CHAPTER 1

INTRODUCTION

1.1 Rationale for the study

From an environmental viewpoint, solar energy is perhaps the most interesting energy to replace fossil fuels. It is clean and has an unlimited supply. The utilization of solar energy is widespread. Many new techniques and equipment designs have been developed to incorporate solar energy. But it is not correct that using solar energy does not produce pollution because the manufacture of all kinds of solar energy equipment uses energy from fossil fuels such as coal, oil or natural gas which do cause CO_2 emission. Therefore, the amount of CO_2 emission from PV manufacturing needs to be studied to reveal effects on the environment.

Since we will be replacing the use of fossil fuels such as kerosene, diesel, coal and natural gas by solar photovoltaics, we must determine their CO_2 production as well as that of the solar equipment manufacture in order to understand what the net saving will be through the use of solar energy for electricity production.

Since the CO_2 for the PV panel is produced by its manufacture but the CO_2 from fossil fuels use is created continuously as it is burned, we can only compare the two on the basis of time of use. So early in the use of a PV panel, the CO_2 per megawatt (MW) capacity will be high but the longer the panel is in service the lower the CO_2 per MW of installed capacity while that of fossil fuels remains constant for each year of use. Therefore, there will be a certain point in time when the PV panel will begin to have less CO_2 per MW effects than the equivalent fossil fuel electricity production. This thesis will determine how long it will take to reach that break even point by estimating the CO_2 per MW of energy produced by PV panel and conventional fuels for each year until PV is the lower CO_2 producer per MW or for 30 years whichever is less.

1.2 Statement of the Problem

Countries that ratified the Climate Change Convention and the Kyoto Protocol convention agreed to reduce or control the amount of CO_2 emissions from all sources in their country. Technology is used to improve CO_2 producing processes including using replacement fuels to reduce CO_2 emissions. In the electricity generating process which uses fossil fuel, pollutants such as sulfur dioxide, a great deal of carbon dioxide and nitrous oxide are produced. This is especially the case for carbon dioxide which is one of the major greenhouse gases. For Thailand, the rate of increase of electricity generation per year is high because of the rapid growth of the economy. When the electricity demand increases, the CO_2 emission increases. Thailand has voluntarily launched several projects leading to the conservation of energy and the creation of carbon sinks. In addition, alternative or renewable energy, which is environmental friendly, is used increasingly especially solar energy. Solar energy is considered a clean energy. There is no pollution from the generation of electricity from a solar

system but manufacturing the solar system takes energy and if that energy comes from fossil fuels there are some CO_2 gases produced. The operation of the solar cell unit does not emit CO_2 but the manufacturing processes do. The question to be answered is whether or not the CO_2 generated during the manufacturing process is more or less than the CO_2 saved by using the solar panel instead of generating the power using fossil fuels.

1.3 Objectives

1. Determine the CO_2 emitted during the preparation of materials for the manufacturing of PV panels.

2. Determine the CO_2 emission from fossil-derived energy which is replaced by solar PV such as small diesel and gasoline generators and grid-delivered electricity. For grid-delivered electricity, CO_2 emission for each type of fuel used for electricity generation in Thailand including coal, oil and natural gas is needed to determine the CO_2 production.

3. Compare the CO_2 emission from PV panel manufacture and from conventional electricity sources per unit of energy produced for each year up to 20 years.

4. Estimate the CO_2 emission from the amount of PV that is presently installed in Thailand and the net effect on CO_2 emission per megawatt hour of electrical energy produced for Thailand for each of the 20 years after the PV was installed.

1.4 Scope of the Study

The data regarding the kWh of electrical energy or the mass of fuels that goes into the manufacturing processes of the solar panels are collected and then converted to the amount of CO_2 emission. The study will show the components needed to make a complete PV panel, the amount of energy put into the process, and the CO_2 emitted in producing the PV panel. This includes CO_2 produced by the manufacture of components of the panel besides the cells themselves, for example, the aluminum and glass used in panel manufacture.

There are different types of PV panels and the processes to make each type of PV panel is also different so this research will be focused on the single crystal PV panel because it is the primary type used in Thailand. When using solar energy instead of conventional energy we need to determine if it can reduce CO_2 emissions to the atmosphere. We must determine the CO_2 emission from other sources of energy which will be replaced by solar such as small diesel and gasoline generators and grid electricity which is made using different kinds of fuels such as coal, oil and natural gas.

The most important point in this research is to determine the effects on Thailand. Most PV panels are manufactured in Europe, USA and Japan though some PV components are assembled in Thailand. While there are no PV panels manufactured entirely in Thailand, the effects from those overseas manufacturers contribute to worldwide greenhouse gas problems and create problems for Thailand indirectly. When estimating the environmental value of replacing fossil fuel by solar PV within Thailand, the CO_2 emitted in manufacturing countries needs to be incorporated.

1.5 Abbreviation

a-Si	=	Amorphous Silicon
atm	=	Atmosphere
C	=	Carbon
CdTe	=	Cadmium Telluride
CFCs	=	Cholofluorocarbons
CH_4	=	Methane
CIS	=	Copper Indium Diselenide
CO	=	Carbon monoxide
CO_2	=	Carbon dioxide
c-Si	=	Crystalline Silicon
Cz	=	Czochralski
BAU	=	Business As Usual
DEDP	=	Department of Energy Development and Promotion
DSM	=	Demand Side Management
EGAT	=	Electricity Generating Authority of Thailand
EPBT	=	Energy Pay-Back Time
EVA	=	Ethylene-Vinyl Acetate
GaAs	=	Gallium Arsenide
Gg	=	Gigagram (10^9 gram)
GHG	=	Greenhouse Gas
GJ	=	Gigajoules (10^9 joules)
G_T	=	Yearly average daily global solar radiation (kWh/m^2)
GTZ	=	Deutsche Gesellschaft fuer Technische Zusammenarbeit
GWh	=	Gigawatt-hour (10^9 watt-hour)
H	=	Hydrogen
IC	=	Integrated-Circuit
ID	=	Inside-Diameter
IPCC	=	Intergovernmental Panel on Climate Change
kJ	=	Kilojoules (10^3 joules)
KMUTT	=	King Mongkut's University of Technology Thonburi
ktoe	=	kilo ton of oil equivalent
kWh	=	Kilowatt - hour (10^3 watt - hour)
mc-Si	=	multicrystalline Silicon technology
ME	=	Ministry of Education
MJ	=	Megajoules (10^6 joules)
MPH	=	Ministry of Public Health

Mwel	=	Megawatt Electricity
MW	=	Megawatt
MWh	=	Megawatt-hour (10^6 watt-hour)
N	=	Nitrogen
n	=	Number of years
NEDO	=	New Energy and Industrial Technology Development Organization
NEPO	=	National Energy Policy Office
N_2O	=	Nitrous oxide
NMVOC	=	Non-Methane Volatile Organic Carbon
NaOH	=	Sodium Hydroxide
ÖKO	=	Oeko-Institut
PDFL	=	Photovoltaic Device Fabrication Laboratory
PEA	=	Provincial Electricity Authority
PFCs	=	Perfluorinated Compounds
Pg	=	Petagram (10^{15} gram)
PJ	=	Petajoules
P_{max}	=	Maximum power from 1 m^2 of PV panel (kWp)
ppbv	=	parts per billion by volume
ppm	=	parts per million
ppmv	=	parts per million by volume
pptv	=	parts per trillion by volume
PV	=	Photovoltaic
PV_{el}	=	Electricity generating from PV
PWD	=	Public Works Department
S	=	Sulphur
sc-SI	=	Singlecrystalline technology
SiC	=	Silicon Carbide
TCA	=	Trichloroethane
Tw	=	Tera-watt (10^{12} watt)
Tg	=	Tera-gram (10^{12} gram)
toe	=	Ton of oil equivalent
UV	=	Ultraviolet
Wp	=	Watt peak