

ห้องสมุดงานวิจัย สำนักงานคณะกรรมการวิจัยแห่งชาติ



E46990

**MODEL OF THE EFFECTIVE UNIVERSITY-INDUSTRY JOINT
RESEARCH FOR PHOTOVOLTAIC TECHNOLOGY
TRANSFER IN THAILAND**

PORNPIMOL SUGANDHAVANJA

***A Thesis Submitted to the Graduate School of Naresuan University
in Partial Fulfillment of the Requirements
for the Doctor of Philosophy Degree in Renewable Energy
(International Program)
August 2010
Copyright 2010 by Naresuan University***



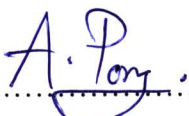
**MODEL OF THE EFFECTIVE UNIVERISITY-INDUSTRY JOINT
RESEARCH FOR PHOTOVOLTAIC TECHNOLOGY
TRANSFER IN THAILAND**




PORNPIMOL SUGANDHAVANIJA

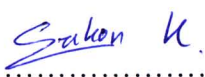
**A Thesis Submitted to the Graduate School of Naresuan University
In Partial Fulfillment of the Requirements
for the Doctor of Philosophy Degree in Renewable Energy
(International Program)
August 2010
Copyright 2010 by Naresuan University**


This thesis entitled “Model of the Effective University-Industry Joint Research for Photovoltaic Technology Transfer in Thailand” submitted by Pornpimol Sugandhavanija in partial fulfillment of the requirements for the Doctor of Philosophy Degree in Renewable Energy (International Program) is hereby approved.

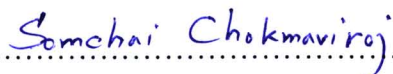

..... Chair
(Anan Pongtornkulpanich, Ph.D.)


..... Committee
(Sukruedee Sukchai, Ph.D.)



..... Committee
(Assistant Professor Nipon Ketjoy, Dr.-Ing.)


..... Committee
(Assistant Professor Sakon Klongboonjit, Ph.D.)


..... Committee
(Associate Professor Sirichai Thepa, D.Sc.)


..... Committee
(Somchai Chokmaviroj, Ph.D.)

Approved


.....
(Assistant Professor Kanungnit Pupatwibul, Ph.D.)

Dean of the Graduate School

August 2010

ACKNOWLEDGEMENT

The completion of this work would not be possible without the enormous personal and professional support the author received from Dr. Sukruedee Sukchai who supervised this thesis, helped her develop her thinking with patience, and encouraged her to keep on working. The author would also like to express her gratitude and special thanks to her thesis co-advisors, Assistant Professor Dr.-Ing. Nipon Ketjoy, who was very helpful in enabling her in development of the idea and research questions of the thesis, and Assistant Professor Dr. Sakon Klongboonjit, for his dedication in sharing insights and experiences and for his great comments on the research methodology.

I would like to thank my thesis committee, Dr. Anan Pongtornkulpanich, Associate Professor Sirichai Thepa, Dr. Somchai Chokmaviroj, for their direction, dedication and invaluable advice along this study.

Most notably, the author would also like to thank and express her sincere appreciation to all informants and participants from eight universities and five photovoltaic firms who must necessarily remain anonymous, without their generous assistances, dedication and cooperation, the project could never been through. The author is also greatly indebted to Associate Professor Dr. Wattanapong Rakwichian for his assistance in allowing her to study in SERT and his meaningful inputs and all lecturers in LISREL class particularly Associate Professor Dr. Supamas Angsuchoti, Associate Professor Dr. Somtawin Wjitwanna and Dr. Ratchaneekool Pinyopanuwat. Her special thanks also go to three experts who remain anonymous for devoting their time in checking the questionnaire content validity and to Associate Professor Dr. Vittaya Amornkitbamrung for his kind assistance in providing insights and constructive criticism.

Special thanks are due to all academics, technical and administrative staffs at SERT, particularly Khun Chutima Songsiyo. The author would also like to extend her great appreciation to the Ministry of Foreign Affairs and her colleagues for their supports and allowing her to take the study leave which helped make this project possible.

Finally, the author would like to extend her sincere appreciation and gratitude to her mother, father and sister who have shared her frustrations and her up-and down feeling throughout the process of making this project possible. They always are supportive and encourage her in keeping on track to complete the work. Last but not least, the author prays with highest respect to Load Buddha, Luangpor Phra Rajchaphrommayan and Luangpor Cha Supatto who always help her in all aspects of her personal life, study and work.

Pornpimol Sugandhavanija

Title MODEL OF THE EFFECTIVE UNIVERSITY-INDUSTRY
JOINT RESEARCH FOR PHOTOVOLTAIC
TECHNOLOGY TRANSFER

Author Pornpimol Sugandhavanija

Advisor Sukruedee Sukchai, Ph.D.

Co - Advisor Assistant Professor Nipon Ketjoy, Dr.-Ing.
Assistant Professor Sakon Klongboonjit, Ph.D.

Academic Paper Thesis Ph.D. in Renewable Energy (International Program)
Naresuan University, 2010

Keywords Technology transfer, Effective university-industry joint
research, Photovoltaic technology, Model of effective U-I
technology transfer

ABSTRACT

E46990

University-industry joint research is a major source of technology transfer that helps enhance the knowledge and capabilities of both parties. In the context of globalized market, and the changing roles of the Thai university as “research-based university” and of the photovoltaic industry as cell and module exporters, it is expected that the Thai university and the photovoltaic industry are likely to be motivated to participate in joint research collaboration, of which its major objective is to achieve technology transfer. However, experience has shown that during the past five years, there has been very little number of university-industry joint researches for photovoltaic technology transfer (UIJRPTT) in Thailand.

This thesis aims to answer the question of why there is little number of UIJRPTT in Thailand and to identify factors affecting the effective UIJRPTT. It also aims to develop a model for the effective UIJRPTT that involves the changing roles and characteristics of the two parties and joint research mechanism. A number of past and existing studies relating to U-I collaboration and technology transfer indicate barriers and identify factors for successful and effective U-I collaboration and technology transfer. But it is obvious that none of them can explain the barriers and

indicate the model that can help improve the effective UIJRPTT in the context of Thailand.

To achieve the objectives of this research, the hypothesized factors affecting growth and effectiveness of UIJRPTT based on the literature review were identified and a conceptual framework for the model of effective UIJRPTT consisting of related factors and variables was developed. Firstly, characteristics of university, characteristics of industry and transfer and organization context were identified as hypothesized factors that affect the formulation and growth of the UIJRPTT. Secondly, three enabling factors namely: characteristics and perspectives of university, characteristics and perspectives of industry and joint research mechanism as well as their variables were identified as the factors affecting the effective UIJRPTT which was the outcome factor.

The author employed the mix research approach in analyzing the quantitative and qualitative data collected through the questionnaire survey and in-depth interview with professionals in university and industry as well as collection of information from reliable sources. Out of 150 questionnaire respondents, 96 were university respondents (64%) and 54 were industry respondents (36%). The numbers of interviewees involving in the research was 63. Among those, the interviewees from the university and industry were 45 and 18 respectively, accounting for 71% and 29%.

The primary study on the factors affecting the formulation and growth of the UIJRPTT was conducted and presented in three parts: data collection and interview results, questionnaire results and interview results. The analysis in potentials and gaps within the Thai context revealed that there were both potentials and gaps in the government support to the photovoltaic technology and market development, in the university and industry characteristics and in the linkage mechanism between university and industry. The factors and variables were further identified as barriers to the formation and growth of the UIJRPTT by Likert scale rating of the questionnaire respondents by which the results were analyzed by descriptive statistical analysis including mean, standard deviation, and *t*-test. The data from the interview was summarized and the content analysis was conducted. The results highlighted the determinants and the root cause of the limited UIJRPTT.

The qualitative and quantitative data from the research instruments were employed to answer the research question related to the factors and their extent in affecting the effective UIJRPTT and to the solutions to improve the situation. The hypotheses on the factors and variables were confirmed that they significantly influenced the outcome factor. The model of effective UIJRPTT was later developed as the results of the confirmatory factor analysis and path analysis. The model was confirmed fit to empirical data (Chi-square=100.84, p-value = 0.31, df = 95, RMSEA = 0.020, Standardized RMR = 0.055, GFT = 0.92, AGFT = 0.90). The current status of the three enabling factors was asked and was rated by the respondents as in the moderately satisfactory/adequate status. However, variables in joint research mechanism were mostly rated by the respondents lower than the other variables showing that the factor may be problematic. The qualitative data from the interviews were analyzed. The results provided evidence and confirmed the importance of variables in each confirmed factor and highlighted what action and practice the university, industry and government should consider in enhancing the performance and improving the situation of each factor variable.

Three project case studies were employed to validate the accuracy of the causal path from the model factor to the outcome factor. 30 respondents representing university and industry professionals participated in an additional indicators questionnaire survey. The results obtained from the study supported the path model developed in the primary study and its associated structural equations.

Photovoltaic technology transfer between the university and industry through joint research has the potential to develop the photovoltaic technology academic research and industry sector of Thailand. However, the number of effective UIJRPTT have typically been much lower than expectations; that is the reason that lead the author to undertake this study by modeling the factors and their effects to the effective UIJRPTT. Nevertheless, the final path model for the effective UIJRPTT requires further development. Firstly, future research should increase more sample size and apply the path model with sample size from different contexts related to renewable energy sectors to further validate the path model. Secondly, a scenario

E46990

study on the recommendations derived from the results on changing roles and characteristics and perspectives of the government, the university and the industry should be conducted to evaluate the results from the robust system model and the outcome it can generate to the effective UIJRPTT.

LIST OF CONTENT

Chapter	Page
I INTRODUCTION	1
Rational for the Study	1
Purpose of the Study	6
Significance of the Study	8
Scope of the Study.....	8
Definition of Terms.....	9
Thesis Layout	11
II LITERATURE REVIEW	12
Introduction	12
Technology Transfer	12
University-Industry Collaboration and Joint Research for Technology Transfer	18
Thai Photovoltaic Industry	26
Factors Affecting Growth of U-I Joint Research for Technology Transfer	34
Factors Affecting Effective U-I Joint Research for Technology Transfer	45
Rationale for Model of Effective U-I Joint Research for Photovoltaic Technology Transfer.....	52
Conceptual Model for Effective U-I Joint Research for Photovoltaic Technology Transfer.....	56
Summary	68

LIST OF CONTENT (CONT.)

Chapter	Page
III RESEARCH METHODOLOGY	69
Introduction	69
Population and Sample.....	70
Research Design.....	76
Summary	91
IV RESULTS AND DISCUSSION	92
Introduction	92
PART ONE Background of Respondents and their Perspectives on U-I Joint Research for Photovoltaic Technology Transfer	93
PART TWO Why There Is Little Number of U-I Joint Research for Photovoltaic Technology Transfer: Analysis of Factor Affecting the Growth of U-I joint Research for Photovoltaic Technology Transfer	101
PART THREE Analysis of Factor Affecting the EffectiveU-I Joint Research for Photovoltaic Technology Transfer	152
PART FOUR Model Implementation and Validation.....	203

LIST OF CONTENT (CONT.)

Chapter	Page
V CONCLUSION AND RECOMMENDATION	227
Introduction	227
Research Objectives and Results.....	228
Policy Recommendation	235
Contribution of Research	241
Limitation of Research Study.....	245
Areas for Further Research.....	245
Conclusion.....	246
 REFERENCES.....	 248
 APPENDIXES	 270
 GLOSSARY	 305
 BIOGRAPHY	 309

LIST OF TABLES

Table	Page
1 Thai Photovoltaic Manufacturers	27
2 Szulanski's Origins of Knowledge 'Stickiness	41
3 Summary of Factors from Studies and Models	52
4 Characteristics and Perspectives of University	60
5 Characteristics and Perspectives of Industry	61
6 Joint Research Mechanism	63
7 Joint Research Performance Sub-factor	66
8 Universities Sampling Units in Preliminary Search.....	73
9 Photovoltaic Firms Sampling Units in Preliminary Search.....	74
10 Summary of Goodness-of-fit and Model Evaluation Indices.....	87
11 Research Design and Outcome.....	90
12 Characteristics of University and Industry Questionnaire Respondents	96
13 Characteristics of University and Industry Case Study Respondents	97
14 Photovoltaic Projects under Ministries and State Enterprises.....	105
15 Overall Funds and Funds for Photovoltaic Technology from Major Government Organizations	107
16 Research in Sample University and Personnel Data	110
17 University Grants and Government Funds	114
18 Equipments and Facilitates in University Faculty and Laboratory	116
19 Technological Performance of Thai Photovoltaic Industry	118
20 Employees and Engineers and Data on In-house Research Activities.....	119
21 Income and Profit of Photovoltaic Firms	120
22 Respondents' Rating on Barriers of UIJRPTT Growth.....	127
23 Factor and Variables Comparison	129
24 Summary of Determinants of Growth, Issues, Obstacles and Their Effects	141

LIST OF TABLES

Table	Page
25 Factor and Variable Mean and Standard Deviation	155
26 Factor Mean Comparison from Column B.....	157
27 KMO and Bartlett's Test	160
28 Correlation Matrix.....	160
29 Analysis Result of Confirmatory Factor Analysis of Three Constructs of Measurement Model.....	163
30 Construct Reliability and Average Variance Extracted of Measurement Model	165
31 Estimated and Standardized Path Coefficient and Significance Level	168
32 Comparison of Mean in Evaluating the Current Status of Model Factor.....	174
33 Summary of Action and Issues in the Model of UIJRPTT	201
34 Indicator for Characteristics and Perspectives of University	205
35 Indicator for Characteristics and Perspectives of Industry.....	208
36 Indicator for Joint Research Mechanism.....	211
37 Indicator for Effective UIJRPTT.....	213
38 Mean and Standard Deviation of Variables and Indicators in Case Studies.....	218
39 Mean and Standard Deviation of Factors and Variables.....	220
40 Actual Mean Equivalent and Predicted Z-scores	222
41 Comparison of Actual and Predicted Mean Value of Model Factor	223

LIST OF FIGURES

Figure	Page
1 University of Tokyo's Joint Research Concept.....	21
2 Overview of Photovoltaic Industry in Thailand	28
3 Production Line Diagram of Technology for Thai PV Products.....	33
4 Factors Determining Successful UITT	49
5 Model.....	51
6 Conceptual Model for the Effective U-I Joint Research for Photovoltaic Technology Transfer	56
7 Conceptual Causal Model for the Effective U-I Joint Research for Photovoltaic Technology Transfer with Factors and Sub-factors.....	66
8 Research Structure.....	76
9 Interviewee's Years of Experiences	94
10 Interviewee Positions	95
11 Renewable Energy R&DD Expenditure during 2004-2008.....	106
12 Confirmatory Factor Analysis with Estimated Results	162
13 Final Model of Effective UIJRPTT with Standardized Factor Loading and Path Coefficient	167
14 Grid Connected Photovoltaic System Demonstration Project at SERT....	215
15 Sprinkler System Project at SERT	216
16 Schematic of Effective UIJRPTT Model with Factors, Variables, and Indicators.....	234

ABBREVIATIONS

ACAP	=	Absorptive Capacity
AGFI	=	Adjusted Goodness of Fit Index
BHEF	=	Business Higher Education Forum
BOI	=	Board of Investment
BOS	=	Balance of System
CAE	=	Center for Alternative Energy
CdTe	=	Cadmium Telluride
CEO	=	Chief Executive Officer
CFA	=	Confirmatory Factor Analysis
CFI	=	Goodness of Fit Index
CIS	=	Copper Indium Deselinide
CU	=	Chulalongkorn University
DEDE	=	Department of Alternative Energy Development and Efficiency
DSC	=	Dye-Sensitized Solar Cell
EGAT	=	Electricity Generating Authority
EVA	=	Ethylene Vinyl Acetate
FIEs	=	Foreign Invested Enterprises
GFI	=	Goodness of Fit Index
GOF	=	Goodness of Fit Statistics
GW	=	Gigawatt
INDUS	=	Industry
IOC	=	Item Objective Congruence
IP	=	Intellectual Properties
IPR	=	Intellectual Property Rights
ITO	=	Coating of Indium Tin Oxide
KKU	=	Khon Kane University
KMITL	=	King Mongkut's University of Technology Thonburi
KU	=	Kasetsart University
MTEC	=	National Metal and Materials Technology Center

ABBREVIATIONS (CONT.)

MU	=	Mahidol University
MW	=	Megawatt
NCURA	=	U.S. National Council of University Research Administration
NECTEC	=	National Electronics and Computer Technology Center
NEPC	=	National Energy Policy Council
NEPO	=	National Energy Policy Office
NFI	=	Normal Fit Index
NRCT	=	National Research Council of Thailand
NSTDA	=	National Science and Technology Development Agency
NU	=	Naresuan University
PROs	=	Public Research Organizations
PV	=	Photovoltaic
QA	=	Quality Assurance
QC	=	Quality Control
R&D	=	Research & Development
R ²	=	Square Multiple Correlation
REAL	=	Renewable Energy Applications Laboratory
RMSEA	=	Root Mean Square Error of Approximation
RPS	=	Renewable Portfolio Standard
S&T	=	Science & Technology
SDRL	=	Semiconductor Device Research Laboratory (SDRL)
SDRL	=	Semiconductor Device Research Laboratory
SEM	=	Structural Equation Modeling
SERT	=	School of Renewable Energy Technology
SET	=	Stock Exchange of Thailand
SMEs	=	Small and Medium-sized Enterprises
SOLARTEC	=	Institute of Solar Energy Technology Development
SPP	=	Small Power Producer

ABBREVIATIONS (CONT.)

SPRL	=	Semiconductor Physics Research Laboratory
SPRL	=	Semiconductor Physics Research Laboratory
STDB	=	Science and Technology Development Board
SU	=	Silpakorn University
TC	=	Technological Capability
TCO	=	Transparent Conducting Oxide
TDRI	=	Thailand Development Research Institute
TISTR	=	Thailand Institute of Scientific and Technological Research
TRF	=	Thailand Research Fund
TT	=	Technology Transfer
TTO	=	Technology Transfer Office
U-I	=	University-Industry
UIJR	=	University-Industry Joint Research
UIJRPTT	=	University-Industry Joint Research for Technology Transfer
UIL	=	University-Industry Linkage
UITT	=	University-Industry Technology Transfer
UNI	=	University
VSPP	=	Very Small Power Producer
D1	=	Characteristics and Perspectives of University
D1.1	=	Capability in receiving and transferring technology in terms of technique and funds
D1.2	=	Adequate specialists, researchers and students
D1.3	=	Adequate research tools and equipment
D1.4	=	Willingness and motivation for teamwork and shared value
D2	=	Characteristics and Perspectives of Industry
D2.1	=	Capability in receiving and transferring technology in terms of technique and funds
D2.2	=	Willingness and motivation in working with university with shared value

ABBREVIATIONS (CONT.)

D2.3	=	Perspectives on worthiness and value of joint research in terms of economic and intelligence value
D2.4	=	Understanding cultural difference
D3	=	Joint Research Mechanism
D3.1	=	Communication effectiveness
D3.2	=	Management of coordination office and joint research program
D3.3	=	Intellectual Property management
D3.4	=	Incentive System
D4	=	Effective U-I joint research for photovoltaic technology transfer
D4.1	=	Growth of U-I joint research for photovoltaic technology
D4.2	=	Quality performance from joint research
D4.3	=	Economic performance from joint research