Energy 93 (2015) 963–975

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

A study of feasible smart tariff alternatives for smart grid integrated solar panels in India

Jagruti Thakur, Basab Chakraborty*

Rajendra Mishra School of Engineering Entrepreneurship, Indian Institute of Technology, Kharagpur 721302, India

ARTICLE INFO

Article history:
Received 12 May 2015
Received in revised form
21 September 2015
Accepted 22 September 2015
Available online 22 October 2015

Keywords:
Feed in tariffs
Community and aggregate net metering
Gross metering
Smart meter

ABSTRACT

With the advent of grid connected solar panels in India, the requirement of a separate mechanism for metering and billing is foreseen. The policy framework for addressing this need is under process in various states of India. In the smart grid pilot project at Puducherry, India, a simple net metering mechanism has been incorporated to evaluate and understand the performance of green energy generation through solar panels. The present paper draws a comparison between net metering and gross metering mechanisms, through the analysis of net meter data collected for three different types of consumers from the pilot project at Puducherry. Different scenarios have been evaluated to infer the impacts of specialized billing mechanisms as well as the payback periods on investment made for solar energy systems and the savings that is reflected in the monthly bills. Feed in tariff renders full credit to the renewable energy customers on their electricity bills for the amount of green power, which is sent back to the main grid. This simple mechanism of a credit system would prove to be the most important energy policy for a nation to encourage sustainable energy generation. Due to wide variations in tariffs, requirements and efficiency of utilities across the different states in India, a policy which can accommodate mechanisms of community net metering and aggregate net metering had become a necessity. The paper signifies the crucial and immediate necessity for a feasible and acceptable energy policy so as to realize the benefits of power from the sun.

1. Introduction

The growth rate of energy usage for the developed countries is about 1% per year whereas it can be up to 5% for the developing nations [1]. The unprecedented growth rate requires a continuous supply of energy to meet the needs of a growing economy. There are various options to meet the demand requirements of energy, like implementing programs and standards for efficient use of energy, increasing the generation of electricity through fossil fuels or by utilizing distributed energy resources and energy storage strategies [2–6]. Increased awareness regarding the benefits of renewable resources and its implied financial benefits in the long run has made people to use it as an alternative for generation of electricity. The policy framework is in the development stage and is being revised from time to time in many developed countries [7] and various mechanisms to incentivize green power are being formulated. Net metering and gross metering are widely used for compensating green power generated by consumers. Various types of mechanisms like PPA (pre-purchase agreement), green pricing, REC (renewable energy credits) etc. are being implemented and revised by utilities for checking the feasibility of the mechanism and realizing the benefits of the renewable energy resources.

In developing countries, where there is high deficit of energy, renewable energy sources can prove to be a significant alternative, which in the long term would give sustainable energy to the people. With the advent of smart grid, export of units generated by a consumer is now made possible. This gives a whole new dimension to generation and usage of electricity by the same person coining a new term prosumer. As the nations are moving towards smart cities, the integration of renewable energy in the smart grid would lead towards a more sustainable economy. Jagruti et al. [8] studied the implementation of smart grid pilot project at Puducherry, India which offers a platform to test various metering features of the installed smart meters. This would in turn require policies and mechanisms to compensate for the energy generated by the user.

* Corresponding author. Tel.: +91 3222282416.
E-mail address: basab@see.iitkgp.ernet.in (B. Chakraborty).

http://dx.doi.org/10.1016/j.energy.2015.09.100
0360-5442/

Abbreviations & nomenclature

AMI	advanced metering infrastructure
CFL	compact fluorescent lamp
CHP	combined heat and power
DCU	data concentrator unit
DSM	demand side management
FIT	feed in tariff
GIS	geographic information system
HT	high tension
IRR	internal rate of return
LED	light emitting diode
LT	low tension
MDMS	master data management system
NPV	net present value
OMS	outage management system
PPA	pre-purchase agreement
PQM	power quality management
REC	renewable energy credits
TLC	transparency, longevity and certainty
ToD	Time of Day;
ToU	Time of Use
B	is the electricity bill in the absence of solar panels
C	is the annual cash inflow
E_g	is the total exported unit of electricity in kWh
E_n	is the exported units of electricity given in the data in kWh
E_p	is the predicted solar output
h	is the assumed output hours of solar electricity per day
i	be the annual interest rate
I	is the investment in INR
I_g	is the total imported units of electricity in kWh
I_n	is the imported unit of electricity given in the data in kWh
PR	is the performance ratio for Indian condition
s	is the government subsidy on investment made in solar panels in India [29]
S	is the size of installed solar panel in kW
S_f	is the seasonal yield factor
B_n	is the electricity bill in net metering
B_g	is the electricity bill in gross metering

2. Renewable energy markets for developing countries

The renewable energy markets of the developing countries vary as compared to the developed countries. The increase in investment in renewable energy market in developing nations was 36% as compared to a modest rise of 3% for developed nations in 2014 [9]. This led to an increase of 6% in global share of renewable energy of developing countries. The investment in renewable energy market in India rose by 25% during the period 2004–11 [9].

Developing countries like China, Brazil and India showed promising increase in investment made in renewable energy. In China, $81 billion were invested in renewable energy market, which is more than double the investment made in the US. In Brazil, which is among the top ten nations in the world for renewable energy investment; $7.4 billion were invested in renewable energy market. There was an increase of 13% in the investments made in India in 2014 as compared to 2013. Apart from this, other countries like South Africa, Kenya, Algeria etc. continued to increase their investment in this market [9]. In Fig. 1 the global investment made in renewable energy in 2014, is seen. Hence, a large renewable energy market exists in developing nations with a diverse set of needs as compared to developed nations. The needs, social conditions, knowledge base and demands for the products and services of the people in these countries are more diversified; hence there is a need to understand the markets before designing a structure for the feed in tariff.

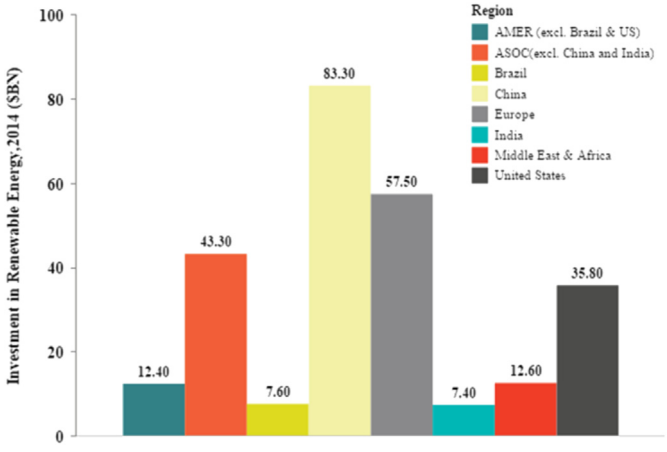

Fig. 1. Global Investment in renewable energy by region, 2014 ($BN) [9].

These markets can be differentiated in following ways

1. Rural residential and Communities' basic need for electricity

There is a basic need of lighting, fan and charging of a mobile phone in the rural population. Micro-grids with solar power, bio mass, small scale wind power are prevalent in various parts of developing communities.

2. Small Scale industries and Agriculture uses

There is a need of electricity for small industries as well as irrigation for agriculture, which accounts for a market which makes electricity productive.

3. Grid based bulk power

This is the most widespread market of energy usage in any country. This consumption grows with the growth of economy in a country.

Electricity generated in the grid, from which maximum energy is supplied to the consumers, was primarily from fossil fuels. Nowadays wind, solar, hydro, biomass, geothermal power has started significant contribution towards the generation of electricity. With the growing demand for electricity, expansion of the grid based power generation or addition of a distributed energy system has become a priority in the annual budget of the developing nations. This leads to a prerequisite for restructuring the whole system of generation of electricity [10].

3. Feed in tariffs

FIT (Feed in tariff) refers to a differential pricing scheme applied to the energy generated by the consumers from renewable energy sources like solar, wind and biomass, which is fed back to the grid.