CHAPTER 1

Introduction

Background

Nowadays energy consumption rates are increasing, and on the other hand, fossil energy resources are depleting gradually. This is a serious problem not only in Thailand but in the whole world. Smart grid, is the solution to manage the energy utilization effectively in the future with the use of information technologies (Metke & Ekl, 2010; Sauter & Lobashov, 2011; Zhai, 2011). Energy Management System (EMS) can be implemented to maintain reliability by using the demand and supply balancing technique in a grid outage moment, within the smart grid area (Khodayar, Barati, & Shahidehpour, 2012). Smart grid consists of interactive demand side management (DSM), advanced energy storage system, real-time communication to enhance the power system's operations during power exchanges between new technologies of renewable generation and new knowledge of information technologies for reporting the status of the smart grid system (F. Li et al., 2010; Moslehi & Kumar, 2010). In the near future, energy production will be under gradual transition from centralized power generation to Distributed Generation (DG) (Ackermann, Andersson, & Söder, 2001; Bayod-Rújula, 2009; Pepermans, Driesen, Haeseldonckx, Belmans, & D'haeseleer, 2005). It can be a multisource interconnected hybrid electricity production system consisting of; Photovoltaic, small Wind Turbines, Biomass Gasification, Diesel Engines, Micro Turbines etc. used to provide the energy closer to the consumers. These

small modular generation technologies interconnected to distribution systems can form a new type of power system, the so-called Micro-grid (MG). The concept of the micro-grid has been presented in (Hatziargyriou, Asano, Iravani, & Marnay, 2007; Kroposki et al., 2008; Lasseter, 2002; Marnay & Bailey, 2004). MG is the low voltage (LV) electric power distribution network with the several DG units installed.

In the future, the cost of energy (COE) from the DG system will be lower than fossil energy sources that is why energy flow between buildings and trading of electricity needs to be studied. The households, buildings, and offices are using the energy from the utility grid as energy consumers (Demand Source) and producing the electricity from DG in their system for supplying the electricity into the utility grid as energy producers (Supply Source) at the same time. If the electricity produced from one building is not enough, the electricity could be transferred from the other connected supply sources, such as homes, buildings, offices or utility power grid, irrespective of the source type, whether from the renewable energy in the consumer's own community, other community or national utilities' power network. Knowing the source of the electricity is beneficial for the power purchase planning and the power management in the owner community.

At present, the normal electricity bills do not report the source of electricity, whether it is from the renewable energy or local electrical utility network. Knowing the source of the electricity is beneficial for the power purchase planning and the power management in the building. This research will demonstrate the algorithm for reporting the source of power generation, the power status of the building and the electric bill for each building as well as the overview of the power management of the eleven case-study buildings. With the development of software to measure real time (10 Sec

intervals) energy flows among different sources and loads has been presented. The energy can be measured and identified through the use of developed software for multiple loads and sources like Grid and or other renewables. Using the building, community and overall power flow algorithm techniques show the routing of energy flow from multiple sources. The software can report the electric bills and power status of the building, community and overall system by using the power unit identification algorithm.

Objective

1. To analyze the energy/power flow behavior in energy demand / supply building

2. To create the algorithm for identifying the real-time power flow between renewable energy sources and the utility grid

3. To develop software by using the algorithm for reporting the monthly electricity bill showing consumption separately from renewable energy source and the utility grid

Scope of the study

1. To analyze the energy/power flow behavior for four buildings at School of Renewable Energy Technology (SERT), Naresuan University.

2. To develop the software using the algorithm in the area supplied through 500 kWp grid connected rooftop Photovoltaic system at University of Phayao.

Definition of Terms

Micro-grid	Micro-grid is the low voltage power distribution network of the several distributed generation such as Photovoltaic, small Wind Turbines, Biomass Gasification, Diesel Engines and Micro Turbines etc. units installed with once interconnected between inside and outside utility grid.
Energy exchange	The energy is produced from DG system and supply to the outside that can be exchanged of energy between two DG sources of the system.
Multiple energy flow	Identification of multiple energy flow can be reported as the source and destination of the multiple energy flows generated from installed DG units.
Energy management system	Using the information technologies for managing, the renewable energy production are called EMS. EMS can be implemented to maintain reliability by using the electricity balancing technique in the MG system.
Net metering	The summation of the energy demand and supply is called net metering that can report the status of the system. If energy demand is more than the energy supply, the status of the system is reported net metering in demand mode. On the other hand, the energy demand is less than the energy supply that can be called net metering in supply mode.

Benefits of the study

1. The algorithm gives a new consumption method for prosumer (buyer and seller of electricity) in their community.

2. This software could be applied to improve the functions of energy management system in the homes, buildings, and offices.

3. This research can support Electricity Generating Authority of Thailand (EGAT) for future grid planning and can be helpful for adaptive forecasting in connection with the consumption and generation.

Abbreviations

A	Ideal factor
A_{PV}	Surface area of the Photovoltaic module (m^2)
AC	Alternating current
AMI	Advanced metering infrastructure
B_i:	Interconnection point power flow reference
COE	Cost of Energy
DC	Direct current
DG	Distributed Generation
DSM	Demand Side Management
EGAT	Electricity Generation Authority
EMS	Energy Management System
G_T	Solar radiation striking the Photovoltaic array (kW/m^2)
$G_{T.NOCT}$	Solar radiation at which the NOCT is defined (0.8 kW/m^2)

$\overline{G}_T$	Solar radiation incident on the Photovoltaic array in the current time step (kW/m^2)
$\overline{G}_{T,STC}$	Incident radiation at standard test conditions (1,000 W/m^2)
$G_{T,STC}$	Radiation at standard test conditions (1,000 W/m^2)
HEMS	Home energy management system
IPP	Independent Power Producers
I_L	Light-generated current or photocurrent
I_0	Cell saturation of dark current
I_{SC}	Cell's short-circuit current at a 25°C and 1 kW/m^2
k	(1.38 x 10-23 J/K) is a Boltzmann's constant
K_I	Cell's short-circuit current temperature coefficient
LV	Low Voltage
MEA	Metropolitan Electricity Authority
MG	Micro-grid
P_{grid}	Interconnection point power flow from power building to grid
$P_{grid\ \min}$	Interconnection point power flow bandwidth minimum value
$P_{grid\ \max}$	Interconnection point power flow bandwidth maximum value
P_{PV}	Output of a solar array
PEA	Provincial Electricity Authority
PLC	Power Line Communication
q	(1.6 x 10-19 C) is an electron charge
R_s	Series resistance

R_{SH}	Shunt resistance
RE	Renewable Energy
SERT	School of Renewable Energy Technology
SEEN	School of Energy and Environment
SPP	Small Power Producers
T_a	Ambient temperature (°C)
T_C	Cell's working temperature
$T_{C,STC}$	Photovoltaic cell temperature under standard test conditions (25°C)
$T_{c,NOCT}$	Nominal operating cell temperature
$T_{a,NOCT}$	Ambient operating cell temperature
$T_{\mathrm{Re}f}$	Cell's reference temperature
TOU	Time-of-use
VSPP	Very Small Power Producers
Y_{PV}	Rated capacity of the Photovoltaic array, meaning its power output under standard test conditions (kW)
λ	Solar insolation in kW/m^2
α_P	Temperature coefficient of power (% per °C)
$\eta_{mp,STC}$	Efficiency of Photovoltaic under standard conditions