

**TECHNO-ECONOMIC EVALUATION OF CO₂ UTILIZATION
PROCESSES: HYDROGENATION, BI- AND TRI-REFORMING OF CO₂
INTO METHANOL PRODUCTION**

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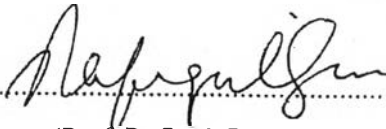


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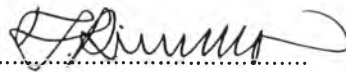
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ABSTRACT

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More efforts to capture CO₂ are being encouraged in order to minimize its concentration in air. However, the CO₂ capture cost is still quite high and is a major problem in advancing more sustainable processes. One viable solution is using captured CO₂ as raw material to convert to valuable products so that CO₂ capture and utilization can become economically feasible. Thus, utilizing CO₂ as feedstock to produce higher value products shows the potential for economy and environment.

Methanol that can be synthesized through CO₂ with the support of catalysts has been broadly aimed as a potential product. Methanol is largely employed in the chemical industry, especially in manufacturing formaldehyde, MTBE and acetic acid. Furthermore, owing to notable combustion characteristics as well as emitting fewer pollutants than conventional fuels permits methanol be employed as fuel in vehicles.

The aim of this research is to model and design feasible processes as a CO₂ treatment approach through the production of methanol as well as to evaluate and compare the methanol production between the different options, which are hydrogenation, bi-reforming and tri-reforming processes, in terms of an established set of performance criteria.

บทคัดย่อ

บุญ สุ ดวน เห่งย่น: การวิเคราะห์เชิงเทคโนโลยีและเศรษฐศาสตร์ของการใช้ประโยชน์ก๊าซคาร์บอนไดออกไซด์ในการผลิตเมทานอลด้วยกระบวนการไฮโดรจีเนชันและรีฟอร์มมิง (Techno-Economic Evaluation of CO₂ Utilization Processes: Hydrogenation, Bi- and Tri-Reforming of CO₂ into Methanol Production) อ. ที่ปรึกษา: ดร. อุทัยพร สุริยประภาคิลก และ ศ.ดร. ราฟีก กานี่ 244 หน้า

ในปัจจุบันได้มีความพยายามในการลดปริมาณของก๊าซคาร์บอนไดออกไซด์ในบรรยากาศ แต่เนื่องจากการดักจับก๊าซคาร์บอนไดออกไซด์มีค่าใช้จ่ายค่อนข้างสูง วิธีการหนึ่งที่จะทำให้กระบวนการลดก๊าซคาร์บอนไดออกไซด์มีความคุ้มค่าและยั่งยืน คือการนำก๊าซคาร์บอนไดออกไซด์ที่ดักจับได้มาเป็นวัตถุดิบในการเปลี่ยนเป็นสารเคมีหรือสารอื่น ๆ ที่สร้างมูลค่าได้และมีความคุ้มค่าในทางเศรษฐศาสตร์ และในขณะเดียวกันสามารถช่วยลดภาวะโลกร้อน

ก๊าซคาร์บอนไดออกไซด์สามารถนำมาเป็นวัตถุดิบในการสังเคราะห์เมทานอลโดยใช้ตัวเร่งปฏิกิริยา เมทานอลเป็นสารเคมีและตัวทำละลายที่มีการใช้อย่างแพร่หลายและมีอัตราการใช้เป็นจำนวนมาก เมทานอลเป็นวัตถุดิบในกระบวนการผลิตฟอร์มัลดีไฮด์ สารเร่งค่าออกเทน ตลอดจนกรดอะซิติก นอกจากนี้ เมทานอลยังมีสมบัติเป็นเชื้อเพลิงที่ดี และปลดปล่อยก๊าซมลพิษในปริมาณที่น้อยกว่าเชื้อเพลิงฟอสซิล ซึ่งมีความเป็นไปได้ในการนำเมทานอลมาใช้เป็นเชื้อเพลิงในเครื่องยนต์

จุดมุ่งหมายของงานวิจัยนี้เพื่อออกแบบและสร้างแบบจำลองกระบวนการผลิตเมทานอล ตลอดจนการวิเคราะห์ ประเมินผล และเปรียบเทียบกระบวนการผลิตเมทานอลด้วยกระบวนการต่าง ๆ ได้แก่กระบวนการไฮโดรจีเนชัน กระบวนไบ-รีฟอร์มมิง และ ไตร-รีฟอร์มมิง ทั้งในเชิงเทคนิคและเศรษฐศาสตร์

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TABLE OF CONTENTS

	PAGE
Title Page	i
Abstract (in English)	iii
Abstract (in Thai)	iv
Acknowledgements	v
Table of Contents	vi
List of Tables	x
List of Figures	xviii
Abbreviations	xxi
List of Symbols	xxii
 CHAPTER	
I INTRODUCTION	1
II LITERATURE REVIEW	3
2.1 Sources of Carbon Dioxide (CO ₂)	3
2.1.1 Fossil Fuel Combustion/Use	4
2.1.2 Land Use Changes	6
2.1.3 Industrial Processes	7
2.2 Carbon Capture and Utilization	8
2.2.1 CO ₂ Fixation into Organic Compounds	9
2.2.2 CO ₂ Reduction to C1 or Cn Molecules	26
2.3 Case Studies	37
2.3.1 Direct CO ₂ Hydrogenation into Methanol	37
2.3.2 Bi-reforming of CO ₂ into Methanol	42
2.3.3 Tri-reforming of CO ₂ into Methanol	45

CHAPTER	PAGE
III EXPERIMENTAL	48
3.1 Materials and Equipment	48
3.1.1 Equipment	48
3.1.2 Software	48
3.2 Experimental Procedures	48
3.2.1 Literature Survey Study	48
3.2.2 Process Simulation	48
3.2.3 Sustainability Analysis	49
3.2.4 Economic Evaluation	49
IV CASE STUDY 1: HYDROGENATION OF CO₂ INTO METHANOL	 50
4.1 Base Case Design	50
4.1.1 Process Simulation	50
4.1.2 Sustainability Analysis	57
4.1.3 Economic Evaluation	58
4.2 Sensitivity Analysis	65
4.2.1 Inlet Methanol Reactor Temperature	66
4.2.2 Inlet Methanol Reactor Pressure	68
4.2.3 Feed Ratio	69
4.2.4 Optimal Design Factors and Performance Results	69
4.3 Alternative Design Ideas	70
4.3.1 Performance Results	71
V CASE STUDY 2: BI-REFORMING OF CO₂ INTO METHANOL	 75
5.1 Base Case Design	75
5.1.1 Process Simulation	75
5.1.2 Sustainability Analysis	80

CHAPTER	PAGE
5.1.3 Economic Evaluation	82
5.2 Sensitivity Analysis	88
5.2.1 Bi-reforming-related Variables	90
5.2.2 Methanol synthesis-related Variables	94
5.2.3 Optimal Design Factors and Performance Results	96
5.3 Alternative Design Ideas	97
5.3.1 Performance Results	97
VI CASE STUDY 3: TRI-REFORMING OF CO₂ INTO METHANOL	102
6.1 Base Case Design	102
6.1.1 Process Simulation	102
6.1.2 Sustainability Analysis	107
6.1.3 Economic Evaluation	108
6.2 Sensitivity Analysis	115
6.2.1 Tri-reforming-related Variables	116
6.2.2 Methanol synthesis-related Variables	120
6.2.3 Optimal Design Factors and Performance Results	122
6.3 Alternative Design Ideas	123
6.3.1 Performance Results	124
VII COMPARISON AMONG DIFFERENT PROCESSES	128
7.1 Net CO ₂ Emission Evaluation	128
7.2 Economic Evaluation	128
VIII CONCLUSIONS AND RECOMMENDATION	130
REFERENCES	132

CHAPTER	PAGE
APPENDICES	149
Appendix A CO ₂ Conversion Process Flowsheet and Steam Tables Implemented by Aspen Plus 8.6	149
Appendix B Economic Evaluation for Each Process	187
Appendix C Calculation of Indirect CO ₂ Emission	243
CURRICULUM VITAE	244

LIST OF TABLES

TABLE		PAGE
2.1	Sources of CO ₂ emissions	3
2.2	The physical and chemical properties of CO ₂	9
2.3	Use of CO ₂ in the chemical industry for the synthesis of organic compounds	9
2.4	Applications and market of different carboxylates	21
2.5	Current processes of carboxylate production	22
2.6	Different catalytic systems for the hydrogenation of CO ₂ to formic acid	24
2.7	Free energy of formation of various C1 molecules	27
2.8	Summary of catalytic reforming of CO ₂ /CH ₄ in the literature	28
2.9	Properties of methanol	29
2.10	Overview of nickel-based catalysts in steam reforming	33
2.11	Overview of catalysts in partial oxidation	34
4.1	Tabulated information of the relevant results from CO ₂ capture simulations	51
4.2	Cost to produce hydrogen with different scenarios	52
4.3	Input data of the methanol synthesis	55
4.4	Mass balance	56
4.5	Product characteristics	56
4.6	Net CO ₂ emission for only methanol synthesis	57
4.7	Net CO ₂ emission for the total process	58
4.8	Profitability of the base case	65
4.9	Relationship between the inlet methanol reactor temperature and net CO ₂ emission	67

TABLE	PAGE
4.10 Relationship between the inlet methanol reactor temperature and production cost	67
4.11 Relationship between the inlet methanol reactor pressure and net CO ₂ emission	68
4.12 Relationship between the inlet methanol reactor pressure and production cost	68
4.13 Comparison of operating conditions between the optimized and base case	69
4.14 Comparison of environmental and economic aspects between the optimized and base case	69
5.1 Input data of the methanol production	79
5.2 Mass balance	80
5.3 Product characteristics	81
5.4 Net CO ₂ emission for methanol production	81
5.5 Profitability of the base case	88
5.6 Relationship between the inlet bi-reforming reactor temperature and net CO ₂ emission	90
5.7 Relationship between the inlet bi-reforming reactor temperature and production cost	90
5.8 Relationship between the inlet bi-reforming reactor pressure and net CO ₂ emission	91
5.9 Relationship between the inlet bi-reforming reactor pressure and production cost	91
5.10 Relationship between the CO ₂ /CH ₄ ratio and net CO ₂ emission	92
5.11 Relationship between the CO ₂ /CH ₄ ratio and production cost	92
5.12 Relationship between the H ₂ O/CH ₄ ratio and net CO ₂ emission	93

TABLE	PAGE
5.13 Relationship between the H ₂ O/CH ₄ ratio and production cost	93
5.14 Relationship between the inlet methanol reactor temperature and net CO ₂ emission	94
5.15 Relationship between the inlet methanol reactor temperature and production cost	94
5.16 Relationship between the inlet methanol reactor pressure and net CO ₂ emission	95
5.17 Relationship between the inlet methanol reactor pressure and production cost	95
5.18 Comparison of operating conditions between the optimized and base case	96
5.19 Comparison of environmental and economic aspects between the optimized and base case	97
5.20 Comparison of environmental and economic aspects between the base and alternative case	99
5.21 Net CO ₂ emission for methanol production	100
5.22 Purge gas stream characteristics	100
6.1 Input data of the methanol production	106
6.2 Mass balance	107
6.3 Product characteristics	107
6.4 Net CO ₂ emission for methanol production	108
6.5 Profitability of the base case	114
6.6 Relationship between the inlet tri-reforming reactor temperature and net CO ₂ emission	116
6.7 Relationship between the inlet tri-reforming reactor temperature and production cost	117
6.8 Relationship between the inlet tri-reforming reactor pressure and net CO ₂ emission	117

TABLE	PAGE
6.9 Relationship between the inlet tri-reforming reactor pressure and production cost	118
6.10 Relationship between the CH ₄ /Flue gas ratio and net CO ₂ emission	118
6.11 Relationship between the CH ₄ /Flue gas ratio and production cost	119
6.12 Relationship between the H ₂ O/Flue gas ratio and net CO ₂ emission	119
6.13 Relationship between the H ₂ O/Flue gas ratio and production cost	120
6.14 Relationship between the inlet methanol reactor temperature and net CO ₂ emission	120
6.15 Relationship between the inlet methanol reactor temperature and production cost	121
6.16 Relationship between the inlet methanol reactor pressure and net CO ₂ emission	121
6.17 Relationship between the inlet methanol reactor pressure and production cost	122
6.18 Comparison of operating conditions between the optimized and base case	123
6.19 Comparison of environmental and economic aspects between the optimized and base case	123
6.20 Comparison of environmental and economic aspects between the base and alternative case	125
7.1 Net CO ₂ emission from alternatives of three conversion processes	128
7.2 Comparison of economic aspects among different scenarios	129

TABLE	PAGE
A1.1 Stream table of the hydrogenation of CO ₂ into methanol for the base case design	151
A1.2 Stream table of the hydrogenation of CO ₂ into methanol for the optimized case design	155
A2.1 Stream table of bi-reforming of CO ₂ into methanol for the base case design	159
A2.2 Stream table of bi-reforming of CO ₂ into methanol for the optimized case design	164
A2.3 Stream table of bi-reforming of CO ₂ into methanol for the alternative case design	169
A3.1 Stream table of tri-reforming of CO ₂ into methanol for the base case design	174
A3.2 Stream table of tri-reforming of CO ₂ into methanol for the optimized case design	179
A3.3 Stream table of tri-reforming of CO ₂ into methanol for the alternative case design	184
B1.1 Raw material and product prices	187
B1.2 Utility price	188
B1.3 Raw materials annual price	188
B1.4 Products annual price	188
B1.5 Annual electricity cost	189
B1.6 Annual cooling water cost	189
B1.7 Equipment sizing and purchase cost	190
B1.8 Breakdown of capital cost	191
B1.9 Breakdown of production cost	192
B1.10 Profitability conditions	193
B1.11 Products annual price	194
B1.12 Raw materials annual price	194
B1.13 Annual electricity cost	195

TABLE	PAGE
B1.14 Annual cooling water cost	195
B1.15 Equipment sizing and purchase cost	196
B1.16 Breakdown of capital cost	197
B1.17 Breakdown of production cost for the methane steam reforming case	198
B1.18 Breakdown of production cost for the wind/electric case	199
B1.19 Breakdown of production cost for the nuclear/steam electrolysis	200
B1.20 Breakdown of production cost for the solar thermal case	201
B1.21 Breakdown of production cost for the biomass case	202
B1.22 Breakdown of production cost for the hydroelectric case	203
B2.1 Raw material and product prices	204
B2.2 Utility price	204
B2.3 Raw materials annual price	205
B2.4 Products annual price	205
B2.5 Annual electricity cost	205
B2.6 Annual generated electricity cost	206
B2.7 Annual cooling water cost	206
B2.8 Equipment sizing and purchase cost	207
B2.9 Breakdown of capital cost	209
B2.10 Breakdown of production cost	210
B2.11 Profitability conditions	211
B2.12 Raw materials annual price	212
B2.13 Products annual price	212
B2.14 Annual electricity cost	212
B2.15 Annual generated electricity cost	213
B2.16 Annual cooling water cost	213
B2.17 Equipment sizing and purchase cost	214
B2.18 Breakdown of capital cost	216

TABLE	PAGE
B2.19 Breakdown of production cost	217
B2.20 Raw materials annual price	218
B2.21 Products annual price	218
B2.22 Annual electricity cost	218
B2.23 Annual cooling water cost	219
B2.24 Equipment sizing and purchase cost	220
B2.25 Breakdown of capital cost	221
B2.26 Breakdown of production cost	222
B3.1 Raw material and product prices	223
B3.2 Utility price	223
B3.3 Raw materials annual price	224
B3.4 Products annual price	224
B3.5 Annual electricity cost	224
B3.6 Annual generated electricity cost	225
B3.7 Annual cooling water cost	225
B3.8 Equipment sizing and purchase cost	226
B3.9 Breakdown of capital cost	228
B3.10 Breakdown of production cost	229
B3.11 Profitability conditions	230
B3.12 Raw materials annual price	231
B3.13 Products annual price	231
B3.14 Annual electricity cost	231
B3.15 Annual generated electricity cost	232
B3.16 Annual cooling water cost	232
B3.17 Equipment sizing and purchase cost	233
B3.18 Breakdown of capital cost	235
B3.19 Breakdown of production cost	236
B3.20 Raw materials annual price	237
B3.21 Products annual price	237

TABLE	PAGE
B3.22 Annual electricity cost	237
B3.23 Annual generated electricity cost	238
B3.24 Annual cooling water cost	238
B3.25 Equipment sizing and purchase cost	239
B3.26 Breakdown of capital cost	241
B3.27 Breakdown of production cost	242
C1 Indirect CO ₂ emission from the hydrogenation of CO ₂ into methanol for the base case	243
C2 Indirect CO ₂ emission from the bi-reforming of CO ₂ into methanol for the base case	243
C3 Indirect CO ₂ emission from the tri-reforming of CO ₂ into methanol for the base case	243

LIST OF FIGURES

FIGURE	PAGE
2.1 CO ₂ emissions by sector.	4
2.2 Human sources of CO ₂ .	4
2.3 CO ₂ emissions from fuel combustion.	6
2.4 Useful chemicals from CO ₂ .	8
2.5 <i>Different</i> carbonate compounds.	12
2.6 Innovative reaction pathways.	18
2.7 Formation of acetic acid.	25
2.8 World market for methanol in 2007.	30
4.1 Flowsheet of the CO ₂ capture unit.	51
4.2 Flowsheet of the hydrogenation of CO ₂ into methanol for the base case design.	54
4.3 Breakdown of the total capital investment.	59
4.4 Breakdown of the direct cost.	60
4.5 Contribution to equipment costs of each area of the process.	60
4.6 Breakdown of the total production cost.	61
4.7 Breakdown of the variable cost.	62
4.8 Breakdown of raw materials cost.	62
4.9 Breakdown of utilities cost.	63
4.10 Sensitivity analysis compare to NPV.	64
4.11 Cumulative cash flow for 20 year project of the base case.	66
4.12 Cumulative cash flow for 20 year project of the optimized case.	70
4.13 Net CO ₂ emission for the total process with different scenarios for hydrogen production.	72
4.14 Comparison of the capital cost and production cost of each alternative.	72

FIGURE	PAGE
4.15 Comparison of NPV of each alternative for 20 years life time.	73
4.16 Comparison of IRR of each alternative for 20 years life time.	74
4.17 Cumulative cash flow for 20 year project of hydroelectric.	74
5.1 Flowsheet of the bi-reforming of CO ₂ into methanol for the base case design.	78
5.2 Breakdown of the total capital investment.	83
5.3 Breakdown of the direct cost.	83
5.4 Contribution to equipment costs of each area of the process.	84
5.5 Breakdown of the total production cost.	85
5.6 Breakdown of the variable cost.	85
5.7 Breakdown of raw materials cost.	86
5.8 Sensitivity analysis compare to NPV.	87
5.9 Cumulative cash flow for 20 year project of the base case.	89
5.10 Flowsheet of the bi-reforming of CO ₂ into methanol for the alternative case design.	98
5.11 Cumulative cash flow for 20 year project of the alternative case.	99
6.1 Flowsheet of the tri-reforming of CO ₂ into methanol for the base case design.	104
6.2 Breakdown of the total capital investment.	109
6.3 Breakdown of the direct cost.	110
6.4 Contribution to equipment costs of each area of the process.	110
6.5 Breakdown of the total production cost.	111
6.6 Breakdown of the variable cost.	112
6.7 Breakdown of raw materials cost.	112

FIGURE	PAGE
6.8 Sensitivity analysis compare to NPV.	113
6.9 Cumulative cash flow for 20 year project of the base case.	115
6.10 Cumulative cash flow for 20 year project of the optimized case.	124
6.11 Flowsheet of the tri-reforming of CO ₂ into methanol for the alternative case design.	126
6.12 Cumulative cash flow for 20 year project of the alternative case.	127
A1.1 Flowsheet of the hydrogenation of CO ₂ into methanol for the base case design.	150
A1.2 Flowsheet of the hydrogenation of CO ₂ into methanol for the optimized case design.	154
A2.1 Flowsheet of the bi-reforming of CO ₂ into methanol for the base case design.	158
A2.2 Flowsheet of the bi-reforming of CO ₂ into methanol for the optimized case design.	163
A2.3 Flowsheet of the bi-reforming of CO ₂ into methanol for the alternative case design.	168
A3.1 Flowsheet of the tri-reforming of CO ₂ into methanol for the base case design.	173
A3.2 Flowsheet of the tri-reforming of CO ₂ into methanol for the optimized case design.	178
A3.3 Flowsheet of the tri-reforming of CO ₂ into methanol for the alternative case design.	183

ABBREVIATIONS

GHGs	Greenhouse gases
CO ₂	Carbon dioxide
DMC	Dimethyl carbonate
DEC	Diethyl carbonate
DPC	Diphenyl carbonate
EC	Ethylene carbonate
PC	Propylene carbonate
CC	Cyclohexene carbonate
SC	Styrene carbonate
BPA-PC	Bis-phenol A-polycarbonate
TON	Turnover numbers
al-PC	Aliphatic polycarbonates
MeOH	Methanol
DMSO	Dimethyl sulphoxide
CH ₄	Methane
MTBE	Methyl tert-butyl ether
MMA	Methyl methacrylate
MDI	Methylenebis (4-phenyl isocyanate)
ETBE	Ethyl tert-butyl ether
DME	Dimethyl ether
RWGS	Reverse water gas shift
CCS	Carbon capture and sequestration
TOF	Turnover frequency
FPSO	Floating production, storage and off-loading
TCI	Total Capital Investment
NPV	Net Present Value
MARR	Minimum Acceptable Rate of Return
IRR	Internal rate of return
GWP	Global warming potential

LIST OF SYMBOLS

ΔH°	Heat of formation at 25°C
S°	Entropy of formation at 25°C
ΔG°	Gibbs free energy of formation at 25°C