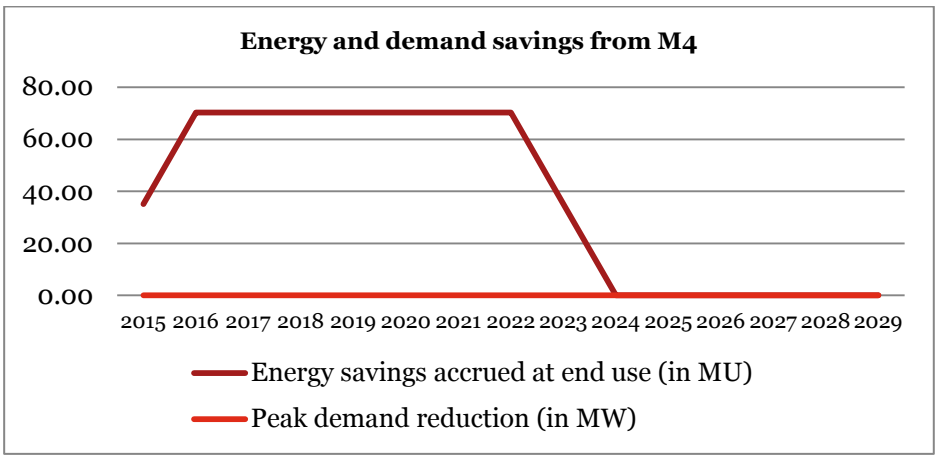
If one does not consider avoided capacity benefits, the tool also indicates that this programme is not cost effective even at INR 0.5/unit under standard offer design and 5% rebate under the rebate design in the NDS category.



M 4: Incentives for purchase and installation of energy efficient refrigerators

This measure considers utility sponsored incentives for purchase and installation of energy efficient refrigerators by residential consumers in State. There is no peak demand reduction considered for this measure.

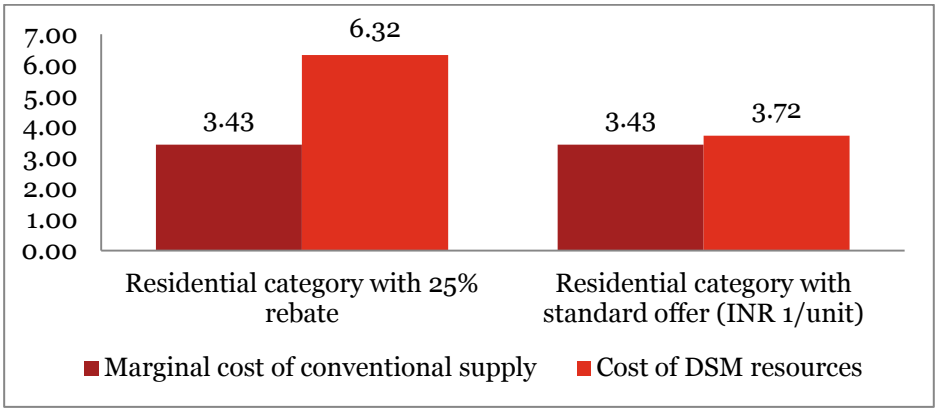
Results for residential category in State (25% rebate and INR 1/unit standard offer)



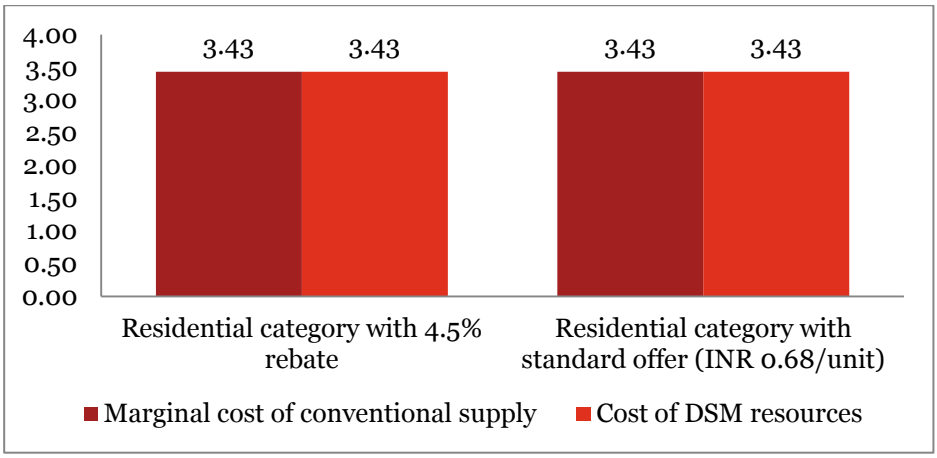
Cost effectiveness ratios for M4 in residential category

Test	Rebate			Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	0.72	1.69	1.69	0.38	1.11	1.11
PACT ratio	0.97	0.97	0.97	3.72	3.72	3.72
RIM ratio	0.54	0.54	0.54	0.92	0.92	0.92
TRC ratio	0.33	0.92	0.92	0.37	1.30	1.30
SCT ratio	0.33	0.93	0.93	0.37	1.32	1.32

The rebate design and retrofit type measures are clearly not cost effective for any of the stakeholders. This is primarily because there are no avoided capacity benefits in the absence of peak demand reduction. Whereas, the replacement and new construction measures coupled with standard offer design have positive TRC test outcomes. However the RIM test has marginally failed the hurdle.



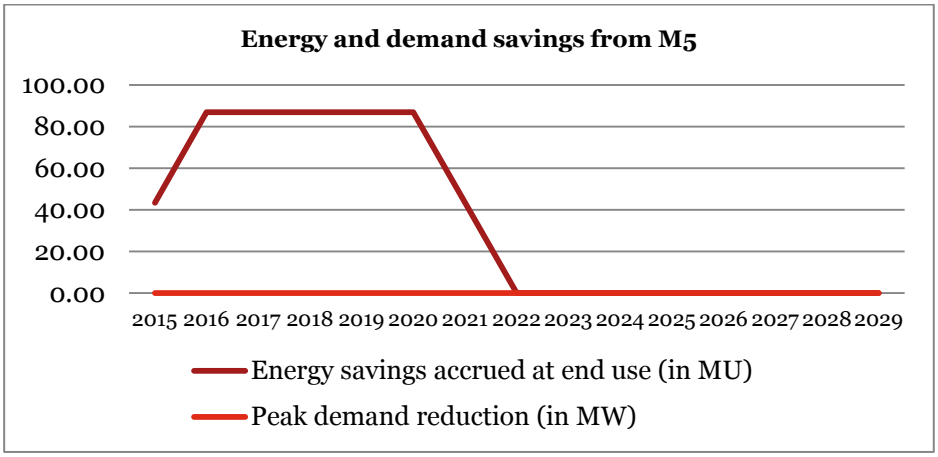
Incentive cap (max.) to remain cost effective in residential category



The tool indicates that State utilities can offer up to 4.5% rebate and INR 0.65/unit under standard offer design to remain cost effective under the replacement and new construction measures.

M 5: Incentives for purchase and installation of energy efficient electric geysers

This measure considers utility sponsored incentives for purchase and installation of energy efficient electric geysers by residential consumers in State. There is no peak demand reduction considered for this measure.

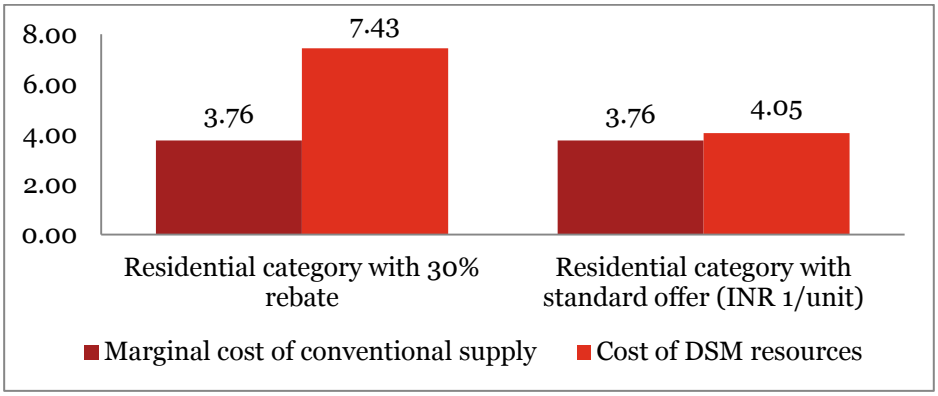


Results for residential category in State (30% rebate and INR 1/unit standard offer)

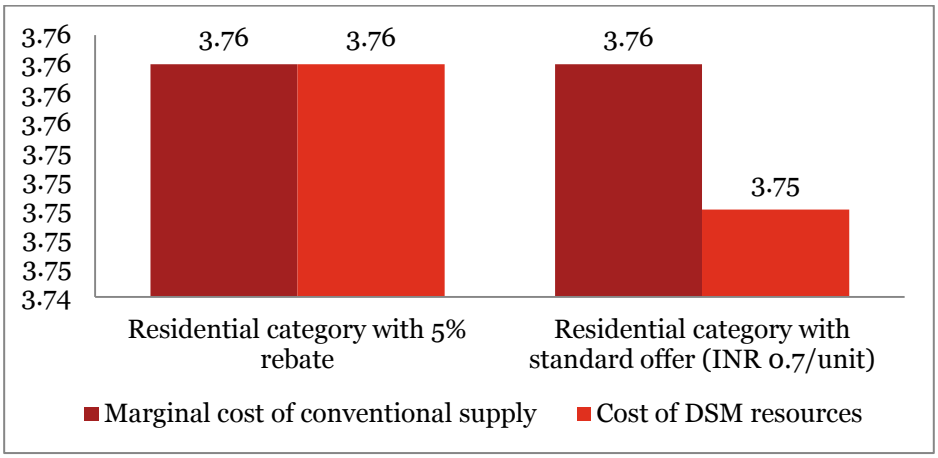
Cost effectiveness ratios for M5 in residential category

Test	Rebate			Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	0.83	1.76	1.76	0.42	1.08	1.08
PACT ratio	0.86	0.86	0.86	2.50	2.50	2.50
RIM ratio	0.51	0.51	0.51	0.83	0.83	0.83
TRC ratio	0.33	0.77	0.77	0.36	1.03	1.03
SCT ratio	0.33	0.78	0.78	0.37	1.04	1.04

The rebate design and retrofit type measures are clearly not cost effective for any of the stakeholders. This is primarily because there are no avoided capacity benefits in the absence of peak demand reduction. Whereas, the replacement and new construction measures coupled with standard offer design have positive TRC test outcomes. However the RIM test has marginally failed the hurdle.



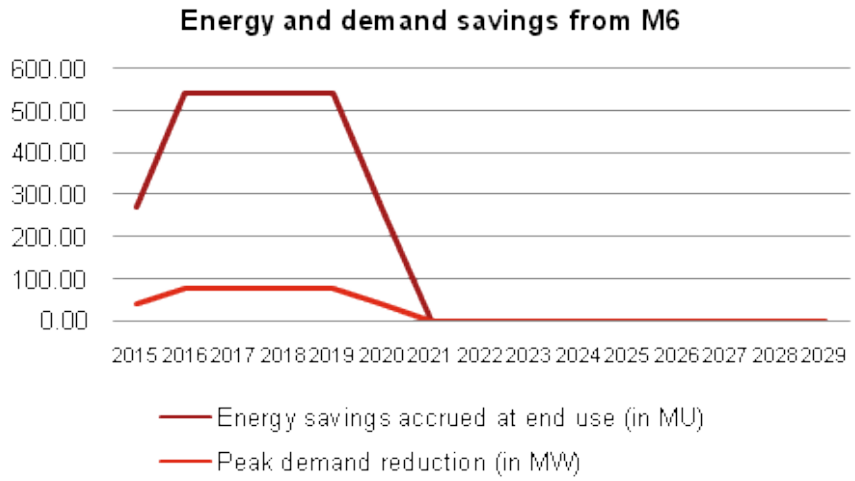
Incentive cap (max.) to remain cost effective in residential category



The tool indicates that State utilities can offer up to 5% rebate and INR 0.7/unit under standard offer design to remain cost effective under the replacement and new construction measures.

M 6: Incentives for purchase and installation of Energy efficient Agriculture pumping system

This measure considers utility sponsored incentives for purchase and installation of energy efficient pumping systems by agriculture consumers in State.



The Ag Tariff is INR 6.28 / unit in State, as fixed by the regulator in the latest tariff order. Therefore if we go by the traditional elements of cost in the five tests, high loss of revenues would be perceived from reduced sales and thereby resulting in low RIM ratios. Also since the state government is providing INR 6.03/unit subsidy to the Ag consumers, the reduction in subsidy burden resulting from this measure can be accounted as an additional element of benefit in the Societal cost test. This would result in High SCT ratios.

Scenario with avoided capacity benefits

Cost effectiveness ratios for M6 (70% rebate and INR 3/unit standard offer)

Test	Rebate			Standard offer		
	Retrofit	Replacement	New Construction	Retrofit	Replacement	New Construction
PCT ratio	2.43	4.74	4.74	1.15	1.88	1.88
PACT ratio	2.28	2.28	2.28	1.67	1.67	1.67
RIM ratio	0.72	0.72	0.72	0.64	0.64	0.64
TRC ratio	1.73	3.85	3.85	1.81	4.24	4.24
SCT ratio	3.27	7.25	7.25	3.41	7.99	7.99

If one considers avoided capacity benefits and loss of revenue at INR 6.28 / unit, this programme clearly fails the RIM test hurdle for the reasons explained above.

Scenario without avoided capacity benefits

However, if the loss of revenues are monetised at INR 0.25 / unit, which is actual tariff paid by farmers, the DSM resource costs decrease substantially and even if one does not consider avoided capacity benefits, this programme remains cost effective even at 100% rebate levels and up to INR 3.28/unit of standard offer.

Comparison of actual costs between DSM and conventional supply