Energy Transition Pathways for the 2030 Agenda

Sustainable Energy Transition Road Map for Surat Thani Province, Thailand

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

NEXSTEP
National Expert SDG Tool for Energy Planning

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Developed using National Expert SDG7 Tool for Energy Planning (NEXSTEP)

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*The shaded areas of the map indicate ESCAP members and associate members.**

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Contents

List of figures

List of tables

List of annex tables

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MINISTRY OF ENERGY

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Economic and Social Commission for Asia and the Pacific

Foreword

The Ministry of Energy is well aware that Thai quality of life can be better via effective energy policy implementation and support, especially for the community. The National Energy Plan (NEP) 2022 is being drafted with the objectives to drive the economic and social development for better life quality for people and to achieve the carbon neutrality target by 2050 from the commitment at COP26 and meet the Sustainable Development Goals (SDGs). Consequently, the Alternative Energy Development Plan (AEDP) and Energy Efficiency Plan (EEP) are also being formulated as parts of NEP which aim to increase the share of renewable energy and alternative energy over 50% and reduce Energy Intensity (EI) more than 30% by 2050.

The excellent cooperation from the Economic and Social Commission for Asia and the Pacific (ESCAP) on the project **"Renewable Energy Technologies in Cities and Urban Planning for Renewable Energy Applications in Thailand"**, started in the early year 2021, aims to develop the SDG7 roadmap for 3 pilot provinces (ie. Surat Thani, Udon Thani and Chiang Rai) along with capacity building programme for the policymakers in targeted areas. This project can help the local energy authorities to assess locally available renewable energy options and energy efficiency measures for their own drawing roadmap in the future.

With full and continued support from ESCAP, Provincial Energy Office and other related both local and central departments. The outcome shall provide high-level technological and policy recommendations on achieving SDG7, responding to climate change goals, and also improving the life quality at a community level. I do hope that the SDG7 roadmap could guide local authorities to pave their ways to the sustainable energy transition and help achieve Thailand's Carbon Neutrality Goal.

On behalf of the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, Thailand, I would like to express my sincere appreciation for ESCAP's efforts and support so far. I would also like to thank all the people and organizations involved in this project for their excellent cooperation and contributions. I look forward to continuing this great collaboration in the near future.

Dr. Prasert Sinsukprasert
Director – General
Department of Alternative Energy Development and Efficiency (DEDE),
Ministry of Energy, Thailand

Foreword

Surat Thani Province is in the upper south of Southern Thailand which the city has wide variety of natural resources and popular tourism destinations i.e., Koh Samui, Koh Pha-Ngan, Koh Tao, Mu Koh Ang Thong, etc. Most of the population is engaged in agriculture i.e., farming, gardening, and planting. The main economic crops are rubber, palm oil, coconut, rambutan, durian, coffee, etc. Most of industrial sectors rely on continuous of agricultural products i.e., fishmeal industry, frozen seafood, canned seafood, palm oil, and rubber production. There are currently five (5) strategic Issues aspects including 1.) increasing competitiveness in the agricultural, agro-industry, and energy sector, 2.) Promoting sustainable tourisms and services industry, 3.) linkage of transportation routes and logistics centers in the upper south, 4.) developing safe society, good quality of life and potential to compete, and 5.) creating a stable natural resource and suitable environment, respectively.

According to all city contexts mentioned above, Surat Thani has two (2) relevant city development aspects include energy, and environment aspect. Therefore, the use of clean energy and environmental enhancement are the key dimensions which should be integrated with all five (5) city development aspects.

The project of Surat Thani Sustainable Energy Transition Roadmap is developed in collaboration between Surat Thani Province, Economic and Social Commission for Asia and the Pacific (ESCAP), and Department of Alternative Energy Development and Efficiency (DEDE). The roadmap includes integrating energy efficiency policies at all levels to minimize energy consumption in the city (especially in industrial sector), promoting sustainable transportation and expanding transportation infrastructure to reduce traffic congestion, increasing number of charging station for electric vehicle (EV) and public transportation infrastructure, promote use of decarbonization in the energy producer sector.

Therefore, the roadmap is developed among the variety local agencies, which the Provincial Energy Office of Surat Thani is the key local agency to create collaboration framework and perform consultation activity to develop the Surat Thani Sustainable Energy Transition Roadmap for the benefit of the Surat Thani community further.

Vijvut Tjinto
Governor of Surat Thani Province

Foreword

Energy transition is critical to reduce the impact of the current energy crisis due to the COVID-19 pandemic, the conflicts that are causing supply and price shocks to energy resources, as well as the impacts of climate change. Energy Division of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) is pleased to partner with the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy and Surat Thani province as one of the three pioneer regions in Thailand to have developed a Sustainable Energy Transition Road Map using the National Expert SDG Tool for Energy Planning (NEXSTEP).

The NEXSTEP methodology has been applied in several countries, to support national policymaking to achieve the SDG 7 targets and emissions reduction through Nationally Determined Contributions (NDCs). Efforts at a sub-national level are also equally important in realizing the global goals on sustainable energy and the objectives of the Paris Agreement on climate change.

The province of Surat Thani, as one of the most visited provinces in Thailand, faces several challenges concerning energy use and environmental sustainability. The development of a sub-national Sustainable Energy Transition Road Map supports the region's endeavour in becoming a low-carbon region.

This Road Map takes a holistic approach to Surat Thani's energy system. It evaluates the region's current progress towards the SDG7 targets, identifies the priorities for action, and suggests opportunities for improvement. For instance, despite the region almost achieving universal access to modern energy, the Road Map proposes the appropriate long-term solutions to closing the remaining gap, which also enhances socio-economic development.

The Road Map also details a range of technical opportunities and policy options for reducing emissions and saving energy across the whole economy that provides multi-fold benefits. A significant amount of energy savings can be expected, through the adoption of energy efficiency measures and industry best practices across different industry sub-sectors. Sustainable mobility options, such as electric vehicles and sustainable maritime transport, also offer a notable energy-saving potential. The Road Map also suggests a substantial increase in the share of renewable energy in the electricity supply chain by, for example, implementing renewable energy auctions or investing in waste-to-energy plants, to achieve the emissions reduction target while paving the way toward a net-zero society and sustainable tourism.

I would like to thank DEDE, the province of Surat Thani, and other stakeholders for their continuous support and contributions, without which the development of this Sustainable Energy Transition Road Map would not have been possible. I look forward to the province of Surat Thani's continuing progress in building a sustainable energy future.

Hongpeng Liu
Director, Energy Division, ESCAP

Abbreviations and acronyms

ADB	Asian Development Bank
AEDP	Thailand's Alternative Energy Development Plan 2018-2037
BAU	business-as-usual
CBA	cost benefit analysis
CO_2	carbon dioxide
CPS	current policy scenario
DEDE	Department of Alternative Energy Development and Efficiency
EE	energy efficiency
EEIO	Energy Efficiency Operational Indicator
EEP	Thailand's 20-year Energy Efficiency Plan 2018-2037
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
GDP	gross domestic product
GPP	gross provincial product
GHG	greenhouse gas
GW	gigawatt
GWh	gigawatt-hour
IFC	International Finance Corporation
IMO	International Marine Organization
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ktoe	thousand tonnes of oil equivalent
kWh	kilowatt-hour
LCOE	Levelized Cost of Electricity
LEAP	Long-range Energy Alternatives Planning
LED	light-emitting diodes
LPG	liquified petroleum gas
MCDA	Multi-Criteria Decision Analysis
MEPS	Minimum Energy Performance Standards
MJ	megajoule
ktCO_2-e	thousand tonnes of carbon dioxide equivalent
MOE	Ministry of Energy
MTF	Multi-Tier Framework
NEXSTEP	National Expert SDG Tool for Energy Planning
PDP	Thailand's Power Development Plan 2018-2037
PEA	provincial electricity agency
RE	renewable energy
REF	reference scenario
SDG	Sustainable Development Goal
SEC	specific energy consumption
SET	Sustainable energy transition
SEEMP	ship energy management plan
STS	Sustainable transport strategies
TFEC	total final energy consumption
TNZ	towards NetZero
TPES	total primary energy supply
TWh	terawatt-hour
UNEP	United Nations Environment Programme
UNSD	United Nations Statistics Division
US$	United States Dollar
USDA	United States Department of Agriculture
WHO	World Health Organization

Executive Summary

Transitioning the energy sector to achieve the 2030 Agenda for Sustainable Development and the objectives of the Paris Agreement presents a complex and difficult task for policymakers. It needs to ensure sustained economic growth as well as respond to increasing energy demand, reduce emissions and, more importantly, consider and capitalize on the interlinkages between Sustainable Development Goal 7 (SDG 7) and other SDGs. In this connection, ESCAP has developed the National Expert SDG Tool for Energy Planning (NEXSTEP). This tool enables policymakers to make informed policy decisions to support the achievement of the SDG 7 targets as well as emission reduction targets (NDCs). The initiative has been undertaken in response to the Ministerial Declaration of the Second Asian and Pacific Energy Forum (April 2018, Bangkok) and Commission Resolution 74/9, which endorsed its outcome. NEXSTEP also garnered the support of the Committee on Energy in its Second Session, with recommendations to expand the number of countries being supported by this tool.

Recognising the imperativeness of subregional efforts in supporting the achievement of the 2030 Agenda for Sustainable Development and the national commitment towards the Paris Agreement, this initiative has been applied to several cities and subregions. ESCAP and the Department of Alternative Energy Development and Efficiency (DEDE), Thailand Ministry of Energy have collaborated to support three provinces of Thailand in developing their Sustainable Energy Transition (SET) road maps using the NEXSTEP tool. This SET road map, developed for Surat Thani province, identifies the technological options and policy measures that will help the province navigate the transition of its energy sector in line with the 2030 Agenda for Sustainable Development, national targets and commitment towards the Paris Agreement.

A. Highlights of the roadmap

Surat Thani province is the largest southern province and the sixth-largest province of Thailand. With a total land area of 13,079.61 km2, Surat Thani had a population of around 1.06 million in 2018. The gross provincial product (GPP) in 2018 was baht 306.9 billion and the GPP per capita was around baht 195,000. The development of Surat Thani province is guided by the 20-year Surat Thani Province Development Plan 2017-2036 (Surat Thani Provincial Office, 2018), which identifies key challenges and strategies for provincial development. Several measures have been proposed for the energy sector, such as raising awareness of energy conservation and promoting the production of energy from local resources.

This SET road map has two main objectives. First, it aims to establish a scenario baseline for the 2019-2030 period, taking into consideration the current policy settings. Second, it identifies the measures and technological options that could raise Surat Thani's efforts to align with the SDG 7 targets and national targets as well as achieving deep decarbonisation of its energy system. The four scenarios that are presented in detail in this road map are:

- The current policy scenario (CPS), which has been developed based on existing policies and plans, and is used to identify the gaps in existing initiatives in aligning with the SDG 7 and national targets and commitment towards the Paris Agreement;
- The SET scenario presents technological options and policy measures that will help the city to align its development with the SDG 7 targets and national targets;
- The Sustainable Transport Strategies (STS) explore how the province can further transition its transport sector through a greater degree of mass public transport and electric vehicle usage;
- The Towards Net Zero (TNZ) scenario, the most ambitious scenario, looks at a pathway of moving towards a net zero society in the near future, through decarbonising the electricity supply, fuel substitution and more ambitious electrification.

An additional scenario – business as usual (BAU) – p has also been modelled to provide a BAU baseline where no enabling policies/initiatives are being implemented, or existing policies/initiatives fail to achieve their intended outcomes. This scenario helps to identify specific national targets, e.g., the emission reduction target.

B. Aligning Surat Thani province's energy transition pathway with the SDG 7 targets and national commitments

1. Access to modern energy

Surat Thani has already achieved universal access to electricity, while the clean cooking access rate is estimated to have been 97.3 per cent in 2018. This includes the 6.4 per cent of households that do not conduct cooking at home. The remaining 2.6 per cent of the population, which corresponds to approximately 9,600 households, relied on the traditional charcoal stove, which contributes significantly towards indoor air pollution and associated health impacts. The national clean cooking access rate was improving at an annual rate of 0.6 per cent during 2015-2019. Continuing on a similar trajectory, a 100 per cent access rate can be expected by 2024.

2. Renewable energy

The share of renewable energy (RE) in the total final energy consumption (TFEC) was 42 per cent in 2018. All scenarios are projected to meet the national renewable energy target, 30 per cent of TFEC, set for 2037. Under the CPS, the share of RE will increase to 44.9 per cent by 2030. The increase in the RE share under the current policies is driven by the high growth of renewable energy share in grid electricity which is projected to increase from 17.8 per cent in 2019 to 24.6 per cent in 2030, and a slight increase in biofuel usage in the transport sector. In the SET scenario, the RE share in TFEC will, however, decrease to 41.5 per cent. As described later in this road map, the SET scenario proposes several energy-efficiency measures to align the province's energy demand reduction and GHG emissions reduction with the national targets. The energy demand reduction potential of the industry sector is the substantial; however, this measure reduces the share of biomass consumption in the energy system, contributing towards a reduced renewable energy share in 2030.

The RE share in TFEC for the STS and TNZ scenarios is expected to be high, particularly in the TNZ scenario, which envisions a decarbonised electricity supply. In the STS scenario, the RE share in TFEC is further increased to 45.9 per cent as the transport system gets more efficient with a higher adoption rate of public mass transport and electric vehicles. Apart from a decarbonised electricity supply, the TNZ scenario also aims to increase the pace towards net-zero carbon through fuel substitution and a higher rate of electrification, reaching a RE share of 75.2 per cent in 2030. As described later in this road map, there are several pathways to achieving a decarbonised electricity supply, with the most promising and cost-effective one being through renewable energy auction.

3. Energy efficiency

Surat Thani's energy Intensity has been estimated as 6.82 ktoe/billion baht$_{2010}$ (in terms of TFEC) in 2018. It is expected to have been reduced to 6.68 ktoe/billion baht$_{2010}$ by 2030 in the CPS, as GDP growth outpaces the growth in energy demand. This corresponds to an annual improvement rate of 0.16 per cent. The SET scenario proposes several energy efficiency interventions across the demand sectors, which further decreases the energy intensity to 5.67 ktoe/billion baht$_{2010}$ by 2030, putting Surat Thani on the path to meeting the national energy efficiency target of 5.98 ktoe/billion baht$_{2010}$ by 2037. The industry sector accounted for about 47.6 per cent of the total energy demand in 2018, and adoption of energy efficiency measures across the sector is expected to provide substantial savings of about 232 ktoe. NEXSTEP proposes an increase of electric vehicle share in the transport fleet to between 15 to 50 per cent, by 2030. The projected result – 57 ktoe reduction in energy demand from the CPS – is due to the high efficiency of electric vehicles. Energy savings can also be sought from the residential and commercial sectors. The proposed measures are further detailed in chapter 4.

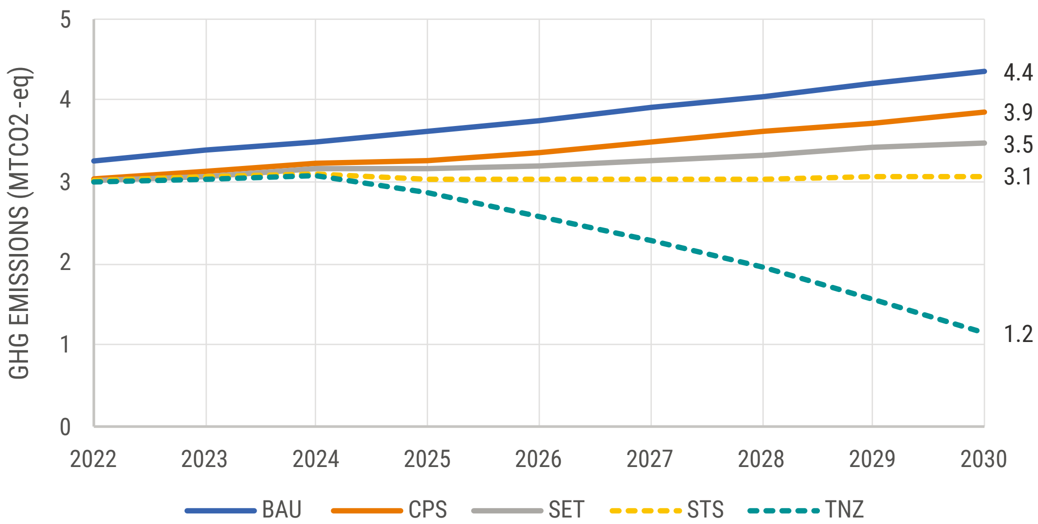
The energy demand reduction could be remarkable, should Surat Thani consider a higher ambition for its transport sector, i.e., expanding mass public transport and electric vehicle adoption. The energy intensity of the STS scenario is projected to decline to 5.08 ktoe/billion baht$_{2010}$, corresponding to a

2.42 per cent energy efficiency improvement per annum. The energy intensity in the TNZ scenario is projected to be 4.98 ktoe/billion baht$_{2010}$.

4. GHG emissions

The GHG emissions in 2018 were an estimated 2.8 MTCO_2-e, which considered the direct fuel combustion from the demand sector and emissions attributable to the grid electricity. Figure ES 1 shows the GHG emission trajectories for the different scenarios. The GHG emissions from the CPS is projected to reach 3.86 MTCO_2-e, while it decreases further to 3.48 MTCO_2-e in the SET scenario. The latter corresponds to a 20 per cent reduction from a BAU baseline, aligning the province's GHG emission reduction with the national unconditional NDC target. More ambitious sustainable transport strategies further reduce the emissions to 3.08 MTCO_2-e in the STS scenario, while a drastic decrease can be observed in the TNZ scenario – only 1.15 MTCO_2-e with a fully decarbonised electricity supply.

Figure ES 1. Comparison of emissions by scenarios 2022-2030



C. Key policy recommendations

As described above, there are ample of opportunities for Surat Thani to transform its energy system in alignment with the national targets and commitment towards the Paris Agreement. The key policy recommendations to help Surat Thani in its sustainable energy transition include:

1. **Adoption of energy-efficiency measures across all industrial subsectors can realise a deep reduction in energy demand.** The provincial government may consider providing financial incentives to encourage widespread adoption of industrial best practices;
2. **Pursue sustainable transport strategies, including expansion of mass public transport and transport electrification.** This will bring multitude benefits, such as reductions in road traffic congestion (with mass public transport), energy demand and GHG emissions. More can be done to encourage such a transition, e.g., expanding EV charging and public transport infrastructure;
3. **Decarbonisation of the power supply provides the highest potential in GHG emission reduction.** Several pathways can be considered, such as solar rooftop and RE auction, which may be the most cost-effective and efficient solutions. The Surat Thani provincial government should consider working with the national Government to identify modalities for implementing RE auction at the local level;
4. **Raised ambitions, particularly a higher level of electrification and a net-zero power sector, puts Surat Thani on path of a net-zero trajectory.** The Government should support this approach by introducing enabling policy measures, e.g., mandating development and implementation of provincial net zero plans.

บทสรุปผู้บริหาร

การปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน (หรือ Sustainable Energy Transition: SET) มีวัตถุประสงค์เพื่อส่งเสริมให้สามารถบรรลุเป้าหมายการพัฒนาอย่างยั่งยืน (หรือ Sustainable Development Goals 2030) ได้ในปี พ.ศ. 2573 ประกอบกับเป้าประสงค์ภายใต้ความตกลงปารีส (หรือ Paris Agreement) มีความยากและซับซ้อนสำหรับผู้พัฒนานโยบาย ด้วยเหตุนี้ เพื่อให้การเจริญเติบโตด้านเศรษฐกิจมีความยั่งยืน, สามารถตอบสนองต่อความต้องการด้านพลังงานที่เพิ่มมากขึ้น และลดปริมาณการปล่อยก๊าซเรือนกระจก ไปจนถึงเกิดความตระหนักและการใช้ประโยชน์จากการเชื่อมโยงระหว่างเป้าหมายการพัฒนาอย่างยั่งยืนในข้อที่ 7 และข้ออื่น ๆ โดยการเชื่อมโยงนี้ ESCAP ได้ดำเนินการพัฒนาเครื่องมือ “National Expert SDG7 Tool for Energy Planning” (หรือ NEXSTEP) ซึ่งเป็นเครื่องมือที่มีส่วนช่วยให้ผู้พัฒนานโยบายสามารถสร้างแบบจำลองสถานการณ์สำหรับประกอบการตัดสินใจเกี่ยวกับนโยบายเพื่อให้บรรลุเป้าหมายการพัฒนาอย่างยั่งยืนในข้อที่ 7 และเป้าหมายการลดก๊าซเรือนกระจกของประเทศ (NDCs) โดยการดำเนินการนี้ได้จัดทำขึ้นเพื่อตอบสนองต่อปฏิญญารัฐมนตรีที่มีต่อการประชุม Asian and Pacific Energy Forum ครั้งที่ 2 (เมษายน พ.ศ. 2561 กรุงเทพฯ) และได้มีมติคณะกรรมการ 74/9 นอกจากนี้ NEXSTEP ยังได้รับการสนับสนุนจากคณะกรรมการด้านพลังงานในสมัยที่ 2 ด้วยคำแนะนำในการขยายจำนวนประเทศที่ได้รับการสนับสนุนจากเครื่องมือนี้

โดยการสนับสนุนนี้ได้มีการนำไปประยุกต์ใช้กับเมืองและอนุภูมิภาคในหลายแห่ง เพื่อก่อให้เกิดความตระหนักถึงความจำเป็นของความพยายามในระดับอนุภูมิภาคอันจะมีส่วนช่วยสนับสนุนให้เป้าหมายการพัฒนาอย่างยั่งยืนประสบความสำเร็จตามที่กำหนดไว้ในปี พ.ศ. 2573 และความมุ่งมั่นระดับชาติที่มีต่อความตกลงปารีส ในการนี้ ESCAP และกรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงาน (พพ.) กระทรวงพลังงาน ประเทศไทย ได้ประสานความร่วมมือกันเพื่อสนับสนุนสามจังหวัดของประเทศไทยในการพัฒนาแนวทางการปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน (SET) โดยใช้เครื่องมือ NEXSTEP ทั้งนี้ แนวทางการปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน (SET) ได้พัฒนาขึ้นสำหรับจังหวัดสุราษฎร์ธานี ซึ่งได้กำหนดตัวเลือกเทคโนโลยีและนโยบาย/มาตรการ เพื่อเป็นทิศทางในการพัฒนาของจังหวัดให้สอดคล้องกับเป้าหมายการพัฒนาอย่างยั่งยืนในปี พ.ศ. 2573, เป้าหมายการพัฒนาประเทศและความมุ่งมั่นต่อความตกลงปารีส

แนวทางการปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน

จังหวัดสุราษฎร์ธานี เป็นจังหวัดที่มีขนาดใหญ่ที่สุดในภาคใต้ของประเทศไทยและเป็นจังหวัดที่มีขนาดใหญ่เป็นอันดับหกของประเทศด้วยเนื้อที่รวม 13,079.61 ตารางกิโลเมตร จังหวัดสุราษฎร์ธานีมีประชากรประมาณ 1.06 ล้านคนในปี พ.ศ. 2561 และผลิตภัณฑ์รวมของจังหวัด (GPP) ในปี พ.ศ. 2561 อยู่ที่ 306.9 พันล้านบาท และผลิตภัณฑ์รวมของจังหวัดต่อประชากร (GPP per capita) อยู่ที่ประมาณ 195,000 บาท โดยการพัฒนาเมืองเป็นไปตามแผนพัฒนาจังหวัดสุราษฎร์ธานี 20 ปี พ.ศ. 2560 - พ.ศ. 2579 (สำนักงานจังหวัดสุราษฎร์ธานี พ.ศ. 2561) ที่กำหนดไว้ ซึ่งระบุความท้าทายและกลยุทธ์สำคัญในการพัฒนาจังหวัด รวมไปถึงมีการนำเสนอมาตรการในภาคพลังงานอย่างหลากหลาย เช่น การสร้างจิตสำนึกการอนุรักษ์พลังงานและส่งเสริมการผลิตพลังงานจากทรัพยากรในจังหวัด เป็นต้น

แนวทางการปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน (SET) นี้ ประกอบด้วยวัตถุประสงค์ 2 ประการ โดยประการแรกมีเป้าหมายเพื่อจัดทำกรณีฐาน (Scenario Baseline) ระหว่างปี พ.ศ. 2562 – พ.ศ. 2579 พิจารณาถึงการกำหนดนโยบายในปัจจุบัน และประการที่สอง คือ เพื่อกำหนดตัวเลือกมาตรการ และเทคโนโลยีซึ่งมีส่วนช่วยส่งเสริมให้การพัฒนาจังหวัดสุราษฎร์ธานีมีความสอดคล้องกับเป้าหมายการพัฒนาอย่างยั่งยืนในข้อที่ 7, เป้าหมายการพัฒนาประเทศและลดการปล่อยก๊าซเรือนกระจกในภาคพลังงาน โดยแบบจำลองสถานการณ์ (Scenario) ทั้งหมด 4 แบบจำลองภายใต้แนวทางการปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน (SET) มีรายละเอียด ดังต่อไปนี้

- แบบจำลองสถานการณ์สำหรับนโยบายในปัจจุบัน (Current Policy Scenario: CPS) ซึ่งได้พัฒนาขึ้นตามนโยบายและแผนที่มีอยู่ในปัจจุบัน และนำมาใช้เพื่อวิเคราะห์ช่องว่างสำหรับนโยบายและแผนที่มีอยู่ โดยสอดคล้องกับเป้าหมายการพัฒนาอย่างยั่งยืนในข้อที่ 7, เป้าหมายการพัฒนาประเทศ และความมุ่งมั่นต่อความตกลงปารีส

- แบบจำลองสถานการณ์การปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน (SET) ได้นำเสนอตัวเลือกเทคโนโลยีและนโยบาย ซึ่งจะมีส่วนช่วยให้การพัฒนาจังหวัดสุราษฎร์ธานีมีความสอดคล้องกับเป้าหมายการพัฒนาอย่างยั่งยืนในข้อที่ 7 และเป้าหมายการพัฒนาประเทศ
- แบบจำลองสถานการณ์การพัฒนาระบบขนส่งอย่างยั่งยืน (Sustainable Transport Strategies: STS) ได้นำเสนอแนวทางการปรับเปลี่ยนด้านการขนส่งผ่านการประยุกต์ใช้ระบบขนส่งสาธารณะในระดับที่สูงขึ้นและยานพาหนะไฟฟ้า (EV)
- แบบจำลองสถานการณ์ที่มุ่งสู่การปลดปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ (Towards Net Zero: TNZ) โดยเป็นสถานการณ์ที่มีความท้าทายมากที่สุด และมุ่งเน้นแนวทางไปสู่การบรรลุการปลดปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ในอนาคตอันใกล้ผ่านการลดปริมาณการปล่อยก๊าซเรือนกระจกจากแหล่งจ่ายไฟฟ้า การทดแทนเชื้อเพลิงและความมุ่งมั่นในการใช้พลังงานในรูปแบบของพลังงานไฟฟ้าที่มีมากขึ้น (Electrification)

นอกจากนี้ แบบจำลองสถานการณ์แบบเป็นไปตามปกติ (BAU) ได้มีการจัดทำขึ้นเพื่อแสดงถึงกรณีฐาน ในกรณีที่ไม่มีการประยุกต์ใช้นโยบาย/การริเริ่มใด ๆ หรือ ในกรณีที่นโยบายและแผนที่มีอยู่ในปัจจุบันไม่สามารถบรรลุผลลัพธ์ได้โดยสถานการณ์นี้มีส่วนช่วยให้สามารถระบุเป้าหมายของประเทศได้ เช่น เป้าหมายการลดการปล่อยก๊าซเรือนกระจก เป็นต้น

การเชื่อมโยงแนวทางการปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืนของจังหวัดสุราษฎร์ธานีเข้ากับเป้าหมายการพัฒนาอย่างยั่งยืนในข้อที่ 7 และเป้าหมายการพัฒนาประเทศ

การเข้าถึงพลังงานสมัยใหม่ (Modern Energy)

จังหวัดสุราษฎร์ธานีได้บรรลุเป้าหมายสำหรับสัดส่วนการเข้าถึงพลังงานไฟฟ้าแล้ว ในขณะที่ปี พ.ศ. 2561 ประชากรประมาณร้อยละ 97.3 มีการใช้เทคโนโลยีสำหรับการประกอบอาหารที่สะอาด ซึ่งรวมไปถึงร้อยละ 6.4 ของครัวเรือนทั้งหมดไม่ได้ประกอบอาหารเองในครัวเรือน และร้อยละ 2.6 ที่เหลือ (หรือ ประมาณ 9,600 ครัวเรือน) ยังคงใช้เทคโนโลยีที่ประสิทธิภาพต่ำ ซึ่งไม่เป็นมิตรต่อสิ่งแวดล้อมและอาจก่อให้เกิดผลกระทบด้านสุขภาพ ทั้งนี้ การเข้าถึงเทคโนโลยีสำหรับการประกอบอาหารที่สะอาดของประเทศมีอัตราเพิ่มขึ้นร้อยละ 0.6 ต่อปี ในระหว่างปี พ.ศ. 2558 - พ.ศ. 2562 โดยคาดว่าจะบรรลุสถานการณ์ที่ครัวเรือนทั้งหมดสามารถเข้าถึงเทคโนโลยีสำหรับการประกอบอาหารที่สะอาดได้ในปี พ.ศ. 2567 หากอัตราเจริญเติบโตยังคงที่

พลังงานทดแทน (Renewable Energy)

สัดส่วนการใช้พลังงานทดแทนในการใช้พลังงานขั้นสุดท้าย (Total Final Energy Consumption: TFEC) ในปี พ.ศ. 2561 มีการใช้พลังงานทดแทนที่ร้อยละ 42.0 เปรียบเทียบกับการใช้พลังงานขั้นสุดท้าย โดยในทุกแบบจำลองสถานการณ์คาดการณ์ว่าจะบรรลุเป้าหมายด้านพลังงานทดแทนของประเทศที่ร้อยละ 30 ของ TFEC ที่กำหนดไว้สำหรับปี พ.ศ. 2580 ทั้งนี้ สัดส่วนการใช้พลังงานทดแทนภายใต้แบบจำลองสถานการณ์สำหรับนโยบายในปัจจุบัน (CPS) ที่ขับเคลื่อนโดยการเพิ่มสัดส่วนการใช้พลังงานทดแทนในโครงข่ายไฟฟ้า ซึ่งคาดว่าจะเพิ่มขึ้นจากร้อยละ 17.8 ในปี พ.ศ. 2562 เป็นร้อยละ 24.6 ในปี พ.ศ. 2573 และการใช้เชื้อเพลิงชีวภาพในภาคขนส่งเพิ่มขึ้นเพียงเล็กน้อย สำหรับสัดส่วนการใช้พลังงานทดแทนในการใช้พลังงานขั้นสุดท้าย (TFEC) ในแบบจำลองสถานการณ์การปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน (SET) จะลดลงร้อยละ 41.5

แบบจำลองสถานการณ์การปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน (SET) ได้นำเสนอมาตรการปรับปรุงประสิทธิภาพการใช้พลังงานต่าง ๆ ซึ่งสอดคล้องกับความต้องการใช้พลังงานที่ลดลงและการปล่อยก๊าซเรือนกระจกที่ลดลงที่สอดคล้องกับเป้าหมายของประเทศ ทั้งนี้ ศักยภาพในการลดความต้องการใช้พลังงานจากภาคอุตสาหกรรมนั้นมีความสำคัญ อย่างไรก็ตาม มาตรการนี้มีส่วนช่วยลดสัดส่วนการใช้เชื้อเพลิงชีวมวลในระบบพลังงาน ซึ่งส่งผลให้สัดส่วนพลังงานหมุนเวียนลดลงในปี พ.ศ. 2573

สัดส่วนการใช้พลังงานทดแทนในการใช้พลังงานขั้นสุดท้าย (TFEC) สำหรับแบบจำลองสถานการณ์การพัฒนาระบบขนส่งอย่างยั่งยืน (STS) และแบบจำลองสถานการณ์ที่มุ่งสู่การปลดปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ (TNZ) คาดหวังว่าจะอยู่ในระดับสูง โดยเฉพาะอย่างยิ่งแบบจำลองสถานการณ์ที่มุ่งสู่การปลดปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ (TNZ) ซึ่งมุ่งเน้นไปที่การจ่ายไฟฟ้าที่ปราศจากการปล่อยก๊าซเรือนกระจก ในแบบจำลองสถานการณ์การพัฒนาระบบ

ขนส่งอย่างยั่งยืน (STS) สัดส่วนการใช้พลังงานทดแทนในการใช้พลังงานขั้นสุดท้าย (TFEC) เพิ่มขึ้นอีกเป็นร้อยละ 45.9 เนื่องจากระบบขนส่งมีประสิทธิภาพมากขึ้นด้วยอัตราการใช้ระบบขนส่งสาธารณะและยานพาหนะไฟฟ้าที่สูงขึ้น นอกเหนือจากการจ่ายไฟฟ้าที่ปราศจากการปล่อยก๊าซเรือนกระจกแล้ว แบบจำลองสถานการณ์ที่มุ่งสู่การปลดปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ (TNZ) ยังมีเป้าหมายที่จะบรรลุการปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ (Net-Zero Carbon) ผ่านการใช้เชื้อเพลิงเพื่อทดแทนเชื้อเพลิงเดิมและอัตราการใช้ไฟฟ้าที่สูงขึ้น โดยสัดส่วนการใช้พลังงานทดแทนในการใช้พลังงานขั้นสุดท้าย (TFEC) บรรลุร้อยละ 75.2 ในปี พ.ศ. 2573 ทั้งนี้ แนวทางต่าง ๆ เพื่อให้บรรลุการจัดหาไฟฟ้าที่ปราศจากการปล่อยก๊าซเรือนกระจก โดยวิธีที่มีประสิทธิภาพและคุ้มค่าที่สุด คือ การประมูลพลังงานหมุนเวียน

การปรับปรุงประสิทธิภาพการใช้พลังงาน (Energy Efficiency)

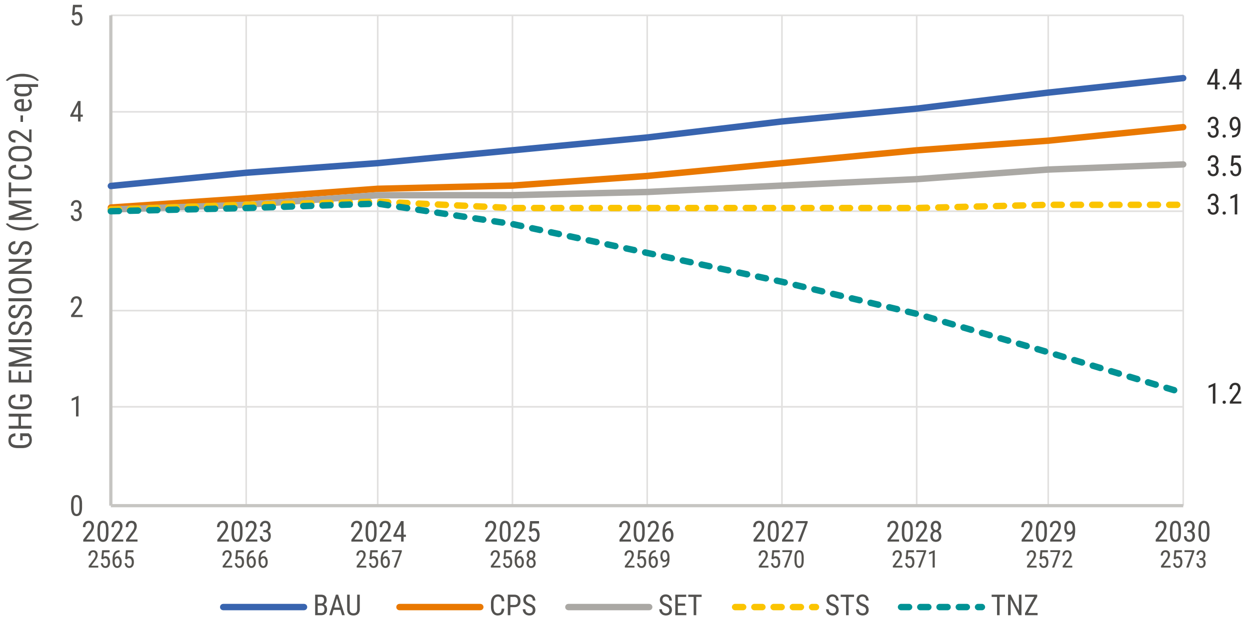
ความเข้มข้นการใช้พลังงาน (Energy Intensity: EI) ของจังหวัดสุราษฎร์ธานี ได้รับการประเมินอยู่ที่ 6.82 ktoe/ล้านบาท2553 (ในแง่ของสัดส่วนการใช้พลังงานทดแทนในการใช้พลังงานขั้นสุดท้าย TFEC) ในปี พ.ศ. 2561 โดยคาดว่าจะลดลงอยู่ที่ 6.68 ktoe/ล้านบาท2553 ในปี พ.ศ. 2573 ในแบบจำลองสถานการณ์สำหรับนโยบายในปัจจุบัน (CPS) เนื่องจากการเติบโตของผลิตภัณฑ์รวมของประเทศ (GDP) จะเพิ่มขึ้นมากกว่าการเติบโตของความต้องการพลังงาน ซึ่งสอดคล้องกับอัตราการปรับปรุงของแต่ละปีที่ร้อยละ 0.16 ทั้งนี้ แบบจำลองสถานการณ์การปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน (SET) เสนอให้มีการประยุกต์การปรับปรุงประสิทธิภาพการใช้พลังงานในภาคที่มีความต้องการใช้พลังงาน ซึ่งสามารถส่งผลให้ความเข้มข้นการใช้พลังงานลดลงเหลือ 5.67 ktoe/พันล้านบาท2553 ภายในปี พ.ศ. 2573 ส่งผลให้จังหวัดสุราษฎร์ธานีมีการดำเนินการที่สอดคล้องกับเป้าหมายการปรับปรุงประสิทธิภาพการใช้พลังงานของประเทศที่ 5.98 ktoe/พันล้านบาท2553 ภายในปี พ.ศ. 2580 ประกอบกับ ภาคอุตสาหกรรมคิดเป็นสัดส่วนประมาณร้อยละ 47.6 ของความต้องการพลังงานทั้งหมดในปี พ.ศ. 2561 และการนำมาตรการประหยัดพลังงานไปประยุกต์ใช้กับหลายภาคส่วนซึ่งคาดว่าจะสามารถช่วยประหยัดได้อย่างมากที่ประมาณ 232 ktoe โดยเครื่องมือ NEXSTEP ได้เสนอให้เพิ่มสัดส่วนการใช้ยานพาหนะไฟฟ้าในภาคการขนส่งให้ครอบคลุมร้อยละ 15 ถึงร้อยละ 50 ภายในปี พ.ศ. 2573 ด้วยเหตุนี้ ผลลัพธ์ที่คาดการณ์ไว้ความต้องการพลังงานจะลดลง 57 ktoe จากแบบจำลองสถานการณ์สำหรับนโยบายในปัจจุบัน (CPS) อันเป็นผลจากจากประสิทธิภาพของยานพาหนะไฟฟ้า นอกจากนี้ มาตรการประหยัดพลังงานในภาคที่อยู่อาศัยและภาคพาณิชยกรรม

ความต้องการพลังงานจะลดลงได้อย่างมากในกรณีที่จังหวัดสุราษฎร์ธานี มีการพิจารณาถึงความทะเยอทะยานที่เพิ่มขึ้นสำหรับภาคการขนส่ง โดยเฉพาะอย่างยิ่งการขยายระบบขนส่งสาธารณะและการใช้ยานพาหนะไฟฟ้า โดยความเข้มข้นการใช้พลังงานของแบบจำลองสถานการณ์การพัฒนาระบบขนส่งอย่างยั่งยืน (STS) คาดว่าจะลดลงเหลือเพียง 5.08 ktoe/พันล้านบาท2553 ซึ่งสอดคล้องกับการปรับปรุงประสิทธิภาพการใช้พลังงานที่ร้อยละ 2.42 ต่อปี ทั้งนี้ ความเข้มข้นการใช้พลังงานในแบบจำลองสถานการณ์ที่มุ่งสู่การปลดปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ (TNZ) คาดว่าจะอยู่ที่ 4.98 ktoe/พันล้านบาท2553 ตามลำดับ

การปล่อยปริมาณการปล่อยก๊าซเรือนกระจก (GHG emissions)

การปล่อยก๊าซเรือนกระจกในปี พ.ศ. 2561 อยู่ที่ 2.8 $MTCO_2$-e ซึ่งพิจารณาครอบคลุมถึงการเผาไหม้เชื้อเพลิงโดยตรงจากภาคที่มีความต้องการใช้เชื้อเพลิงและการปล่อยก๊าซเรือนกระจกที่เกิดจากไฟฟ้าในสายส่ง โดย ES 1 แสดงถึงระดับการปล่อยก๊าซเรือนกระจกจากสถานการณ์ต่าง ๆ โดยการปล่อยก๊าซเรือนกระจกจากแบบจำลองสถานการณ์สำหรับนโยบายในปัจจุบัน (CPS) คาดว่าจะเพิ่มถึง 3.86 $MTCO_2$-e ในขณะที่แบบจำลองสถานการณ์การปรับเปลี่ยนสู่การใช้พลังงานสะอาดอย่างยั่งยืน (SET) ลดลงอยู่ที่ 3.48 $MTCO_2$-e โดยลดลงร้อยละ 20 จากกรณีฐาน (BAU) ซึ่งสอดคล้องกับเป้าหมายการลดการปล่อยก๊าซเรือนกระจกของจังหวัดและเป้าหมายการลดก๊าซเรือนกระจกของประเทศ (NDC) แบบไม่มีเงื่อนไข ทั้งนี้ ความทะเยอทะยานที่เพิ่มขึ้นสำหรับยุทธศาสตร์การขนส่งที่ยั่งยืนจะสามารถลดการปล่อยก๊าซเรือนกระจกลงเหลือ 3.08 $MTCO_2$-e ภายใต้แบบจำลองสถานการณ์การพัฒนาระบบขนส่งอย่างยั่งยืน (STS) ในขณะที่ในแบบจำลองสถานการณ์ที่มุ่งสู่การปลดปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ (TNZ) จะสามารถลดการปล่อยก๊าซเรือนกระจกได้อย่างมาก หรือเพียง 1.15 $MTCO_2$-e ในกรณีที่มีการจ่ายไฟฟ้าที่ปราศจากการปล่อยก๊าซเรือนกระจกทั้งหมด

ตัวอย่าง เปรียบเทียบการปล่อยก๊าซเรือนกระจกในแต่ละสถานการณ์ ระหว่างปี พ.ศ. 2565 – พ.ศ. 2573



ข้อเสนอแนะเชิงนโยบาย

ตามที่ได้นำเสนอไว้ข้างต้นนั้น จังหวัดสุราษฎร์ธานียังมีโอกาสมากมาย ที่จะปรับเปลี่ยนระบบพลังงานให้สอดคล้องกับเป้าหมายของประเทศและความมุ่งมั่นต่อความตกลงปารีส ทั้งนี้ ข้อเสนอแนะเชิงนโยบายที่สำคัญเพื่อมีส่วนช่วยให้ จังหวัดสุราษฎร์ธานีสามารถมุ่งไปสู่การเปลี่ยนแปลงด้านพลังงานอย่างยั่งยืน ประกอบด้วย

1. การบูรณาการนโยบายเพิ่มประสิทธิภาพการใช้พลังงานที่ครอบคลุมถึงกลุ่มย่อย ๆ จะสามารถลดการใช้พลังงานลงได้ หน่วยงานราชการในระดับจังหวัดอาจพิจารณาถึงการให้งบประมาณสนับสนุนเพื่อ เพื่อกระตุ้นให้เกิดการประยุกต์ใช้นโยบายให้มากขึ้นโดยเฉพาะในภาคอุตสาหกรรม
2. ยุทธศาสตร์การขนส่งอย่างยั่งยืนควรได้รับการดำเนินการ ซึ่งรวมถึงการขยายโครงสร้างพื้นฐานการขนส่งสาธารณะเพื่อลดปัญหาการจราจรติดขัด โดยยุทธศาสตร์นี้จะนำมาซึ่งประโยชน์มากมาย เช่น ลดความแออัดของการจราจรบนถนนผ่านการใช้ระบบขนส่งสาธารณะ) ลดความต้องการใช้พลังงานและลดปริมาณการปล่อยก๊าซเรือนกระจก เป็นต้น ทั้งนี้ จังหวัดสามารถดำเนินการเพิ่มเติมเพื่อสนับสนุนให้เกิดการเปลี่ยนแปลงดังกล่าวได้โดยการเพิ่มจำนวนสถานีชาร์จสำหรับยานพาหนะไฟฟ้า และโครงสร้างพื้นฐานการขนส่งสาธารณะ
3. การใช้พลังงานที่ไม่ทำให้เกิดคาร์บอนไดออกไซด์ (Decarbonization) ในภาคผู้ผลิตพลังงานถือได้ว่ามีศักยภาพในการลดการปล่อยก๊าซเรือนกระจกสูงสุด ซึ่งสามารถดำเนินการได้โดยการติดตั้งระบบโซลาร์เซลล์บนหลังคา (Solar Rooftop) และการประมูลพลังงานทดแทน (RE Auction) โดยเป็นแนวทางดำเนินการที่มีการลงทุนน้อยที่สุด ทั้งนี้ หน่วยงานราชการในระดับจังหวัดอาจพิจารณาถึงการดำเนินงานร่วมกับหน่วยงานกลางเพื่อกำหนดแนวทางการประมูลพลังงานทดแทนในระดับจังหวัด
4. เพิ่มความท้าทายโดยมุ่งเน้นไปที่การเพิ่มระดับของการใช้พลังงานไฟฟ้า และการปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ในภาคพลังงานซึ่งทำให้จังหวัดสุราษฎร์ธานีอยู่บนเส้นทางของการขับเคลื่อนการปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ ทั้งนี้ หน่วยงานกลางควรสนับสนุนเพื่อขับเคลื่อนแนวทางนี้ เช่น การมอบหมายให้จังหวัดดำเนินการพัฒนาได้ และดำเนินการตามแผนการปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ของจังหวัด

1. Introduction

1.1. Background

Transitioning the energy sector to achieve the 2030 Agenda for Sustainable Development and the objectives of the Paris Agreement presents a complex and difficult task for policymakers. It needs to ensure sustained economic growth, respond to increasing energy demand and reduce emissions, and consider and capitalise on the interlinkages between Sustainable Development Goal 7 (SDG 7) and other SDGs. In this connection, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) has developed the National Expert SDG Tool for Energy Planning (NEXSTEP). This tool enables policymakers to make informed policy decisions to support the achievement of the SDG 7 targets as well as emission reduction targets (NDCs). The initiative has been undertaken in response to the Ministerial Declaration of the second Asian and Pacific Energy Forum (April 2018, Bangkok) and Commission Resolution 74/9 which endorsed its outcomes. NEXSTEP has also garnered the support of the Committee on Energy in its second session, with recommendations to expand the number of countries being supported by this tool.

NEXSTEP has been specially designed to support policymakers in analysing the energy sector and developing an energy transition plan in the context of SDG 7. Further details of the NEXSTEP methodology are discussed in chapter 2 of this road map. While this tool has been designed to help develop the SDG 7 road map at the national level, it can also be used for subnational energy planning.

1.2. SDG 7 targets and indicators

SDG 7 aims to ensure access to affordable, reliable, sustainable and modern energy for all. It has three key targets, which are outlined below.

- Target 7.1. "By 2030, ensure universal access to affordable, reliable and modern energy services." Two indicators are used to measure this target: (a) the proportion of the population with access to electricity; and (b) the proportion of the population with primary reliance on clean cooking fuels and technology.
- Target 7.2. "By 2030, increase substantially the share of renewable energy in the global energy mix". This is measured by the renewable energy share in TFEC. It is calculated by dividing the consumption of energy from all renewable sources by total energy consumption. Renewable energy consumption includes consumption of energy derived from hydropower, solid biofuels (including traditional use), wind, solar, liquid biofuels, biogas, geothermal, marine and waste. Due to the inherent complexity of accurately estimating traditional use of biomass, NEXSTEP focuses entirely on modern renewables (excluding traditional use of biomass) for this target.
- Target 7.3. "By 2030, double the global rate of improvement in energy efficiency", as measured by the energy intensity of the economy. This is the ratio of the total primary energy supply (TPES) and GDP. Energy intensity is an indication of how much energy is used to produce one unit of economic output. As defined by the IEA, TPES is made up of production plus net imports, minus international marine and aviation bunkers, plus stock changes. For comparison purposes, GDP is measured in constant terms at 2017 PPP.

2. NEXSTEP methodology

The main purpose of NEXSTEP is to help design the type and mix of policies that would enable the achievement of the SDG 7 targets and the emission reduction targets (under NDCs) through policy analysis. However, policy analysis cannot be done without modelling energy systems to forecast/backcast energy and emissions, and economic analysis to assess which policies or options would be economically suitable. Based on this, a three-step approach has been proposed. Each step is discussed in the following sections.

2.1. Key methodological steps

(a) Energy and emissions modelling

NEXSTEP begins with the energy systems modelling to develop different scenarios to achieve SDG 7 by identifying potential technical options for each scenario. Each scenario contains important information including the final energy (electricity and heat) requirement by 2030, possible generation/supply mix, emissions and the size of investment required. The energy and emissions modelling component use the Long-range Energy Alternatives Planning (LEAP). It is a widely used tool for energy sector modelling and to create energy and emissions scenarios. Many countries have used LEAP to develop scenarios as a basis for their Intended Nationally Determined Contributions (INDCs). Figure 1 shows the different steps of the methodology.

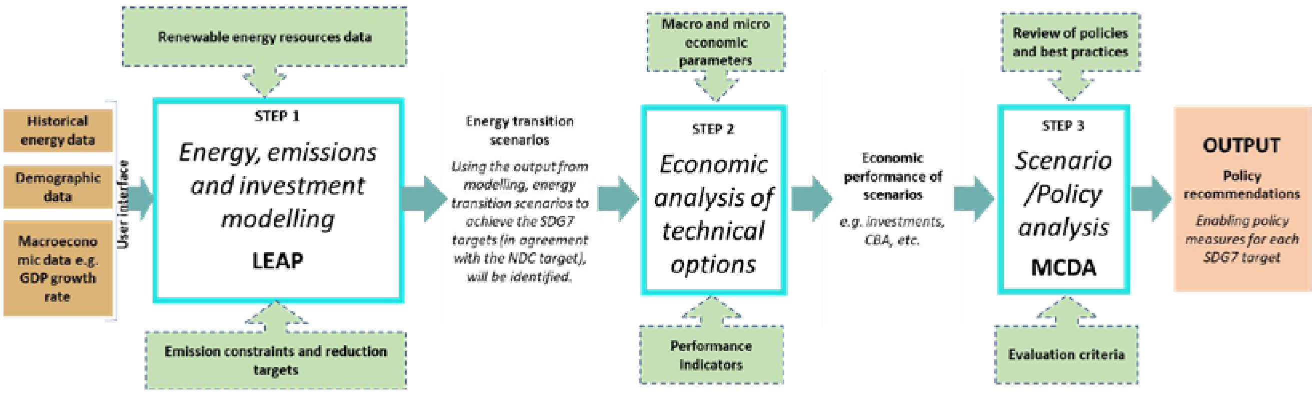
(b) Economic analysis module

The energy and emissions modelling section selects the appropriate technologies, and the economic analysis builds on this by selecting the least cost energy supply mix for the country. The economic analysis is used to examine economic performances of individual technical options identified and prioritize least-cost options. As such, it is important to estimate some of the key economic parameters such as net present value, internal rate of return and payback period. A ranking of selected technologies will help policymakers to identify and select economically effective projects for better allocation of resources. The economic analysis helps present several economic parameters and indicators that would be useful for policymakers in making an informed policy decision.

(c) **Scenario and policy analysis**

Using Multi-Criteria Decision Analysis (MCDA) tool, this prioritised list of scenarios is assessed in terms of their techno-economic and environmental dimensions to convert to a policy measure. The top-ranked scenario from the MCDA process is essentially the output of NEXSTEP, which is then used to develop policy recommendations.

Figure 1. Different components of the NEXSTEP methodology



This tool is unique in a way that no other tools look at developing policy measures to achieve SDG 7. The key feature that makes it outstanding is the backcasting approach for energy and emissions modelling. This is important when it comes to planning for SDG 7 as the targets for the final year (2030) is already given and thus the tool needs to be able to work its way backward to the current date and identify the best possible pathway.

2.2. Scenario definitions

The LEAP modelling system is designed for scenario analysis, to enable energy specialists to model energy system evolution based on current energy policies. In the NEXSTEP model for Udon Thani province three main scenarios have been modelled: (a) BAU scenario; (b) Current Policy scenario (CPS); and (c) Sustainable Energy Transition (SET) scenario. In addition, an ambitious scenario (d) Towards Net Zero (TNZ), has been modelled, which explores how Udon Thani may move towards a net zero future:

(a) The BAU scenario. This scenario follows historical demand trends, based on simple projections, such as using GDP and population growth. It does not consider emission limits or renewable energy targets. For each sector, the final energy demand is met by a fuel mix reflecting the current shares in TFEC, with the trend extrapolated to 2030. Essentially, this scenario aims to indicate what will happen if no enabling policies are implemented or the existing policies fail to achieve their intended outcomes;

(b) CPS. Inherited and modified from the BAU scenario, this scenario considers relevant local and national policies and plans in place – for example, the recently adopted building energy code and Thailand's Power Development Plan 2018-2037;

(c) SET scenario. This scenario aims to align the province's energy transition pathway with the national energy intensity and renewable energy targets as well as the unconditional NDC target;

(d) TNZ scenario. This is an ambitious scenario, which considers several ambitious measures to realise a more rapidly declining GHG emissions reduction trajectory, paving the way towards achieving net zero in the near future.

2.3. Economic analysis

The economic analysis considers the project's contribution to the economic performance of the energy sector. The purpose of a Cost-Benefit Analysis (CBA) is to make better-informed policy decisions. It is a tool to weigh the benefits against costs and facilitate an efficient distribution of resources in public sector investment.

2.3.1. Basics of economic analysis

The economic analysis of public sector investment differs from a financial analysis. A financial analysis considers the profitability of an investment project from the investor's perspective. A project is financially viable only if all the monetary costs can be recovered in the project's lifetime. Project financial viability is not enough in an economic analysis; the contribution to societal welfare should be also examined. For example, in the case of a coal power plant, the emissions from the combustion process emits particulate matter that is inhaled by the local population, causing health damage and acceleration of climate change. In an economic analysis, a monetary value is assigned to the GHG emission to value its GHG emissions abatement. This is done in the scenario analysis, as discussed in subsection 2.3.3.

2.3.2. Cost parameters

The project cost is the fundamental input in the economic analysis. The overall project cost is calculated using the following:

(a) Capital cost – capital infrastructure costs for technologies, these are based on country-specific data to improve the analysis. They include land, building, machinery, equipment and civil works;

(b) Operation and maintenance cost consists of fuel, labour and maintenance costs. Power generation facilities classify operation and maintenance costs as fixed ($/MW) and variable ($/MWh) cost;

(c) Decommissioning cost – retirement of power plants costs related to environmental remediation, regulatory frameworks and demolition costs;

(d) Sunk cost – existing infrastructure investments are not included in the economic analysis, since it does not have any additional investment required for the project;

(e) External cost – refers to any additional externalities that place costs on society. Use of externalities is omitted in this road map due to the absence of a well-recognized framework for cost estimation;

(f) GHG abatement – avoided cost of CO2 generation is calculated in monetary value based on carbon price. The 2016 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories is followed in the calculation of GHG emission for the economic analysis. The sectoral analysis is based on the Tier 1 approach, which uses fuel combustion from national statistics and default emission factors.

2.3.3. Scenario analysis

The scenario analysis evaluates and ranks scenarios, using the Multi-Criteria Decision Analysis (MCDA) tool, with a set of criteria and weights assigned to each criterion. Ideally, the weights assigned to each criterion should be decided in a stakeholder consultation. If deemed necessary, this step can be repeated using the NEXSTEP online portal in consultation with stakeholders where the participants may wish to change weights of each criterion where the total weight needs to be 100 per cent. Although the criteria considered in the MCDA tool can include the following, stakeholders may wish to add/remove criteria to suit the local context:

- Access to clean cooking fuel;
- Energy efficiency
- Share of renewable energy
- Emissions in 2030
- Alignment with Paris Agreement
- Fossil fuel subsidy phased out
- Price on carbon
- Fossil fuel phase-out
- Cost of access to electricity
- Cost of access to clean cooking fuel
- Investment cost of the power sector
- Net benefit from the power sector

This step is generally applied to all countries utilizing NEXSTEP in developing the national SDG 7 or the subnational SET road map, as a means to suggest the best way forward for the countries or cities by prioritising several scenarios.

3. Overview of Surat Thani province’s energy sector

3.1. Overview of Surat Thani province

Surat Thani, which is translates into "City of Good People", is the largest southern province of Thailand. Located on the western shore of the Gulf of Thailand and covering a total area of 13,079.61 km2, Surat Thani is the sixth-largest province in the country. Surat Thani encompasses a wide variety of terrain and landscapes. These include the famous tourist islands of Ko Samui, Ko Pha Ngan and Ko Tao in the Gulf of Thailand. The central part of the province is the coastal plain of the Tapi River, which consists of grassland, rubber trees and coconut plantations. Hills and mountains can be found on both the west and east sides of the province, and which cover about 49 per cent of the land area. Several nature-protected areas can be found throughout the province, including national parks, marine parks and non-hunting areas. Surat Thani province enjoys a warm tropical climate, while also being influenced by the south-west monsoon and the north-east monsoon.

The province is administratively divided into 19 districts, which are further divided into 131 subdistricts and 1,074 villages (Surat Thani Provincial Office, 2018). The local government units include one Provincial Administration Organization, 97 subdistrict Administrative Organizations and 40 municipality-level Administrative Organizations.

The province of Surat Thani has a population of 1.06 million in 2018, which translates into a population density of 81 people per km2. Urban population accounts for 43.6 per cent of the population in Surat Thani. The gross provincial product (GPP) in 2018 was 206.9 billion baht and the GPP per capita was around 195,000 baht. The largest economic sector of the province is the agricultural sector, which contributed around 24.7 per cent of the GPP in 2015. It is followed by the hotel and restaurant sector at 18.1 per cent, the industrial sector at 14 per cent and the wholesale retail sector at 11.7 per cent (Surat Thani Provincial Office, 2018).

The development of Surat Thani province is guided by the 20-year Surat Thani Province Development Plan, 2017-2036 (Surat Thani Provincial Office, 2018). The development plan identifies several key challenges and opportunities for the province, and outlines five main strategies for guiding the development of the province moving forward. Several measures have been proposed for the energy sector, such as raising awareness on energy conservation and promoting the production of energy from local resources.

3.2. Provincial energy profile

(a) Access to modern energy. The population of Surat Thani province in 2018 was reported to be 1.06 million, while the number of households stood at 355,500 households. Surat Thani has already achieved universal access to electricity, while the clean cooking access rate is estimated to be 97.3 per cent. This also includes the 6.4 per cent of households that do not cook at home. The remaining 2.7 per cent of the population were relying on inefficient and unclean technologies such as charcoal/wood stoves and kerosene stoves as their primary cooking technologies. Overall, liquefied petroleum gas (LPG) cooking stoves are the most dominant primary clean cooking technology, with an estimated share of 86.7 per cent. This is followed by electric cooking stoves, estimated be 4.2 per cent.

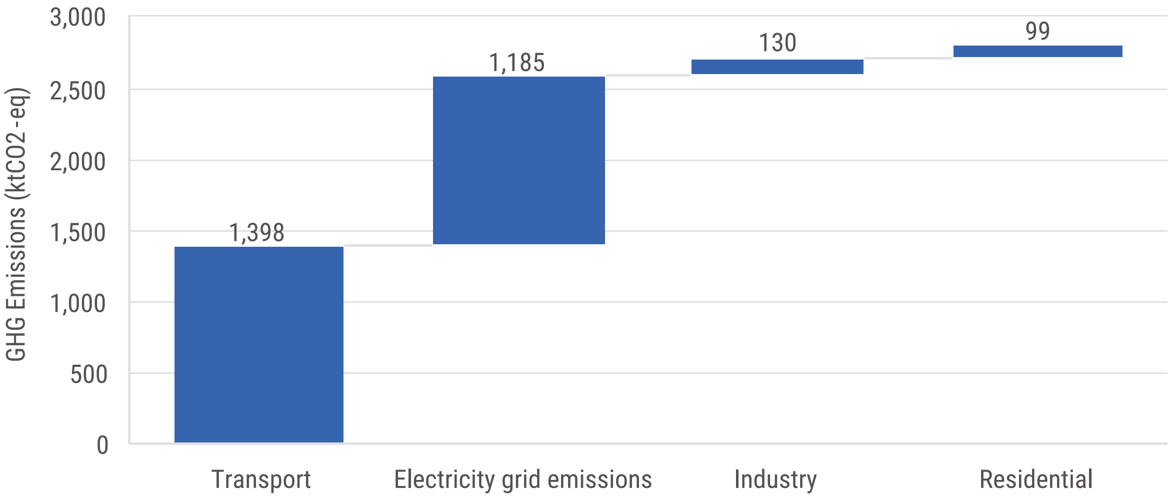
(b) Modern renewable share in TFEC. Modern renewable energy delivered approximately 42 per cent of TFEC in 2018, contributed by renewable electricity, biofuels usage in the transport sector and a substantial biomass consumption in the industrial sector, as explained further below. The electricity requirement of the region is fulfilled, almost exclusively, by electricity from the central grid. Considering the share of renewable electricity of the central grid, the percentage share of renewable energy (RE) in Surat Thani was estimated at 17.8 per cent in 2018.[2] Other usage of RE includes a small amount of biofuel consumption in the transport sector (37.6 ktoe). The national biodiesel mandate in 2018 was 7 per cent, while several blend rates are available on the market (USDA, 2021). NEXSTEP modelling assumes an average blend rate of 13 per cent for transport gasoline usage. The biomass consumption in the industrial sector is the most substantial, at 442.3 ktoe (35.3 per cent of TFEC) in 2018 for heating and electricity self-generation purposes.

2 Based on the Power Development Plan, 2018-2037.

(c) Energy intensity. The energy intensity in 2018, calculated in accordance with the SDG 7.3 target (total primary energy supply per GDP (in terms of PPP_{2017}), was 3.31 $MJ/US\$_{2017}$. In terms of total final energy consumption per GDP_{2010}, it was estimated at 6.82 ktoe/billion baht.[3]

(d) GHG emissions. The GHG emissions from the energy sector were an estimated 2.8 $MTCO_{2-e}$ in 2018. The GHG emissions breakdown is given in figure 2. The emissions from the transport sector were the largest at 1.4 $MTCO_{2-e}$, arising from direct fuel combustion in internal combustion engines. Direct combustion of fuels is also relevant to the industrial and residential sectors, which emit around 130 $ktCO_{2-e}$ and 99 $ktCO_{2-e}$, respectively. Emissions related to electricity usage are not attributable to the demand sectors but are attributable to the supply side, i.e., purchased grid electricity. As electricity is the only energy supply in the commercial, agriculture and non-specified sectors (figure 3), emissions attributable to these sectors are already accounted for in the electricity supply category. The grid emission factor considered for the base year of 2018 is 0.413 tCO_2/MWh[5]. The total emissions attributable to overall electricity usage was an estimated 1.2 $MTCO_{2-e}$. Considering both the emissions from direct fuel combustion and electricity usage, the emission profile is: transport, 50 per cent; industry, 26 per cent; residential, 16 per cent; commercial, 8 per cent; and non-specified, 0.4 per cent. The progress of Surat Thani's energy sector in accordance with the SDG indicators are summarized in Annex I.

Figure 2. GHG emissions in 2018



3.3. Provincial energy balance, 2018

The following describes the estimated energy consumption built up using data collected with a bottom-up approach, based on data such as activity level and energy intensity data. The majority of the following 2018 energy data have been provided ESCAP's local consultant, Mr. Kamol Tanpipat, and his team, unless stated otherwise, and all the data have been reviewed and approved by both DEDE and the Provincial Authority. Further details of the data and assumptions used can be found in Annex II.

The TFEC in 2018 was 1,254 ktoe. The largest energy-consuming sector was the industrial sector at 597 ktoe, around 47.6 per cent of the TFEC. The largest demand was from the wood and other products industries (41.2 per cent), followed by the food and beverages industry (35.9 per cent) and others (21.9 per cent). The majority of the energy supply comes from biomass (74.1 per cent), as shown in figure 3. The transport sector comes second in terms of the final energy consumption, at 497 ktoe – 39.7 per cent of Surat Thani's TFEC. This can be further categorised into road transport (93.3 per cent), marine transport (5.9 per cent), air transport (0.8 per cent) and rail transport (0.01 per cent).

3 The provincial GDP was registered at 206.9 billion baht in 2018. Considering a CPI of 112.47 for 2018 and CPI of 100 for 2010 (World Bank database), the GDP 2010 for 2018 is estimated to have been 183.9 billion baht.

Residential sector consumption was 112 ktoe (8.9 per cent) in 2018. A total 70 per cent of the energy consumed was in the form of electricity, while LPG (28.6 per cent) and charcoal (1.3 per cent) were used for residential cooking purposes. The energy consumed in the commercial sector, non-specified sector, and agricultural sector was exclusively electricity, at 45.7 ktoe (3.6 per cent), 1.9 ktoe (0.15 per cent) and 0.04 ktoe (~0 per cent), respectively. Figure 3 shows the fuel demand from the demand sectors, while figure 4 shows the TFEC breakdown by fuel type in 2018.

Figure 3. TFEC breakdown by sector and fuel type, 2018

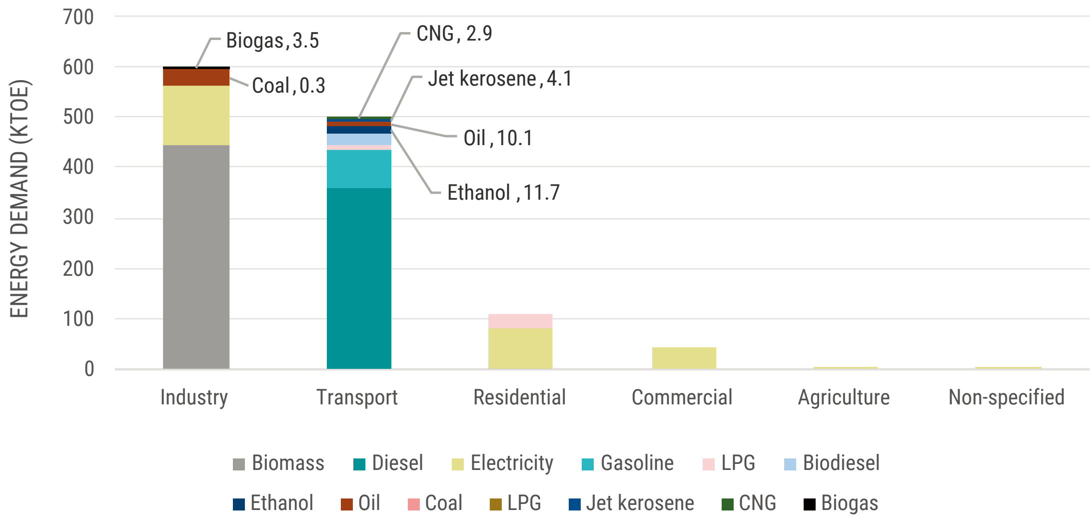
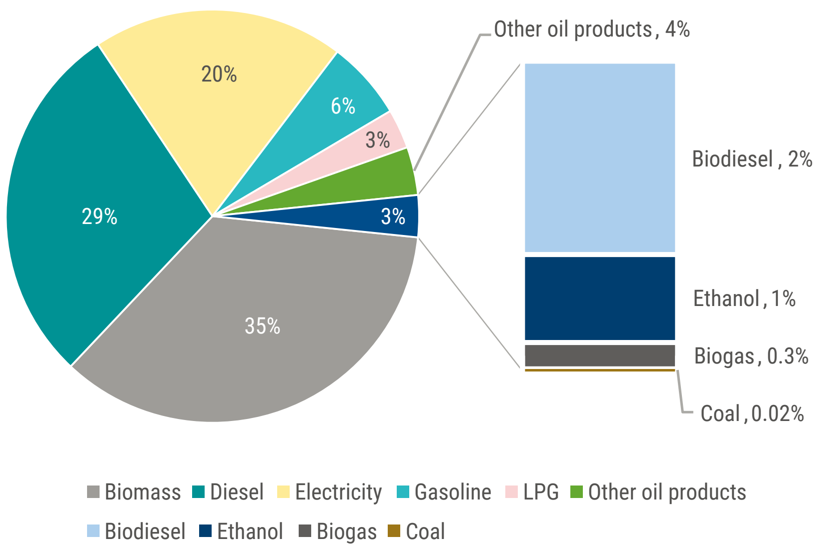


Figure 4. TFEC breakdown by fuel type, 2018



The total primary energy supply was 1,254 ktoe in 2018. As stated above, the province meets almost all of its electricity requirement from the central grid, while the proportion of self-generation is minimal.

3.4. Energy modelling projections

The future energy demand is projected based on a bottom-up approach, using activity levels and energy intensities, with the LEAP model. The demand outlook throughout the NEXSTEP analysis period is influenced by factors such as annual population growth, annual GDP growth as well as other demand sector growth projections. The assumptions used in the NEXSTEP modelling are further detailed in Annex II, while table 1 provides a summary of the key modelling assumptions for the three main scenarios (BAU, CPS and SET).

Table 1. Important factors, targets and assumptions used in NEXSTEP modelling

<table>
<tr><th>Parameters</th><th>Business as usual scenario</th><th>Current policy scenario</th><th>Sustainable energy transition scenario</th></tr>
<tr><td>Economic growth</td><td colspan="3">3.99 per cent per annum</td></tr>
<tr><td>Population growth</td><td colspan="3">0.42 per cent per annum</td></tr>
<tr><td>Urbanization rate</td><td colspan="3">43.6 per cent in 2017, growing to 52.7 per cent in 2030.[4]</td></tr>
<tr><td>Commercial floor space</td><td colspan="3">- Designated buildings: Total commercial floorspace of 3.7 million m² in 2018. The commercial floorspace is projected to grow with an annual rate of 3.99 per cent.
- Non-designated buildings: No floorspace data available. The electricity consumption was 34.12 ktoe in 2018 and the activity is projected to grow with an annual rate of 3.99 per cent.</td></tr>
<tr><td>Industrial activity</td><td colspan="3">Industrial activity is projected to grow with an annual rate of 3.99 per cent.</td></tr>
<tr><td>Transport activity</td><td colspan="3">- Road transport: Passenger transport activities were estimated at 3.97 billion vehicle-kilometres and freight transport activities 1.92 billion vehicle-kilometres, in 2018. These are assumed to grow at a rate similar to the growth in GDP per capita (3.56 per cent).
- Rail and air transport-related energy consumption is estimated at 0.06 ktoe and 4.1 ktoe in 2018, respectively. These are assumed to grow at a rate similar to the growth in GDP.
- Marine transport energy consumption is estimated at 29.1 ktoe in 2018. This is assumed to grow at a rate similar to the growth in GDP.</td></tr>
<tr><td>Residential activity</td><td colspan="3">The appliance ownership for electrical appliances is projected to grow at a rate similar to the growth in GDP per capita, up until reaching a 100 per cent saturation.</td></tr>
<tr><td>Access to electricity</td><td colspan="3">100% access rate has been achieved.</td></tr>
<tr><td>Access to clean cooking fuels</td><td colspan="3">Projected based on the national historical improvement rate of 0.6 per cent, during 2015-2019. Clean cooking access rate is projected to reach 100 per cent in 2024.</td></tr>
<tr><td>Energy efficiency</td><td>Additional energy efficiency measures not applied</td><td>Additional improvement based on implemented policy measures.</td><td>Energy intensity is 5.67 ktoe/billion baht, on track to meet the national energy intensity target of 5.98 ktoe/billion baht by 2037</td></tr>
<tr><td>Power plant</td><td>Considers 2018 RE share in power generation and grid emissions</td><td colspan="2">Considers the increasing RE share and decreasing grid emissions, in accordance with the Power Development Plan, 2018</td></tr>
</table>

3.5. Energy policies and targets

Surat Thani's energy sector development is guided by several national policies and legislation. These policies have been used as guiding references for the NEXSTEP modelling, to better-understand the country context and to provide recommendations in adherence to the national Government's overarching direction. Where applicable, the currently implemented and adopted policies or

4 This assumes that the urbanisation rate grows at an annual rate of 2.5 per cent, with reference to the national historical urbanisation growth from 43.9 per cent in 2010 to 51.4 per cent in 2020.

regulations are considered in the current policy scenario, in order to identify gaps in achieving the SDG 7 targets.[Only policies with concrete and implemented measures are considered in the scenario modelling for the current policy scenario. To further explain, measures mentioned in strategy policy or planning documents that are yet to be enforced or implemented, prior to October 2021 (i.e., plans stipulated in the Energy Efficiency Plan), are not considered in the modelling of the current policy scenario.] The following policies or strategic documents have been consulted:

- **Thailand's Nationally Determined Contribution –** Thailand intends to reduce its GHG emissions unconditionally by 20 per cent from the BAU baseline by 2030. The conditional target is 25 per cent from the BAU baseline by 2030, subject to adequate and enhanced access to technology development and transfer, financial resources and capacity building support.
- **Thailand's Power Development Plan, 2018-2037 (PDP 2018)** aims to improve energy efficiency and enhance energy security in Thailand, while setting goals for new power production capacity.
- **Thailand's 20-year Energy Efficiency Plan, 2018-2037 (EEP 2018)** sets out an energy intensity reduction target of 30 per cent by 2037 compared to the 2010 baseline, reaching an energy intensity (in terms of final energy consumption) of 5.98 ktoe/billion baht. It sets out several compulsory measures and voluntary measures in achieving this target.
- **Thailand's Alternative Energy Development Plan, 2018-2037 (AEDP 2018)** aims to promote the development of renewable energy production in the country and sets out a goal to increase the share of renewable energy and alternative energy in total final energy consumption (TFEC) to 30 per cent by 2037.
- **Thailand biofuel mandate** stipulates a minimum biodiesel blending of 7 per cent from 2014 onwards, which has been increased to 10 per cent in 2020 (for compatible vehicles) (USDA, 2021).[6]
- **Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation, B.E. 2563 (2020)** mandates an energy-efficient design for all new building with a total floor area in all stories of 2,000 square meters or more[7].
- **Minimum Energy Performance Standards (MEPS)** have been implemented for refrigerators and air conditioners since 2005 and 2011, respectively (IEA, 2020 and 2017). MEPS for washing machines were recently announced in August 2021. In addition, voluntary certification is available for several types of electrical equipment through the Energy Efficiency Labelling No. 5 Programme and for several types of non-electrical equipment through the Energy Efficiency Labelling Programme.

3.6. Surat Thani's energy system projections in the current policy settings

The Current Policy scenario (CPS) explores how Surat Thani's energy system may evolve under the current policy settings. It takes into account initiatives implemented or scheduled for implementation during the analysis period of 2018-2030. Consideration of high-level strategies have been outlined in national policies (i.e., energy efficiency measures outlined in the Energy Efficiency Plan, 2018-2037); however, NEXSTEP modelling only takes into account policy measures that have come into force or already have a concrete implementation timeline within the analysis period. Otherwise, energy intensities from the different demand sectors are assumed to be constant throughout the analysis period, with demand growth as detailed in table 1. The policies/initiatives considered in the modelling of CPS are:

(a) Power Development Plan (PDP) 2018-2037. The PDP 2018-2037 is considered in modelling the share of RE electricity and the emission factors of the central grid. In accordance

5 Only policies with concrete and implemented measures are considered in the scenario modelling for the current policy scenario. To further explain, measures mentioned in strategy policy or planning documents that are yet to be enforced or implemented, prior to October 2021 (i.e., plans stipulated in the Energy Efficiency Plan), are not considered in the modelling of the current policy scenario.

6 It is noted that there is no bio-ethanol mandate in Thailand, although several blend rates are available on the market (USDA, 2021). NEXSTEP modelling assumes an average blend rate of 13 per cent for transport gasoline usage.

7 As noted, the 2009 ministerial regulation is applicable to nine types of new or renovated governmental buildings while for private buildings it is on a voluntary basis.

with the expansion plan stipulated in the PDP, an increasing share of RE electricity and a decreasing grid emission factor are expected;

(b) **Thailand biofuel mandate.** The biodiesel mandate was 7 per cent in 2018. This has been increased to 10 per cent from 2020 onwards;

(c) **Implementation of the Ministerial Regulation (2020),** which mandates an energy-efficient design for all new buildings with a total area in all stories of 2,000 square metres or more. NEXTEP modelling assumes the following:

   (i) The energy savings shall take effect in buildings completed in 2023 onwards, considering the grace period and construction time required;

   (ii) The energy saving is assumed to be 36 per cent, compared to the baseline intensity (EEP 2015);

   (iii) All new designated buildings are assumed to meet the minimum floorspace requirement.

   (iv) Fifty per cent of new designated buildings (in terms share of electricity consumption) are assumed to meet the minimum floorspace requirement.

The following subsection describes the energy and emission outlook further in the current policy settings.

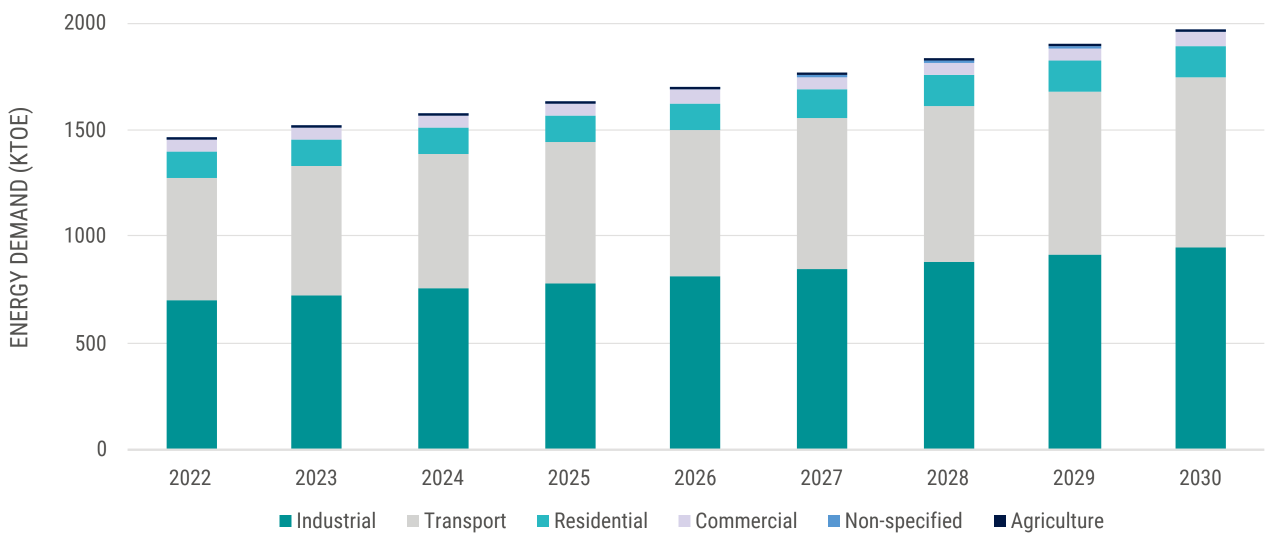
3.6.1. Energy demand outlook

In the current policy settings, TFEC is projected to increase from 1,253.6 ktoe in 2018 to 1,963.6 ktoe in 2030. Slight energy savings of 4 ktoe can be expected, relative to the BAU scenario, from the implementation of the new building code, through the Ministerial Regulation (2020).

The industry sector consumption will remain the largest at 954.6 ktoe (48.6 per cent), followed by the transport sector at 795.2 ktoe (40.5 per cent), the residential sector at 141.7 (7.2 per cent), the commercial sector at 69.0 ktoe (3.5 per cent), non-specified at 3.1 ktoe (0.2 per cent),and the agricultural sector at 0.1 ktoe (~ zero per cent).

The sectoral overview of energy demand in the CPS is discussed below and is shown in figure 5.

Figure 5. Surat Thani's energy demand outlook, CPS 2022-2030



(a) Industry sector

The industrial sector energy demand will continue to dominate Surat Thani's TFEC, and is projected to increase from 597 ktoe in 2018 to 954.6 ktoe in 2030. The industrial activities are relatively developed and can be classified into eight main categories. The modelling of CPS assumes that the energy intensity of the industrial sector remains constant throughout the analysis period, while industrial energy productivity increases by 3.99 per cent annually. Table 2 shows the TFEC and share of TFEC by industry sub-categories.

Table 2. TFEC and share of TFEC by industry sub-categories

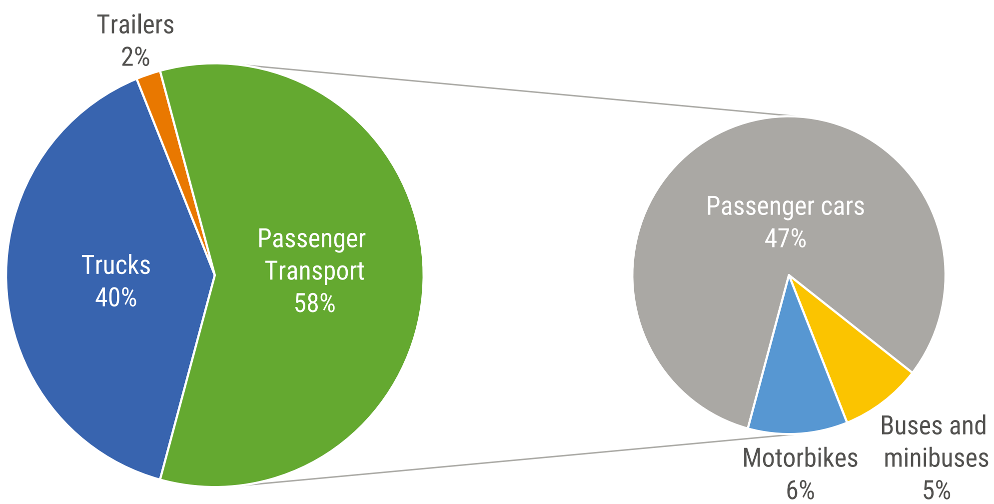
Branch	TFEC in 2030 (ktoe)	Share of TFEC (%)
Wood and other products	392.9	41.2
Food and beverages	343.0	35.9
Other Industries	208.8	21.9
Cement and non-metallic quarry products	5.8	0.6
Fertilizer, chemical, and rubber products	2.1	0.2
Textile and leather	1.1	0.1
Machinery and transportation tool	0.5	0.06
Iron and steel	0.4	0.04

(b) Transport sector

The transport sector energy demand is projected to increase from 497 ktoe in 2019 to 795 ktoe in 2030. In 2030, the subsector share of transport energy demand is projected to be road passenger transport at 433.7 ktoe (54.6 per cent), road freight transport at 308 ktoe (38.8 per cent), marine transport at 46.5 ktoe (5.9 per cent), air transport at 6.6 ktoe (0.8 per cent) and rail transport at 0.1 ktoe (0.01 per cent).

Road passenger transport is subdivided into three sub-categories, i.e., passenger cars, motorcycles, buses and minibuses, while freight transport consists of trucks and trailers. The demand share in 2030 by road transport subcategories is shown in figure 6. The left-hand chart shows the share of freight transport (i.e., freight trucks) and passenger transport, while the right-hand chart provides the demand breakdown of passenger transport subcategories. As observed, 47 per cent of the road transport energy demand is expected to come from passenger cars.

Figure 6. Energy demand distribution by transport sector sub-categories, CPS in 2030



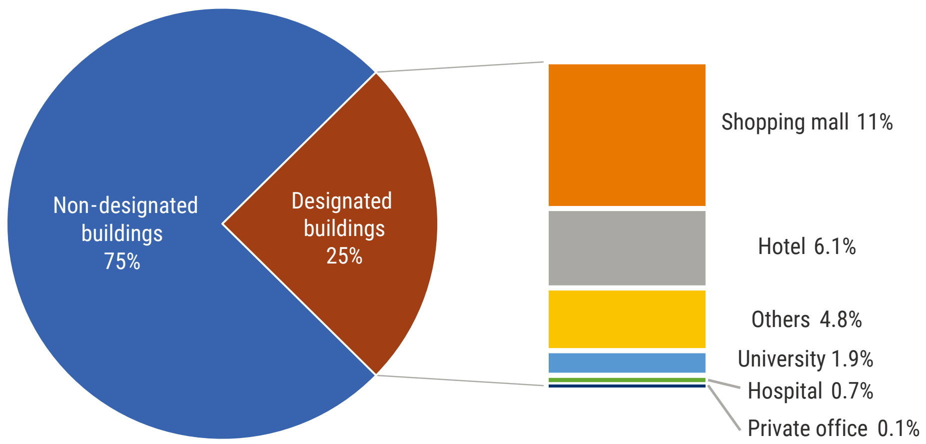
(c) Residential sector

The residential sector energy demand is projected to increase to 141.7 ktoe by 2030, compared with 111.7 ktoe in 2018. Residential cooking is projected to take up around 25.4 per cent of TFEC, with the remaining 74.6 per cent contributed by various electric appliances, i.e., air conditioners and refrigerators.

(d) Commercial sector

The commercial sector energy demand is projected to increase from 45.7 ktoe in 2018 to 69 ktoe in 2030. The implementation of the Ministerial Regulation (2020) which mandates an energy-efficient design for all new buildings with a total area in all stories of 2,000 square metres or more is projected to allow an energy savings of 4.1 ktoe, compared to the BAU scenario. The energy demand distribution in 2030 is shown in figure 7.

Figure 7. Energy demand distribution by commercial sector sub-categories, CPS in 2030



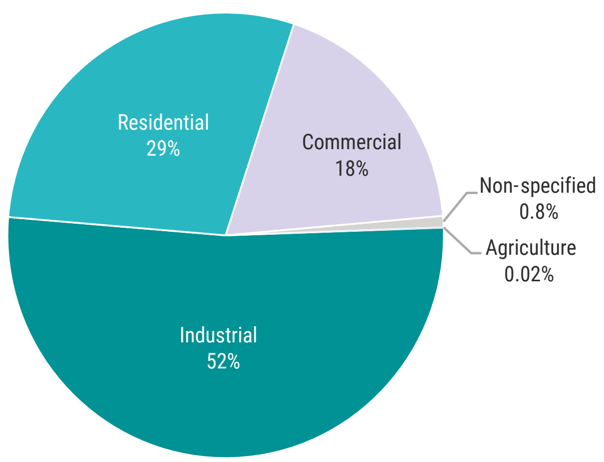
(e) Non-specified sector and agriculture sector

The energy demand from the non-specified and agriculture sectors is relatively insignificant; in 2019 it was only 0.14 per cent, in total. The energy demand is expected to increase from 1.95 ktoe to 3.1 ktoe by 2030.

3.6.2. Electricity generation outlook

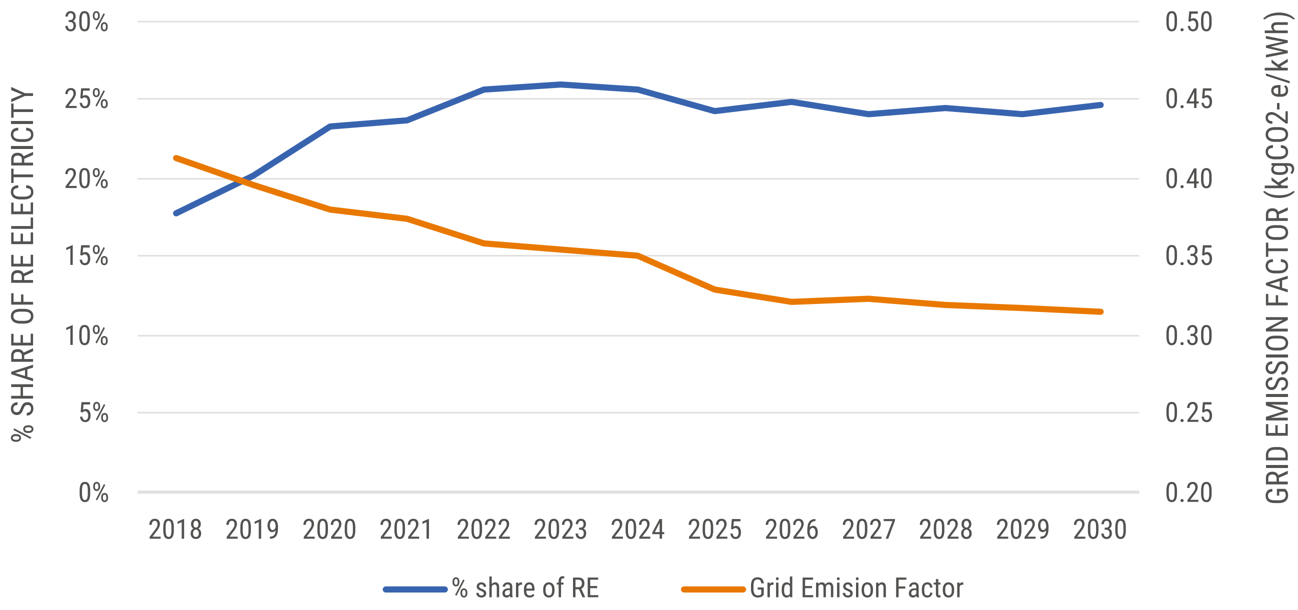
The 2030 demand for electricity in the current policy scenario is projected to be 4,330 Gigawatt-hours (GWh), an increased from 2,870 GWh in 2018. The demand will be the highest in the industrial sector at 2,246 GWh (51.9 per cent) followed by the residential sector at 1,46 GWh (28.8 per cent), the commercial sector at 803 GWh (18.5 per cent), the non-specified sector at 35.5 GWh (0.8 per cent) and the agriculture sector at 0.7 GWh (0.02 per cent) (figure 8).

Figure 8. Electricity demand distribution by demand sector in 2030, CPS



The electricity required to fulfil the demand in Surat Thani is almost exclusively purchased from the grid, while generation for self-use is limited in the province (figure 9. As stipulated in Thailand's Power Development Plan, 2018-2037, the central grid electricity is expected to have a decreasing emission factor, as the percentage of renewable energy increases.

Figure 9. Percentage share of renewable electricity and grid emission factor of central grid, 2018-2030



3.6.3. Energy supply outlook

In the CPS, figure 10 shows the TPES breakdown by fuel type, while figure 11 shows the energy flows in 2030.

Figure 10. TPES breakdown by fuel type, CPS in 2030

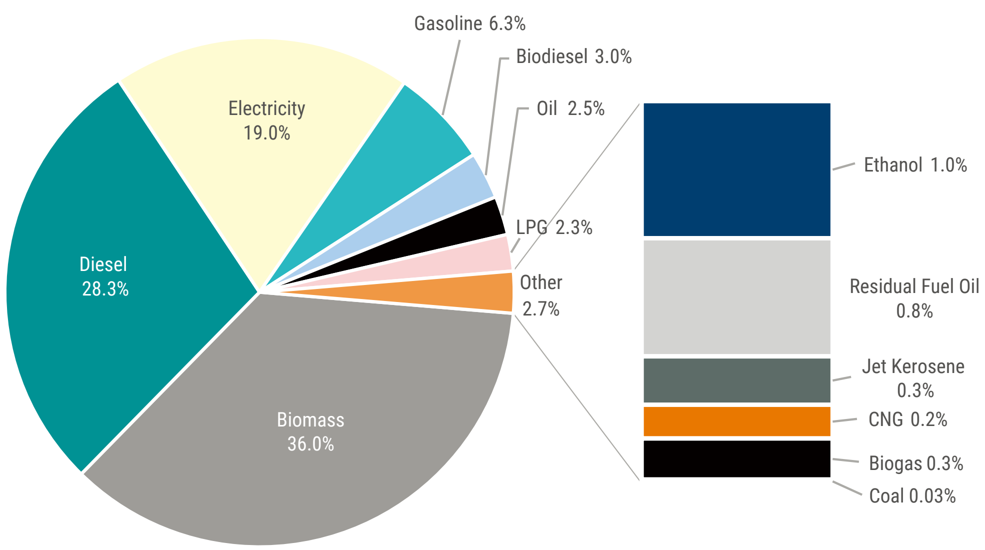
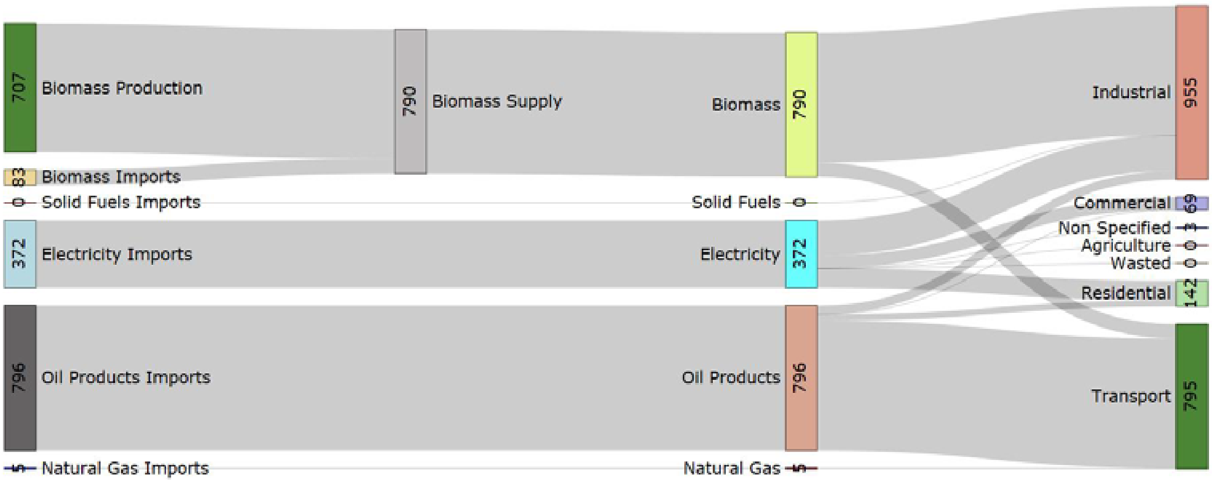


Figure 11. Sankey Diagram, CPS in 2030 (unit: ktoe)



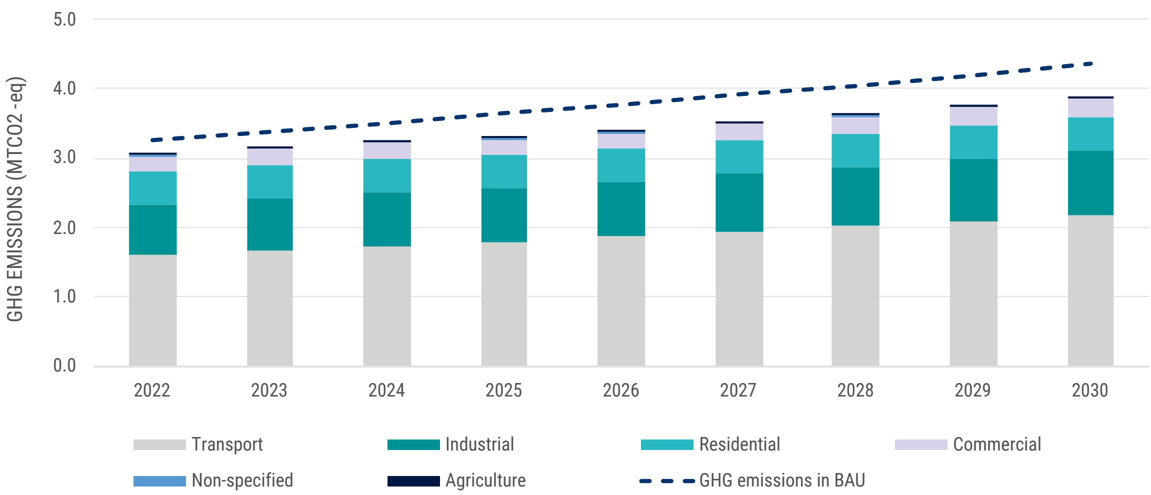
3.6.4. Energy sector emissions outlook

The energy sector emissions, from the combustion of fuels, is calculated based on the IPCC Tier 1 emission factors assigned in the LEAP model. The combustion of biomass products (i.e., biodiesel and ethanol) is considered carbon neutral. The emission attributable to grid electricity has been included, while considering the projected decrease in the grid emission factor throughout the analysis period (see figure 9).

In the CPS, the total GHG emissions from the energy sector increase from 2.81 $MTCO_2$-e to 3.86 $MTCO_2$-e (figure 12). The largest contributor of GHG emissions in 2030 will be the transport sector (56.5 per cent), followed by the industrial sector (23.7 per cent), residential sector (13 per cent), commercial sector (6.5 per cent), non-specified sector (0.3 per cent) and the agriculture sector (~zero per cent). These consider emissions from both direct fuel combustion and electricity usage. The total emissions attributable to overall electricity usage is estimated at 1.36 $MTCO_2$-e .[8]

The emission reduction is 11.4 per cent, relative to the BAU scenario, largely contributed by the decreasing emission factor of the central grid electricity. However, in the event that the share of RE in the electricity mix increases less rapidly than modelled, the emission reduction will be much less substantial. For example, total GHG emission is estimated to be 4.3 $MTCO_2$-e in 2030, if the emission factor remains similar to the 2018 level – a 74 $ktCO_2$-e reduction compared to the BAU scenario.

Figure 12. Surat Thani's energy sector emissions outlook, CPS, 2022-2030



8 Electricity usage from all demand sectors will make up around 35.3 per cent of the total emissions in 2030.

4. SET scenario – sustainable energy transition pathway for Surat Thani province

Both subnational and national efforts are imperative in achieving the 2030 Agenda for Sustainable Development and Paris Agreement on climate change. This chapter provides details of the SET scenario, exploring how economy-wide efforts may improve the energy and climate sustainability of the Province of Surat Thani, in alignment with the national targets. Table 3 shows a summary of the targets considered in the SET scenario.

Table 3. Summary of the targets considered in the SET scenario

Indicator	National target	Comparative SDG 7 target
Access to modern energy	No set target	7.1. By 2030, ensure universal access to affordable, reliable, and modern energy services.
Renewable energy	30 per cent by 2037	7.2. By 2030, increase substantially the share of renewable energy in the global energy mix.
Energy efficiency	30 per cent energy intensity reduction by 2037, compared to the 2010 baseline: • NEXSTEP considers an energy intensity target of 6.64 ktoe/billion baht by 2030.[9]	7.3. By 2030, double the global rate of improvement in energy efficiency.
GHG emissions reduction	20 per cent GHG emission reduction compared to the BAU baseline in 2030, as per Thailand's unconditional NDC target	n/a

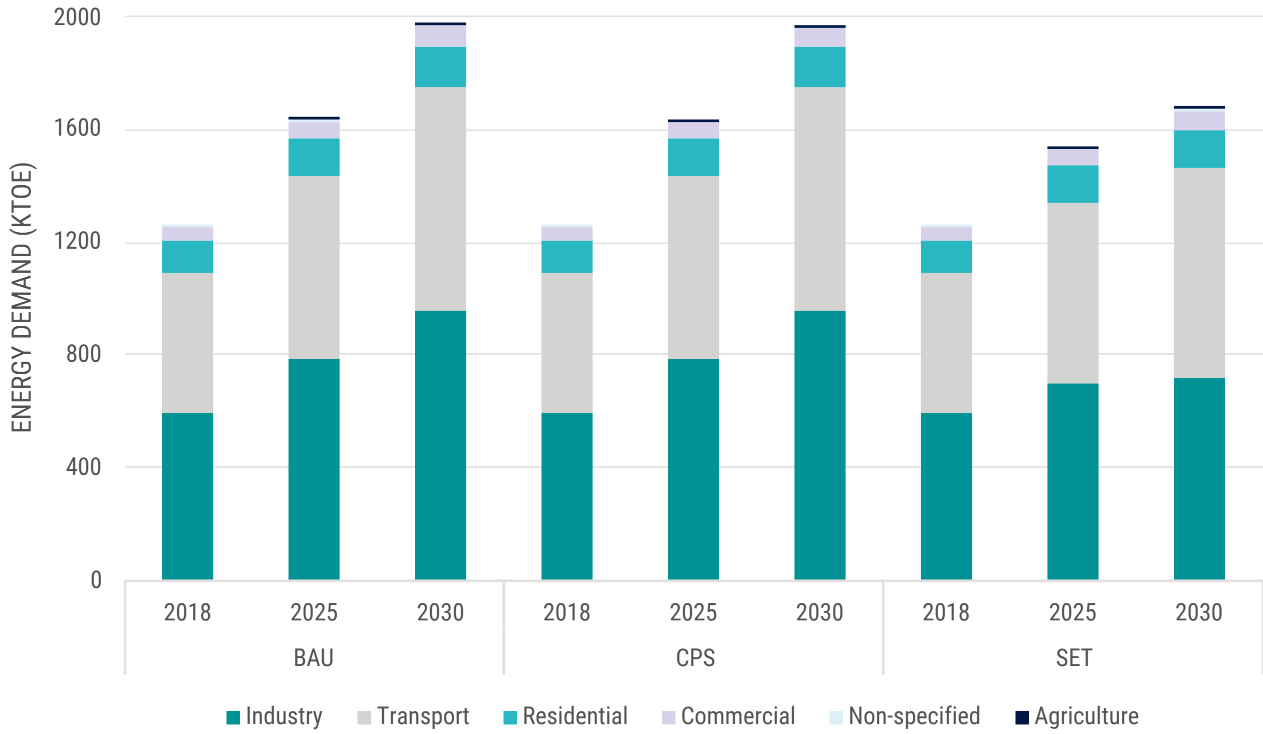
The following sections discuss the energy system trajectory under the SET scenario in relation to different indicators.

4.1. SET energy demand outlook

In the SET scenario, TFEC increases at a much slower pace than CPS, from 1,254 ktoe in 2018 to 1,668 ktoe in 2030. The reduction of 295 ktoe in TFEC in this scenario, compared with CPS, is due to the improvement in energy efficiency across the demand sectors. The proposed energy efficiency interventions are further described in subsection 4.2.3. In 2030, the transport sector will have the largest share of TFEC at 737.9 ktoe (44.2 per cent), followed by the industrial sector at 723.1 ktoe (43.3 per cent), the residential sector at 138.4 ktoe (8.3 per cent) and the commercial sector at 65.9 ktoe (3.9 per cent). Figure 13 shows TFEC by scenarios in 2030.

9 As interpolated using the energy intensity target (in terms of final energy consumption) of 5.98 ktoe/billion baht in 2037, and the 2010 baseline of 8.54 ktoe/billion baht.

Figure 13. Projection of TFEC by sector, 2030



4.2. progress towards main sustainable energy indicators

4.2.1. Access to modern energy

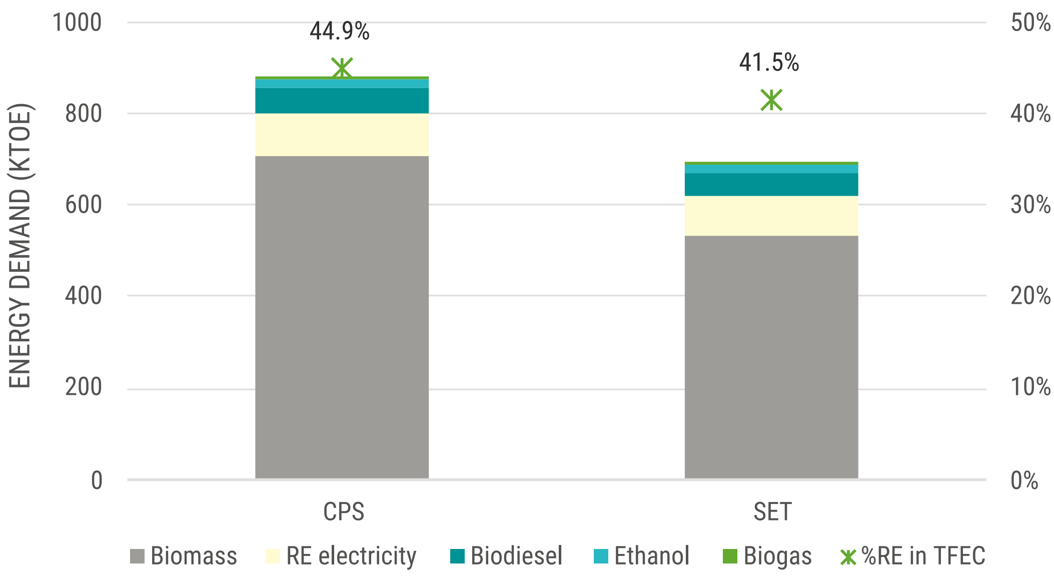
Surat Thani province has already achieved universal access to electricity. In 2018, the clean cooking rate was estimated at 97.3 per cent. Projected based on a national historical annual improvement rate of 0.6 per cent during 2015-2019 per year, the clean cooking access rate can be expected to reach 100 per cent in 2024.

4.2.2. Renewable energy

Thailand's Alternative Energy Development Plan, 2018-2037 (AEDP, 2018) has set forth a renewable energy target of 30 per cent by 2037. On the other hand, SDG 7.2 does not have a quantitative target, but requires a substantial increase of renewable energy share in TFEC. The RE share in TFEC was estimated at 42 per cent in 2018, excluding a small amount of traditional biomass usage in the residential cooking sector. Such a high percentage of usage is attributable to the substantial biomass consumption in the industrial sector. Accordingly, the BAU and CP scenarios are expected to meet the 30 per cent RE target, set forth in the AEDP 2018, at 42.7 per cent and 44.9 per cent, respectively. A higher RE share is expected from the CP scenario, due to an increasing share of RE electricity to 24.6 per cent in the central grid, in accordance with the PDP 2018.

In the SET scenario, the RE renewable energy share in TFEC is projected to decrease to 41.5 per cent by 2030 (figure 14). The decrease in the RE share in TFEC compared with both the BAU and CP scenarios is mainly due to the reduced use of biomass in the industrial sector through energy efficiency measures (as described further in subsection 4.2.3). It also assumes a 24.6 per cent share of RE electricity in the central grid, the same as in the CP scenario.

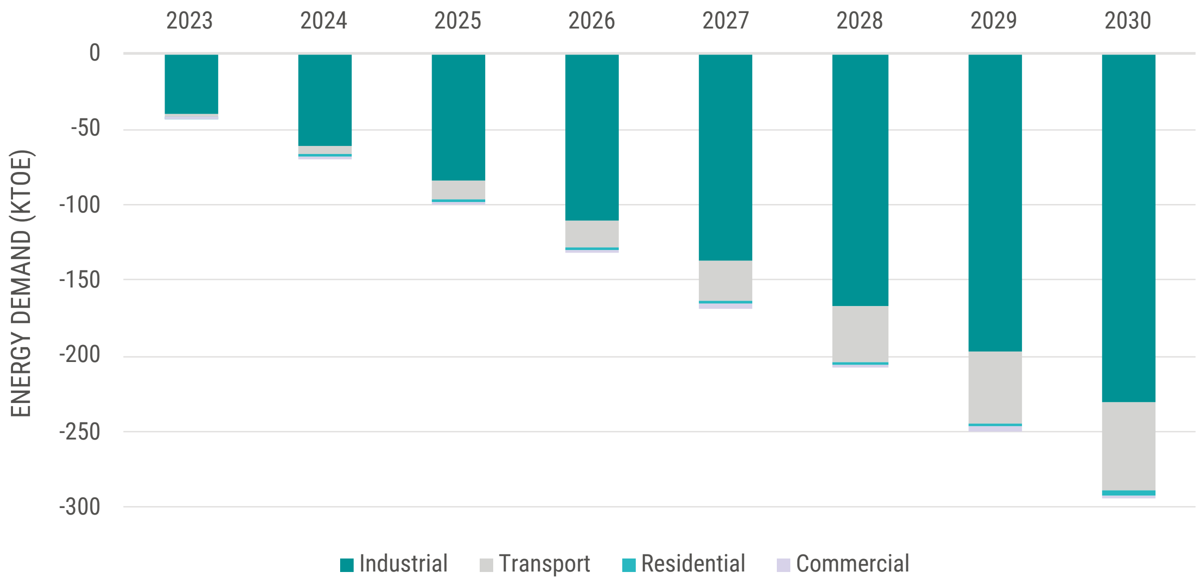
Figure 14. Renewable energy in TPES and TFEC, 2030



4.2.3. Energy efficiency

Energy intensity is projected to reach 5.67 ktoe/billion baht$_{2010}$ in 2030, considering the energy efficiency measures proposed for the SET scenario. This meets the energy intensity set out for 2030[10] by a relatively huge margin, while at the same time achieving the national energy intensity target of 5.98 ktoe/billion baht$_{2010}$ set forth for 2037. The energy efficiency measures proposed for the SET scenario have been designed to achieve Surat Thani's GHG emission reduction with the national unconditional target of 20 per cent, relative to a BAU baseline.

Figure 15. Energy savings in SET scenario, compared to CPS



10 The energy intensity target is 6.64 ktoe/billion baht by 2030, as interpolated using the energy intensity target (in terms of final energy consumption) of 5.98 ktoe/billion baht in 2037, and a 2010 baseline of 8.54 ktoe/billion baht.

Figure 15 shows the energy savings that may be achieved through the implementation of energy efficiency measures across the demand sectors, compared to the CPS. The industrial sector is the largest energy consuming sector in Surat Thani province, which can be expected to provide the largest contribution (231.6 ktoe in 2030), through the increased adoption of energy efficiency measures across the industrial sub-categories. Energy demand reduction can also be realised through the adoption of electric vehicles, such as buses, cars and motorcycles. In addition, measures can be sought from the residential and commercial sectors, albeit with a smaller energy savings potential. Further details of the energy efficiency measures, and their impacts are provided in figure 15.

4.2.3.1. Industrial sector

The industrial sector is the largest energy consuming sector in Surat Thani province. With that, a significant amount of energy savings can be expected, through the adoption of energy efficiency measures and industrial best practices across different industry subsectors. The potential savings, as modelled in the SET scenario, references the energy conservation potential assessment findings in the Thailand 20-Year Energy Efficiency Development Plan, 2011-2030 (MOE, 2011), with the exception of cement and non-metallic quarry products industry (table 4). The energy savings potential in this report is assessed approximately by comparing Thailand's average specific energy consumption (SEC) in 2009 with the best SEC in other countries or within Thailand. On the other hand, the economic potential of the cement industry is assumed to be 25 per cent (ADB, 2015).

Table 4. Energy efficiency measure applied and the estimated annual savings in 2030 (relative to CPS) in the industrial sector

Sub-category	Potential savings compared to BAU baseline	Annual saving in 2030 (ktoe)
Food and beverages	28 per cent [a]	96.0
Other industry	22 per cent [b]	45.9
Wood and wood products		86.4
Machinery and transportation tool		0.1
Textile and leather		0.3
Fertilizer, chemical and rubber products	44 per cent [c]	1.3
Iron and steel	11 per cent [d]	0.05
Cement and non-metallic quarry products	25 per cent [e]	1.5
Total		**231.6**

Note:

(a) Based on energy savings potential for "food and beverage" category (MOE, 2011).

(b) Based on energy savings potential for "others" category (MOE, 2011).

(c) Based on energy savings potential for "chemical" category (MOE, 2011).

(d) Based on energy savings potential for "basic metal" category (MOE, 2011).

(e) Assumes the economic potential savings of 25 per cent for the cement industry (ADB, 2015).

4.2.3.2. Transport sector

The current share of electric vehicles in the existing fleet is very low. however, promotion of electric vehicles is an effective way of reducing demand consumption in the transport sector as well as GHG emissions. In the SET scenario, NEXSTEP proposes that the uptake of electric vehicles can be promoted across the different vehicle categories, to reach a considerable share of the transport fleet by 2030. Further details and the estimated annual savings are as shown in table 5.

Table 5. Energy efficiency measure applied and the estimated annual savings in 2030 (relative to CPS) in the transport sector

Sub-category	Energy efficiency measures	Annual saving in 2030 (ktoe)
Passenger cars	Increase the share of electric passenger cars to 15 per cent by 2030	40.7
Buses and minibuses	Increase the share of electric buses to 50 per cent by 2030	10.7
Motorcycles	Increase the share of electric motorbikes to 15 per cent by 2030	5.8
Total		**57.3**

An increase in the yearly sales share of electric vehicles is required to reach the targeted shares by 2030. For example, the yearly sales share of electric-type motorcycles and passenger cars should aim to start from 5 per cent in 2023, gradually rising to 30 per cent by 2028. On the other hand, electric buses may take on a higher ambition through stronger co-ordination with bus companies. For example, the province can aim to have a yearly sales share of 50 per cent in 2023, rising to 100 per cent by 2030.

4.2.3.3. Residential sector and commercial sector

Energy demand reduction can also be realized in the residential and commercial sectors, albeit much less significantly than the industrial and the transport sectors. Energy savings from the residential sector may come from the adoption of energy efficient appliances, which in the case of Thailand, are promoted through the minimum energy performance standards and voluntary certification for several types of electrical equipment. NEXSTEP suggests the gradual phasing out of non-energy efficient lighting, with replacement by light-emitting diodes (LEDs) lights, realizing an energy savings of around 3.2 ktoe in 2030. In addition, potential investment of energy efficiency measures can be promoted through the enforcement of the Energy Conservation Promotion Act for existing designated buildings[11].

11 According to (MOE, 2016), this encompasses regulatory approaches for energy management, set and tracked in a systematic way in accordance to standards. It also includes developing tracking system and database, as well as energy efficiency indicators, and preparation of a system that allow special fees to be levied.

Table 6. Energy efficiency measure applied and the estimated annual savings in 2030 (relative to CPS) in the residential and commercial sectors

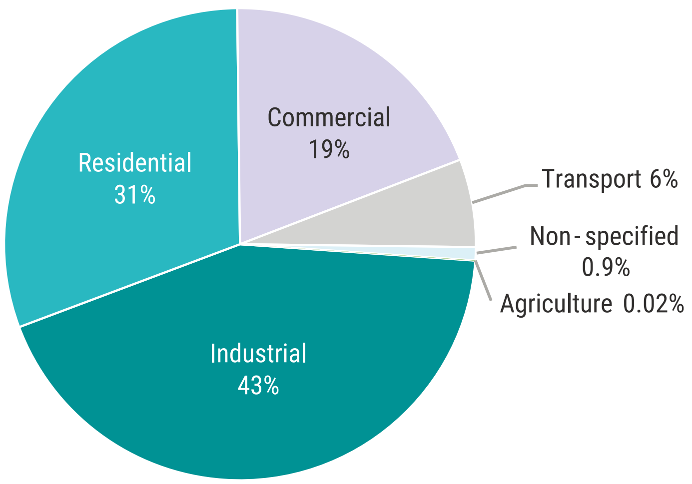
Sub-category	Energy efficiency measures	Annual saving in 2030 (ktoe)
Residential	Phase out of non-LED lighting	3.2
Commercial	Enforcement of the Energy Conservation Promotion Act for existing designated buildings. • The energy savings potential is assumed to be 28 per cent (EEP 2015).	3.1
Total		**6.3**

4.3. Electricity supply and demand in the context of sustainable energy transition

The demand for electricity in 2030 is projected to be 3,958 GWh in the SET scenario, an increase of 372 GWh compared to the CPS. Reduction in electricity demand can be expected from the industrial, residential and commercial sectors as energy efficiency measures and energy-efficient appliances are adopted. On the other hand, electricity demand from the transport sector is projected to increase by 238.4 GWh, due to widespread adoption of electric vehicles.

The largest electricity demand can be expected from the industrial sector at 1,709 GWh. This is followed by the residential sector at 1,208 GWh, the commercial sector at 238 GWh, the non-specified sector at 36 GWh and the agricultural sector at 0.7 GWh (figure 16).

Figure 16. Share of electricity demand in 2030 by demand sector, SET scenario



4.4. Energy flows and balance, 2030

In the SET scenario, TPES is forecast to increase from 1,254 ktoe in 2018 to 1,964 ktoe in 2030. Figure 17 further shows the TPES breakdown by fuel type, while figure 18 shows the energy flows in 2030.

Figure 17. **TPES breakdown by fuel type, SET in 2030**

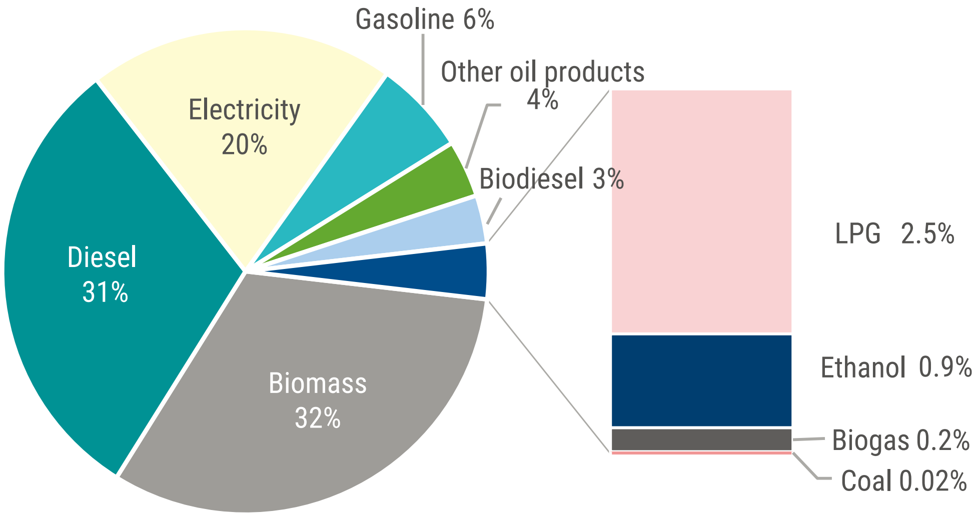
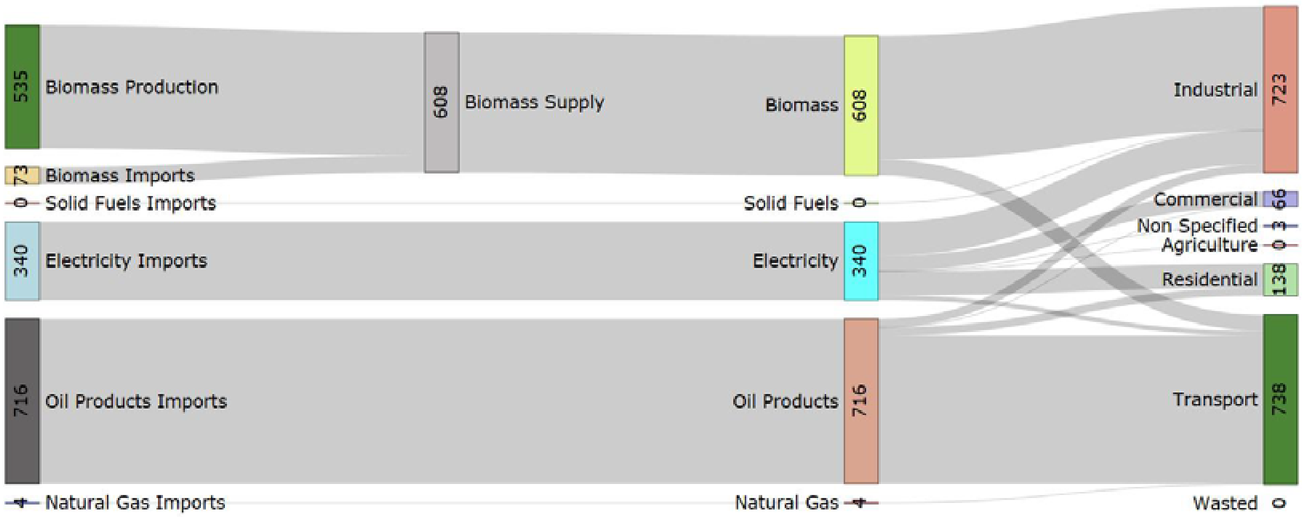


Figure 18. **Sankey Diagram, SET in 2030 (unit: ktoe)**



4.5. GHG emission reduction with sustainable energy transition

The GHG emissions in 2030 are projected to total 3.48 $MTCO_2$-e, a reduction of 377 $ktCO_2$-e from CPS. This corresponds to a 20.1 per cent reduction from the BAU scenario, or a 9.8 per cent reduction from CPS (figure 19).

The net GHG emission reduction by demand sectors, relative to CPS, in 2030 is further summarised in table 6. The emissions reduction from the residential, industrial and commercial sectors is due to the reduced direct fuel combustion and/or electricity usage. The GHG emission reduction due to reduced direct fuel combustion by the transport sector is significant. However, this is slightly affected negatively by the emissions associated with the increased electricity demand. The total estimated emissions attributable to overall electricity usage in this scenario will be 1.25 $MTCO_2$-e.

Figure 19. GHG emission trajectories 2022-2030, by scenario

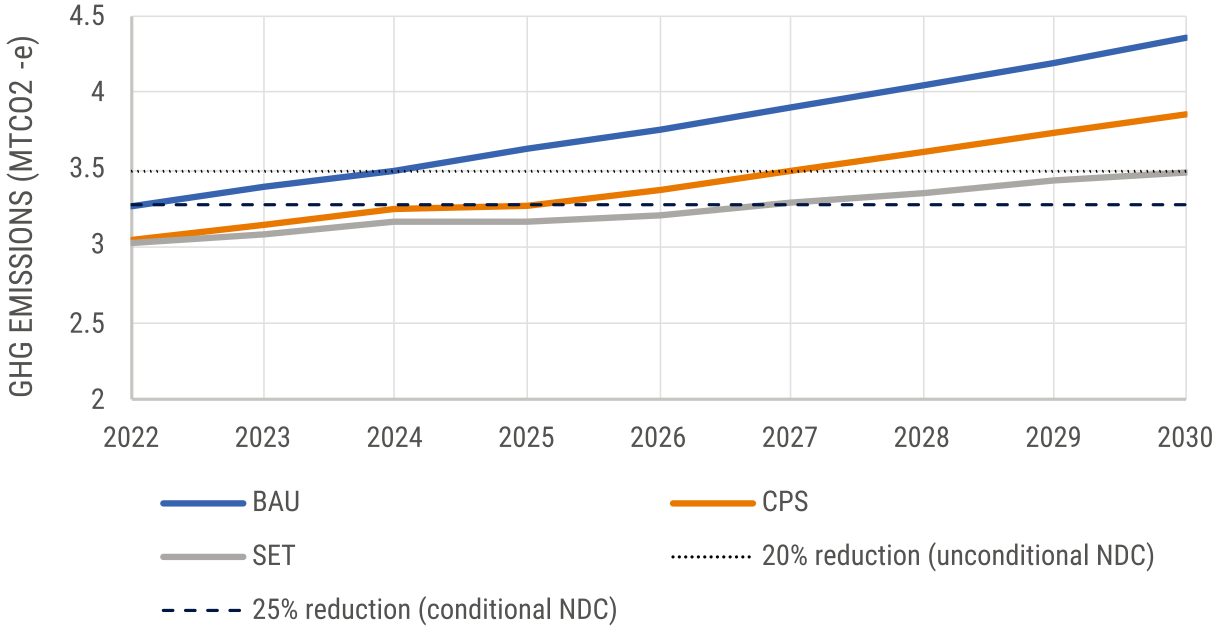


Table 7. Emission reduction estimates (relative to CPS) in 2030 from various energy efficiency measures

Sector	Measure	Emissions reduction attributable to direct fuel combustion ($ktCO_2$-e)	Emissions reduction attributable to electricity usage ($ktCO_2$-e)	Net emissions reduction ($ktCO_2$-e)
Residential	Phase-out of non-LED lighting	-	11.8	11.8
Industrial	Adoption of energy efficiency measures (assuming 100 per cent adoption rate)	48.9	169.2	218.1
Commercial	Enforcement of the Energy Conservation Promotion Act for existing designated buildings.	-	11.4	11.4
Transport	Increase the share of electric passenger cars to 50 per cent by 2030	50.7	-27.6	23.1
	Increase the share of electric motorbikes to 25 per cent by 2030	142.8	-44.4	98.4
	Increase the share of electric freight vehicles to 25 per cent by 2030	16.9	-3.1	13.8
Total		**259.3**	**117.3**	**376.6**

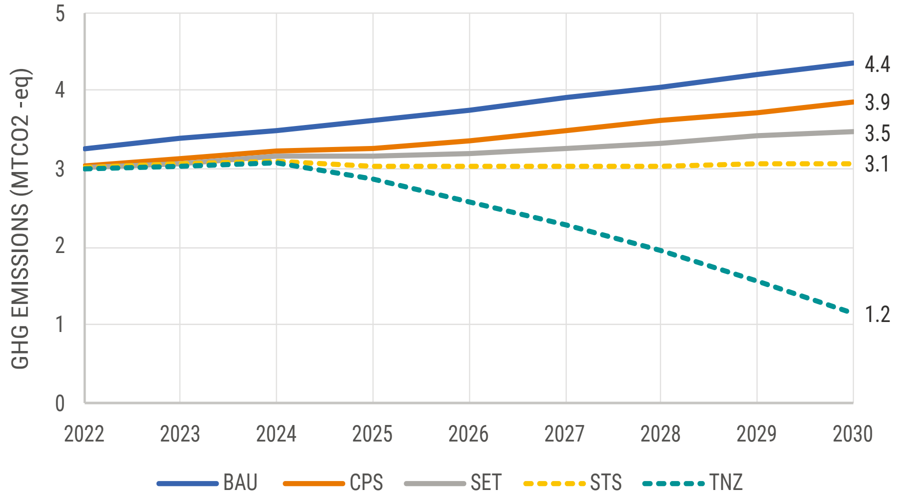
5. Raising ambitions with sustainable transport strategies and moving towards a net zero society

The SET scenario sets out various strategies in facilitating an economy-wide energy efficiency improvement in alignment with the national targets and commitment towards the Paris Agreement. However, Surat Thani province may consider more ambitious pathways, moving towards a net zero society.

Substantial energy demand and emissions reduction have been achieved in the SET scenario through energy efficiency improvement measures. These measures allow energy demand reduction of 295 ktoe and emission reductions of 377 $ktCO_2$-e, (9.8 per cent) relative to CPS. This also corresponds to a 20.1 per cent reduction from the BAU scenario, aligning with the national unconditional NDC commitment. Two ambitious scenarios have been modelled to further explore how Surat Thani may adopt more vigorous sustainable transport strategies and realise a steeper GHG emission reduction trajectory, moving towards a net zero energy system in the near future.

The Sustainable Transport Strategies (STS) scenario focuses on the opportunities in transitioning its transport sector through a greater degree of mass public transport and electric vehicles usage, realising a significant energy demand and GHG emissions reduction. On the other hand, the Towards Net Zero (TNZ) scenario, the most ambitious scenario, aims to pave the way towards achieving net zero in the near future. The measures proposed are, for example, decarbonising the province's power supply and fuel/clean technology substitution. The GHG emissions reduction that may be achieved with the two ambitious scenarios are shown in figure 20 and are further described in the following sections.

Figure 20. GHG emission trajectories, 2022-2030



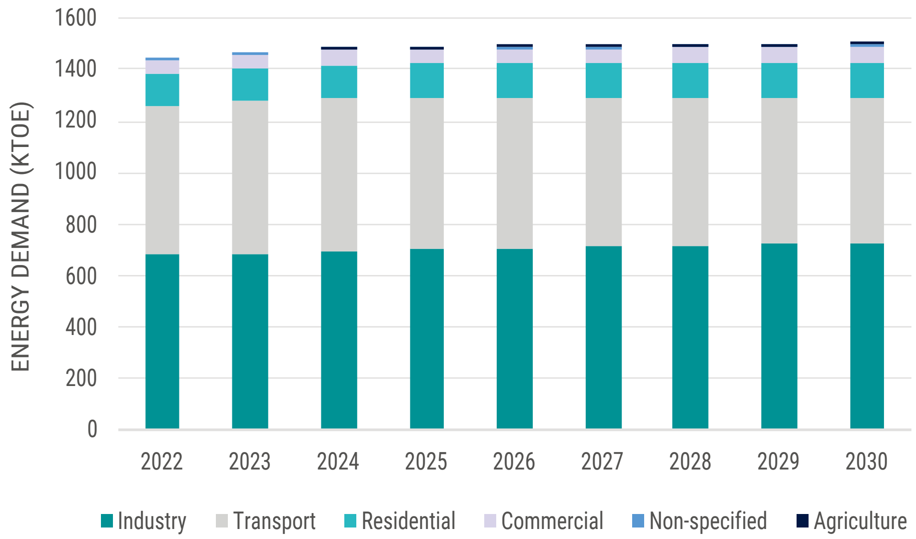
5.1. Ambitious scenario: Sustainable Transport Strategies (STS) scenario

Building on the SET scenario, the STS scenario explores how the province can further transition its transport sector through a greater degree of mass public transport and electric vehicles usage. It also allows the GHG emission reduction to align with the national conditional target (25 per cent compared to the BAU baseline). The energy demand reduction and GHG emission reduction are further explained below.

5.1.1. Energy demand outlook

The total final energy consumption is expected to increase from 1,254 ktoe in 2018 to 1,494 ktoe in 2030, a reduction of 175 ktoe compared with the SET scenario. The industrial sector will have the largest share, at 48.4 per cent, followed by the transport sector 37.7 per cent, the residential sector at 9.3 per cent and commercial sector at 4.4 per cent. Figure 21 shows the projected TFEC by sector under the STS scenario.

Figure 21. Projection of TFEC by sector, STS scenario, 2022-2030



5.1.2. GHG emission reduction and energy savings

The measures considered in the STS scenario and the respective energy demand and GHG emission reductions (compared to the SET scenario) are summarized in table 7. In terms of fuel usage, electricity demand in the transport sector will increase by 74.1 ktoe (861.5 GWh) while oil product consumption will decrease by 222.3 ktoe. Natural gas and biodiesel consumption will decrease by 1.6 ktoe and 25.2 ktoe, respectively. Therefore, net energy saving in the transport sector is estimated to reach around 174.9 ktoe.

Table 8. Energy efficiency measure applied and the estimated annual savings in 2030 (relative to SET) in the transport sector

Sector	Measure	Energy demand reduction (ktoe)	GHG emission reduction ($ktCO_2$-e)
Road – passengers	Reduces vehicle-km travelled in passenger cars by 20 per cent compared to the BAU baseline, through adoption of public mass transport (i.e., buses and minibuses)	131.8	327.7
	Increase the share of electric buses to 100 per cent by 2030		
	Increase the share of electric passenger cars to 45 per cent by 2030		
	Increase the share of electric motorbikes to 55 per cent by 2030	15.5	36.6
Road - freight	Increase the share of electric freight trucks to 20 per cent by 2030	18.3	14.3
Marine	Mandating Ship Energy Efficiency Management Plan (SEEMP) • Assumes achieving a 20 per cent reduction in energy intensity by 2030, relative to the 2018 baseline.	9.3	28.1
Total		**174.9**	**406.7**

The GHG emission reduction is significant, particularly with a simultaneous increase in public transport usage and ambitious electric buses and cars adoption. This, however, requires great coordination by the public and private sectors in expanding public transport reach and charging facilities, while providing incentives for electric vehicle adoption by the general public.

The travelled-kilometres by minibuses and buses are projected to more than double that in 2018. In addition, a 100 per cent electric bus fleet requires a vigorous adoption from early years onwards as well as early retirement of internal combustion engines. The yearly sales share of electric-type motorcycles and passenger cars should aim to start from 25 per cent in 2023, rapidly rising to 100 per cent by 2026. Freight trucks may, on the other hand, take a more conservative approach as options are currently less abundant – starting from a yearly sales share of 15 per cent in 2023, rising to 50 per cent by 2030.

In the marine transport sector, the provincial government may consider mandating a Ship Energy Efficiency Management Plan (SEEMP) for all shipping companies, while establishing an energy intensity reduction target of 20 per cent compared to a baseline. SEEMP can be described as an operational measure that establishes a mechanism to improve the energy efficiency of a ship in a cost-effective manner (IMO, 2019). It allows shipping operators to track and improve operational and fleet performance with the aid from Energy Efficiency Operational Indicator (EEIO) as a voluntary monitoring tool. Such measures have been mandated by the International Maritime Organisation (IMO) to reduce the environmental impacts from international shipping.

Box 1. Examples of marine energy efficiency measures

A Ship Energy Efficiency Management Plan (SEEMP) has been made mandatory for new and existing ships above 4,000 gross tonnages from 2013 onwards, with the exception of ships operating domestically. The implementation of SEEMP is ship-specific and can be implemented in the following four steps:

1. **Planning** – to determine the current status of ship energy usage and identify the ship energy efficiency measures. This stage also encourages identifying measures in improving company specific-measures (i.e., stakeholder coordination) and human resource development;

2. **Implementation** – to establish systems for implementation of the selected measures, which include task-setting and delegation to qualified personnel as well as implementation timeline planning. The measures should be carried out according to the systems established and the process should be recorded to aid self-evaluation at a later stage;

3. **Monitoring** – the energy efficiency of a ship should be continuously monitored quantitatively, in accordance with an internationally recognised standard such as,, for example, the Energy Efficiency Operational Indicator (EEOI) monitoring tool;

4. **Self-evaluation and improvement** – to evaluate the effectiveness of the planned measures and of their implementation.

The following table lists examples of energy efficiency measures that may be explored within each ship's SEEMP.

Category	Measure
Fuel efficient operations	Improved voyage planning
	Weather routeing
	Just in time
	Speed optimization
Optimised ship handling	Optimized shaft power
	Optimum trim
	Optimum ballast
	Optimum propeller and propeller inflow considerations
	Optimum use of rudder and heading control systems (autopilots)
Hull maintenance	Proper maintenance of the hull system

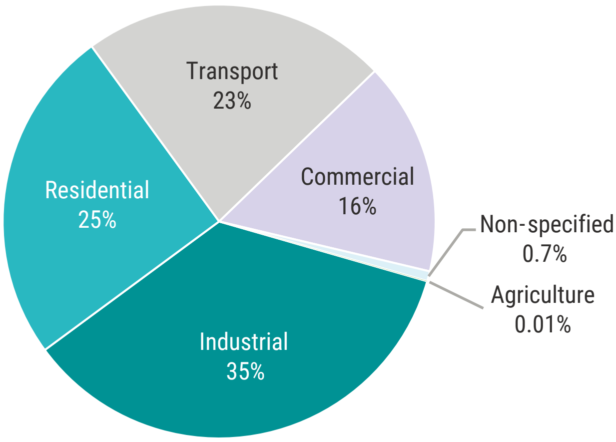
Propulsion system	Propulsion system maintenance
Waste heat recovery	Utilize waste heat from the engine system
Improved fleet management	Efficient management of fleet to avoid fuel wastage

Source: Lloyd's Register, 2012, MEPC.213(63).

5.1.3. Electricity demand and supply in 2030

The demand for electricity in 2030 is projected to be 4,819 GWh in the STS scenario, an increase of 861 GWh compared to the SET scenario. Such increase is solely due to the proposed increase in the share of electric vehicles across the vehicle subcategories. As shown in figure 22, the transport sector has a 23 per cent share of electricity demand in the STS scenario, compared to a 6 per cent share in the SET scenario. This increase in electricity demand in the transport sector is due to rapid electrification of vehicles.

Figure 22. Electricity demand in 2030 by demand sector, STS scenario



5.1.4. Energy flows and balance, 2030

In the STS scenario, TPES is forecast to increase from 1,254 ktoe in 2018 to 1,494 ktoe in 2030. Figure 23 further shows the TPES breakdown by fuel type, while figure 24 shows the energy flows in 2030.

Figure 23. TPES breakdown by fuel type, STS in 2030

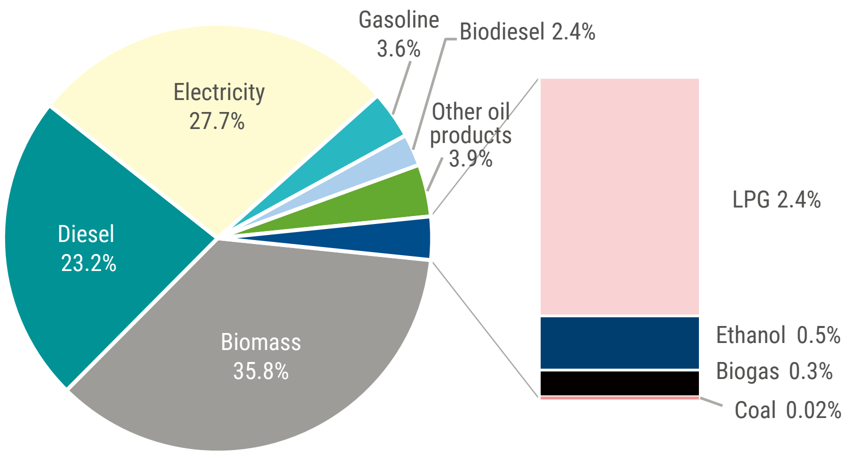
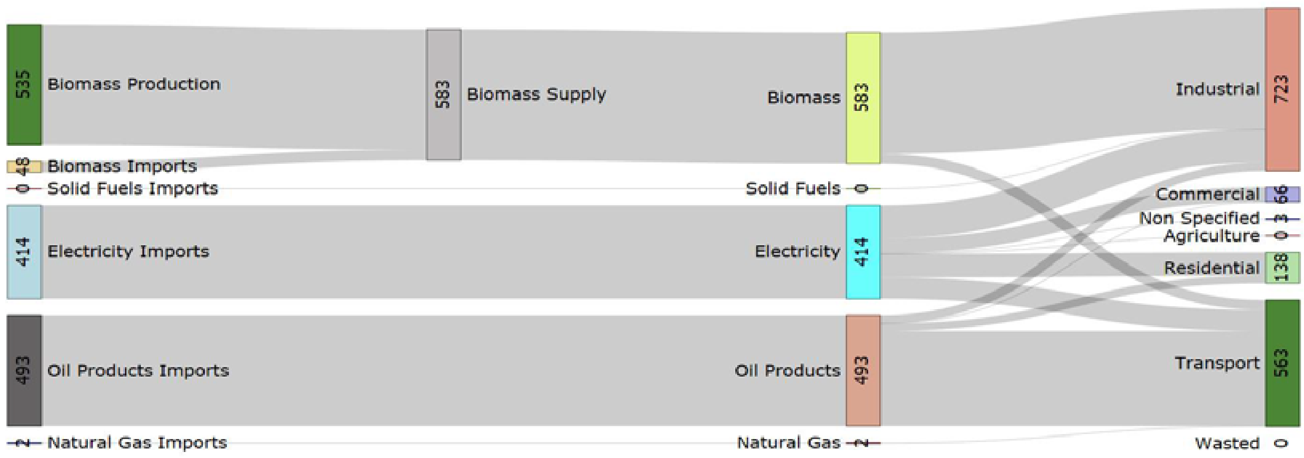


Figure 24. Sankey Diagram, STS in 2030 (unit: ktoe)



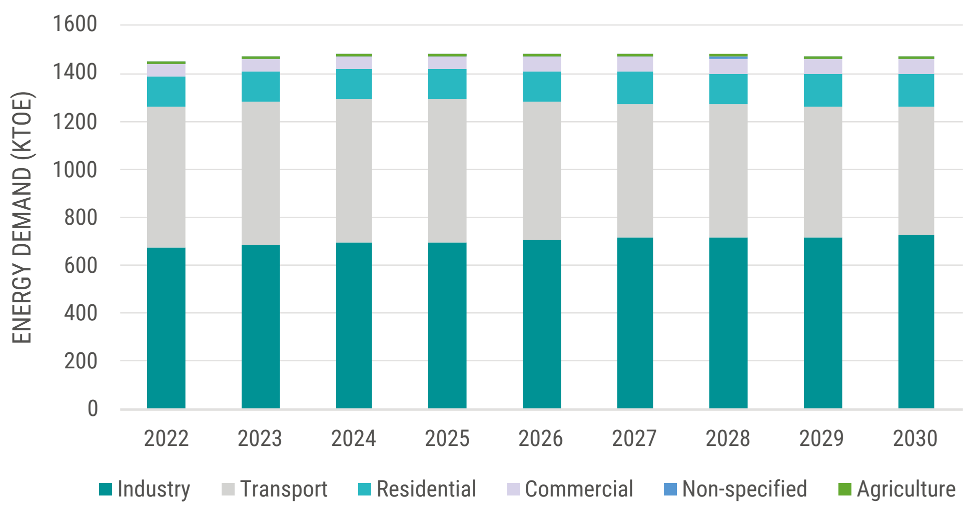
5.2. Ambitious scenario: Towards Net Zero (TNZ) scenario

Climate change has become one of the most pressing global issues, whereby a net zero goal within the coming decades is essential to limit the impacts of climate change. Achieving a net zero goal by 2030 is challenging. However, Surat Thani may consider several ambitious measures to realise a more rapid decline in the GHG emissions reduction trajectory, paving the way towards achieving net zero in the near future. The measures are, for example, decarbonising the province's power supply and a fuel/clean technology substitution. The measures proposed (in addition to the ones already proposed for the SET and SST scenarios) are further explained in the following subsections.

5.2.1. Energy demand outlook

The total final energy consumption is expected to increase from 1,254 ktoe in 2018 to 1,463 ktoe in 2030. The industrial sector still has the largest share, at 49.4 per cent, followed by the transport sector at 36.6 per cent, the residential sector 9.3 per cent and the commercial sector at 4.5 per cent. Figure 25 shows the projected TFEC by sector under the TNZ scenario.

Figure 25. Energy demand by sector, TNZ scenario, 2022-2030



5.2.2. GHG emission reduction and energy savings

The measures considered in the TNZ scenario, and the respective energy demand and GHG emission reductions (compared to the STS scenario), are summarized in table 9.

Table 9. Energy efficiency measure applied and the estimated annual savings in 2030 (relative to STS) in the TNZ scenario

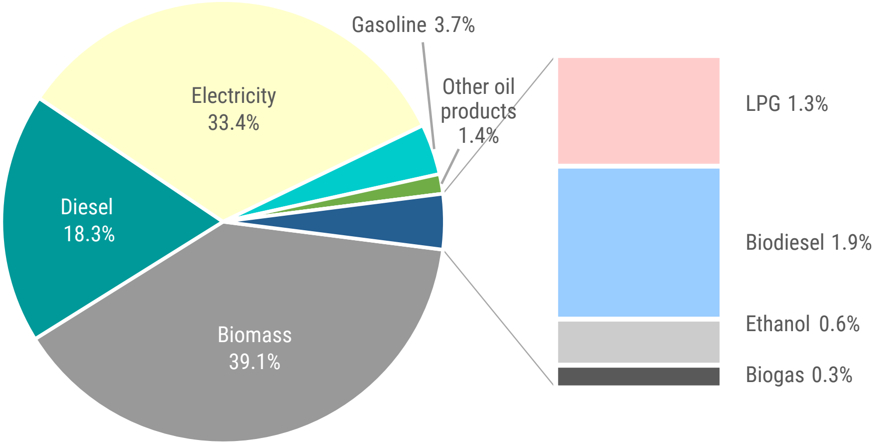
Sector	Measure	Energy demand reduction (ktoe)	GHG emission reduction ($ktCO_2$-e)
Power	Achieving a 100 per cent decarbonised power supply by 2030	-	1,518.1
Industry	Fuel substitution in the industry sector[12]	-	111.1
Transport	Increase the share of electric freight trucks to 50 per cent by 2030[13]	27.4	244.3[14]
Residential	Increase the adoption of electric cooking stoves to 50 per cent by 2030	2.6	50.5[14]
Total		**30.0**	**1,923.9**

The power sector is often regarded as the low-hanging fruit in achieving a net zero energy system, particularly with the competitive cost of renewable electricity. Although the emissions associated with electricity usage made up around 41 per cent of Surat Thani's GHG emissions in 2018, decarbonising the electricity supply can be a cost-effective and efficient way of achieving a substantial GHG emissions reduction. Other measures are also important to Surat Thani's net zero endeavour – fuel substitution can be considered in the industrial sector, while electrification can be further promoted, such as in the transport and residential sectors.

5.2.3. Energy flows and balance, 2030

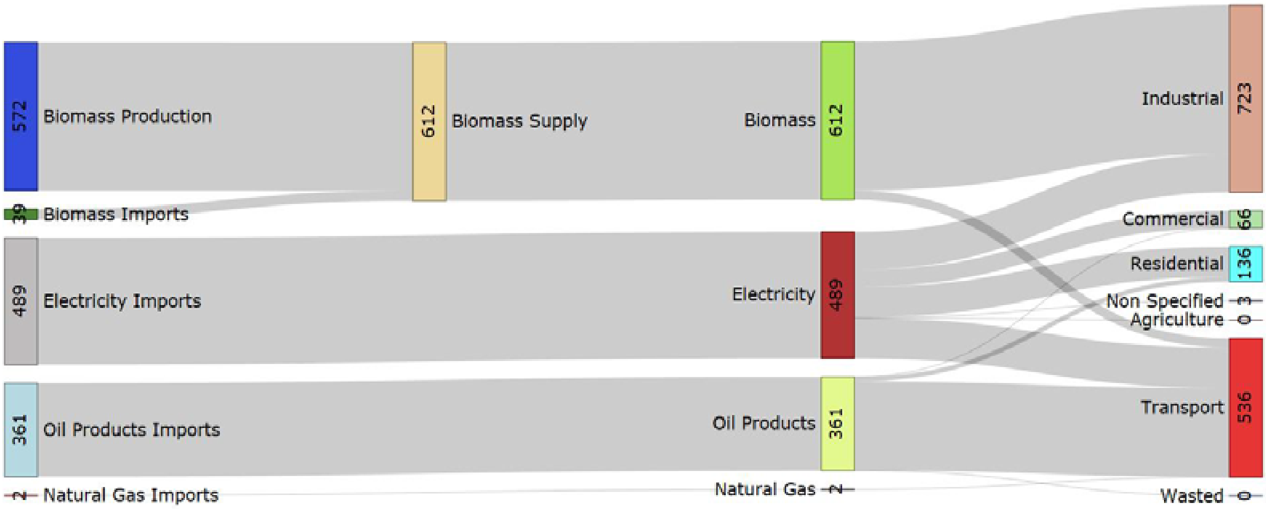
In the TNZ scenario, TPES is forecast to increase from 1,254 ktoe in 2018 to 1,463 ktoe in 2030. Figure 26 shows the TPES breakdown by fuel type, while figure 27 shows the energy flows in 2030.

Figure 26. TPES breakdown by fuel type, TNZ in 2030



12 A small amount of coal and oil products are currently used in the industrial sector for heating purposes. NEXSTEP proposes fuel/technology substitution with biomass boilers, assuming that the energy intensity remains the same.
13 This requires the market penetration rate of electric freight trucks to be 25 per cent in 2023, rising to 100 per cent by 2030.
14 Savings in direct fuel combustion.

Figure 27. Sankey Diagram, TNZ in 2030 (unit: ktoe)



5.2.4. Pathways to decarbonizing Surat Thani province's electricity supply

The electricity demand is projected to be 5,687.8 GWh in 2030. Surat Thani currently fulfils almost all its electricity requirements with electricity from the central grid. Significant challenges exist for the province to increase the share of renewable energy in its electricity supply, as the province currently does not have direct control on the central grid, be it the RE share or the grid emissions. Nevertheless, there are a few pathways that the province may explore, ins collaboration with the citizens and/ or private investors, in order to achieve a net-zero carbon power supply objective:

(a) Rooftop solar PV installation can be promoted for both new and existing buildings. Incentivising rooftop solar PV installation provides two benefits to the province – (i) reducing the financial burden on the city for establishing the province's own utility-scale solar PV system, and (ii) reducing land-use requirement from ground-mounted PV. The provincial government may consider offering incentives to increase the uptake of solar PV rooftop systems (see figure 28 for LCOE comparisons);

(b) Establishing power purchase agreement (PPA).The province can enter into a special renewable energy power purchase agreement with interested RE suppliers. In turn, the supplier will provide Surat Thani with an agreed RE share electricity (solar, wind, biomass etc.) at an agreed price. However, this may not allow the province to take advantage of the lower generation costs available, such as through renewable energy auction;

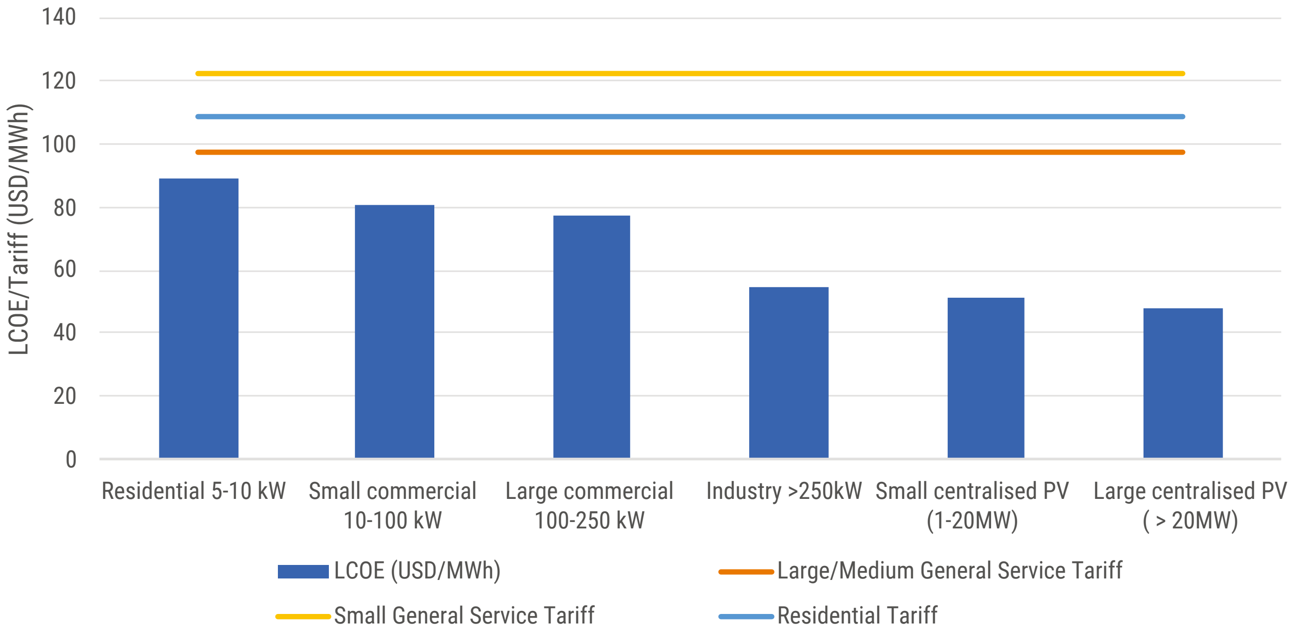
(c) Lowering cost through renewable energy auctions. A more workable solution and the recent policy instrument is the renewable energy auction. This approach is likely to substantially decrease the cost of electricity supply through competitive pricing bidding and, therefore, return a greater net benefit, e.g., the 60 MW solar PV auction in Cambodia achieved US$ 0.0387 per kWh (ADB, 2019). Further details of renewable auctions are given in box 5;

(d) Promotion of biomass generation. Surat Thani currently has a 60 MW biogas plant and a 101 MW biomass plant. Depending on the remaining biomass resource potential, additional capacity may be added as a way to increase the RE share of the province's electricity supply. As mentioned above, these may be done through a PPA and/or renewable energy auction, in collaboration with interested investors and facility operators. Moving forward, a feasibility study can be conducted to investigate the resource potential as well as the business case for such facilities. Public perception should be one of the deciding factors.[15]

15 As noted during the inception workshop, the province currently faces strong opposition against the construction of a biomass plant.

The above are four pathways that the province may pursue. A combination of one or more pathways, specifically with urban solar PV and renewable energy auction, may be a good solution. Figure 28 shows that the LCOE of solar PV systems[16] are cheaper in comparison to the different tariff categories. The cost assumptions are included in the annex III.

Figure 28. LCOE of solar PV systems at different scales, in comparison to the average tariffs[17]



Box 2. Cost-benefit of decarbonized power supply and GHG reduction

The tables below in this box show further the financial savings and GHG reduction that can be achieved with different levels of a provincially-arranged/generated renewable electricity target.[18] For example, at a 100 per cent renewable electricity target, the GHG emissions are reduced to only 1.15 $MTCO_2$-e. This remaining GHG emission is attributable to the remaining usage of LPG stoves for residential cooking, the use of fossil fuel in internal combustion engine (ICE) vehicles yet to be phased out as well as in other transport sectors that are hard-to-abate in the near term (i.e., road freight, marine and aviation). Nonetheless, the TNZ scenario puts Surat Thani on a path towards realising net-zero in the coming decades, as technologies continue to develop and mature.

The financial benefits to be gained through a decarbonised power supply depend on the pathways the province undertakes. The following cost-benefit analysis considers the price difference between an average tariff US$ 0.107[19] and a low auction price that has been reached in the ASEAN region of US$ 0.0387 per kWh. At a 100 per cent renewable electricity target, the annual saving is around US$ 386 million in 2030.

16 It considers only CAPEX and fixed O&M, and assumed discount rate of 5.37 per cent.

17 The different tariffs are the averaged tariff with reference to the data provided on the Metropolitan Electricity Authority website.

18 Provincially-arranged/generated renewable electricity target refers to the target share of electricity demand fulfilled through renewable electricity generated within the province, or renewable electricity purchased through a PPA or RE auction.

19 It is noted the tariff quoted includes charges for transmission and distribution, and other service costs; hence the financial savings estimated might be an overestimation. A more precise estimation can be made if generation cost data are available.

GHG emissions and financial savings at different levels of RE target, DPS

	Self-arranged RE target				
	0%	**25%**	**50%**	**75%**	**100%**
Province's self-arranged RE generation in 2030 (GWh)	0	1422	2844	4266	5688
Emissions from central grid electricity supply (kTCO$_2$-e)	1.8	1.3	0.90	0.45	0
Total emissions in 2030 (ktCO$_2$-e)	2.94	2.50	2.05	1.60	1.15
Emission reduction relative to BAU in 2030	32.5%	42.8%	53.0%	63.3%	73.6%
Financial savings (US dollar million)	0	96	193	289	386

The RE price is likely to decrease further in the near-future as the technology costs decline. The grid generation cost may also decrease as RE penetration increases, lowering the central grid tariff. The table below shows the estimated financial savings at different uncertainty points. It can be observed that, in almost all cases, financial savings are positive. Considering the low solar PV generation costs compared with other conventional power plants, financial gains through 100 per cent renewable-based electricity are guaranteed.

		Financial savings (million US dollars)				
		Change in RE price				
		50%	**25%**	**0%**	**-25%**	**-50%**
Change in average grid tariff	**50%**	579	634	689	744	799
	25%	427	482	537	592	647
	0%	276	331	386	441	496
	-25%	124	179	234	289	344
	-50%	27	28	83	138	**193**

In 2016, approximately direct employment for 17,750 persons was created in Thailand's renewable energy industry in contrast to direct employment for 1,950 persons in the coal generation industry (Greenpeace, 2018). The biomass industry accounts for 80 per cent of employment rate (14,323 jobs) followed by solar energy industry (2,588 jobs). The biogas and wind industries provided around 757 and 90 jobs, respectively. As a result, the decarbonization of the power supply in Surat Thani might offer further creation of direct and indirect job opportunities in the province.

6. Low carbon transition for Koh Samui

Surat Thani province encompasses several famous tourist islands, which contribute substantially to the province's economy. In particular, Koh Samui is the largest island in the province, and the second largest in Thailand. Koh Samui is located in north-easteast Surat Thani, about 20 km distance from the mainland. It has a total land area of 228 km^{2}, with an estimated population of 70,000 in 2019 (Thomas Brinkhoff, 2020). The island welcomed 2.7 million tourists in 2018 (Worrachaddejchai, 2019). The strong economic activity arising from its tourism industry also results in a high energy demand and carbon emissions from the island. However, measures proposed in chapters 4 and 5 of this report can similarly be implemented on the island of Koh Samui, transitioning it towards a low-carbon town.

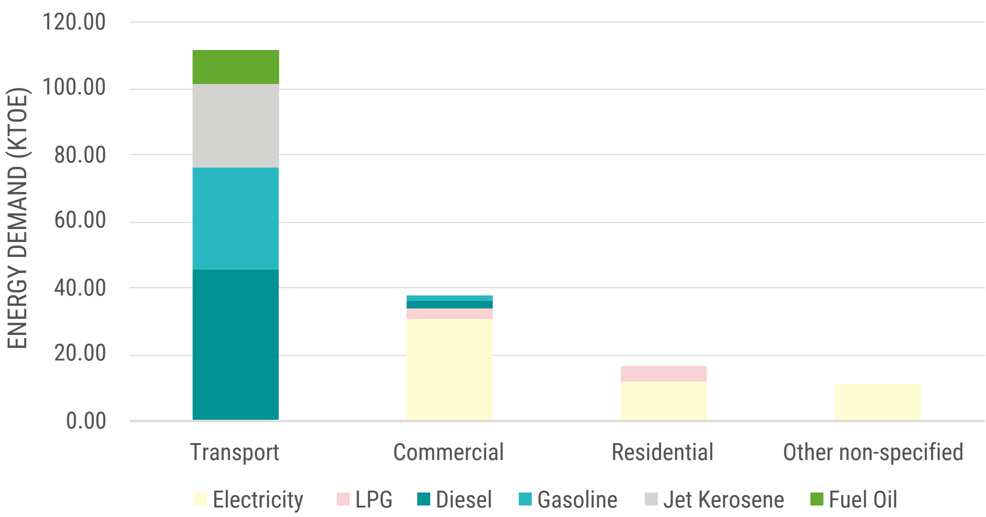
This chapter details Koh Samui's energy demand and carbon emissions in its baseline year of 2017, and projected growth towards 2030. It then explores the energy savings potential from the different measures proposed in chapters 4 and 5.

Disclaimer: The data collection for Surat Thani and Koh Samui was conducted during two separate exercises at different times. Hence, slight data discrepancies are present due to the different collection approaches employed. In addition, 2017 is used as the baseline year for the energy demand and GHG emissions projections for Koh Samui as data for the later years are not available. On the other hand, 2018 is used as the baseline year for Surat Thani.

6.1. Energy demand and GHG emissions in 2017

Koh Samui's demand sectors are classified into residential, commercial, road transport[20] and non-specified sectors[21] (figure 29). The total energy demand in 2017 was 177 ktoe. The largest demand was from the transport sector, at around 63 per cent of the energy demand. The demand for electricity[22] is the highest – at 53.3 ktoe (620 GWh).

Figure 29. Energy consumption in Koh Samui by sector in 2017



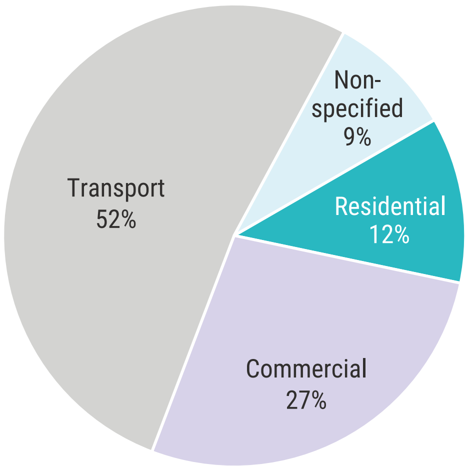
20 The transport sector considers road passenger transport, marine transport and air transport sectors.

21 NEXSTEP does not consider the industrial sector as one of the demand sectors due to limited clarity of the measured data available. It is noted that around 43 factories are registered (EEC Engineering Network, 2012) that are categorized as small and medium-sized enterprises (SMEs), but are not a major source of carbon emissions.

22 Type 2 to type 6 electricity users (as per the Provincial Electricity Authority (PEA) classification) are assumed to be commercial sector.

The GHG emissions was estimated at 610 ktCO_2-e in 2017. Figure 30 shows the emission distribution, which considers emissions from direct fuel combustion as well as emissions from electricity usage.

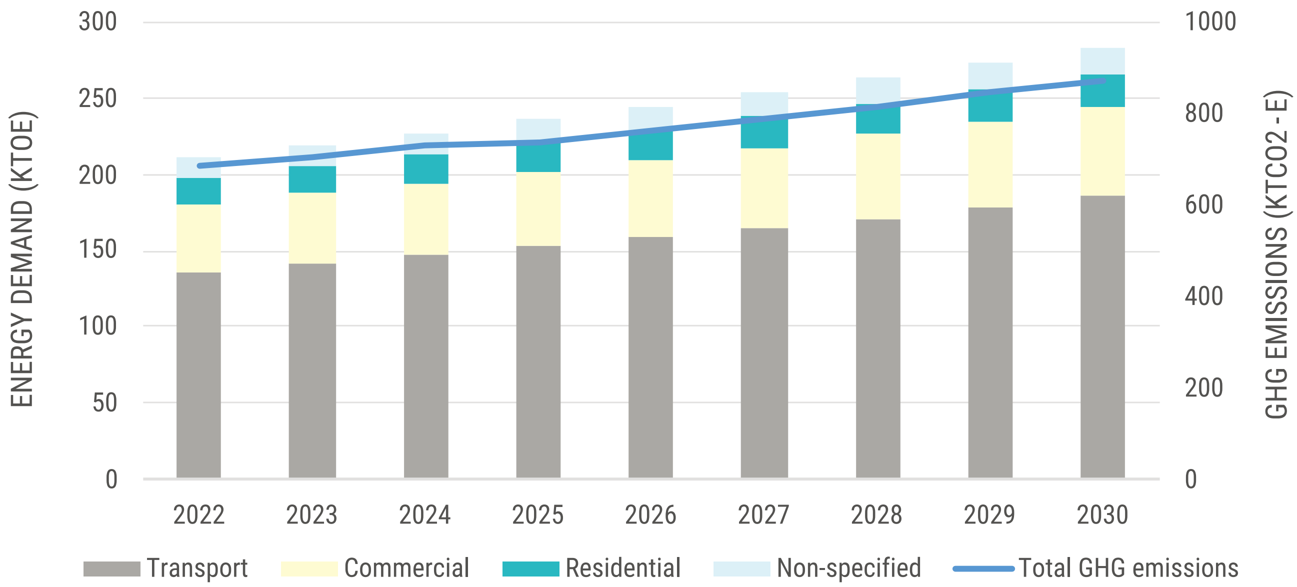
Figure 30. GHG emissions by sector, 2017



6.2. Energy demand and GHG emissions outlook under the current policy settings

The population of Koh Samui has increased during recent years. In 2005, the population was recorded at 47,000, rising to 53,000 in 2009. In 2019, the population was estimated to be 70,000. Tourism similarly increased substantially from around 1 million per year during 2006-2010 to 2.7 million in 2018. In turn, increases in energy demand and GHG emissions can be expected under the current policy settings. Energy demand is projected to rise to 284 ktoe, while GHG emissions are projected to reach 872 ktoe in 2030. Figure 31 shows the energy demand and GHG emission outlook towards 2030, assuming the activity growth summarized in table 1.

Figure 31. Energy demand and GHG emissions outlook, Koh Samui



6.3. Energy savings and GHG emission reduction potential under energy transition pathways

Chapters 4 and 5 of this report explore the energy transition pathways for Surat Thani under varying ambition levels. The SET scenario explores energy efficiency measures required to put Surat Thani on the path to meeting the national energy efficiency target as well as aligning emission reduction with the national unconditional target. On the other hand, further energy savings and GHG emission reductions can be realised, as proposed under the STS and TNZ scenarios.

The energy efficiency measures proposed can be similarly applied to Koh Samui. For example, transport electrification strategies can be pursued, such as encouraging the adoption of electric vehicles by the local population as well as a part of rental vehicle offerings. On the other hand, energy efficiency measures can be adopted by existing commercial buildings, making Koh Samui a green tourism destination.

Figure 32 shows the energy demand projections of the different scenarios and the potential savings relative to the CP scenario. As can be observed, the energy savings potential is substantial with ambitious transport strategies.

Figure 32. Energy demand outlook under different scenarios and potential energy savings

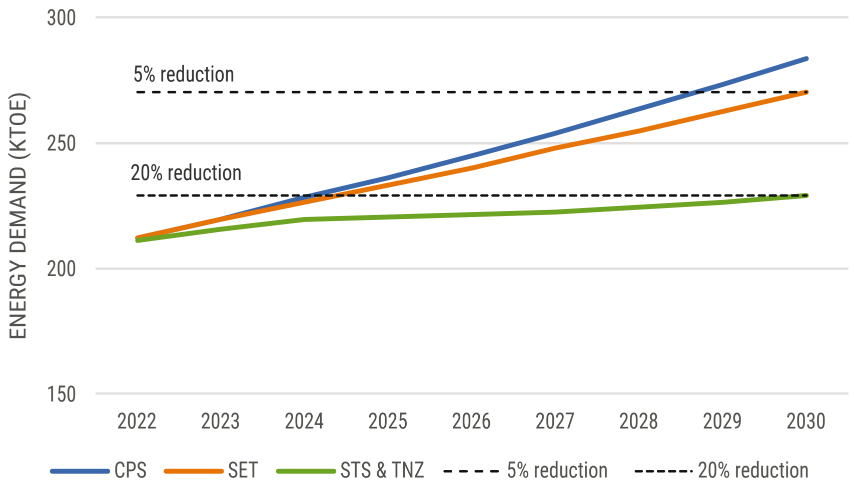
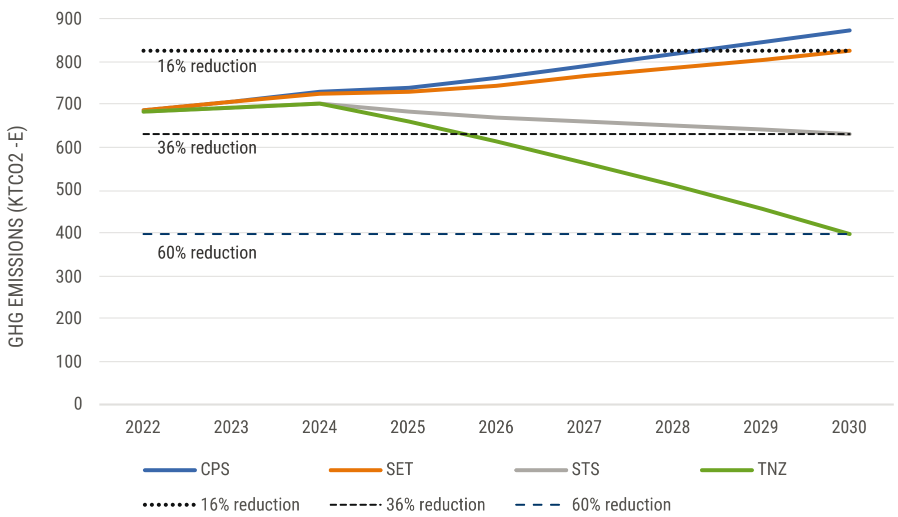


Figure 33 shows the GHG emission projections under different scenarios for Koh Samui. Similar to the projections for Surat Thani, GHG emissions reduction is significant under a 100-per cent decarbonised power supply.

Figure 33. GHG emission projections under different scenarios for Koh Samui



Box 3. Estimation of energy savings potential and GHG emissions potential for Koh Samui

The energy consumption data provided for Koh Samui is provided in terms of total fuel consumption, as activity level and energy intensity are not available. Such data would enable detailed and more accurate modelling, similar to the one performed for Surat Thani province, to be performed. The energy savings potential for Koh Samui has been quantified using a simple estimation method. The energy savings potential for the different demand sectors (and fuel types) are based on the percentage reduction for Surat Thani, relative to the CP scenario. GHG emissions are then quantified based on the final estimation of energy demand. In reality, the energy savings potential and GHG emission reduction are likely to differ from those estimated. Further study should be conducted to better estimate and identify measures best tailored for Koh Samui.

6.4. Decentralising renewable energy generation for Koh Samui

The electricity demand from activities on Koh Samui is currently fulfilled by several submarine cables from the mainland of Surat Thani province. Sooner or later, the electricity demand will surpass the cable capacity. With electricity demand expected to increase further from transport electrification strategies, the provincial authority should align the island's power capacity planning with its low-carbon development.

As part of the province's low-carbon endeavour, particularly with decarbonization of the power sector, Koh Samui may consider the adoption of decentralised renewable energy generation. This will lessen the need to expand power supply capacity from the mainland. The capacity potential as estimated by experts (EEC Engineering Network, 2012) is summarised in table 10.

Table 10. Renewable electricity potential in Koh Samui

Technology	Capacity potential	Generation potential	Further details
Solar PV farm	35 MW	52.5 MWh/day	Taling Ngam is suggested as a suitable place for solar PV installation. A total 35 MW of ground-mounted installation is estimated to take up around 560,000 square metres of surface area.
Solar PV rooftop	50 MW	52.5 MWh/day	This considers every potential commercial and residential rooftop of more than $10m^2$
Wind turbine	0.24 MW	52.5 MWh/day	Wind generation potential is quite limited in Koh Samui. Approximately 20 turbines of 12kW capacity could be installed along the coastal area of Ang Thong Road.
Small hydropower	0.75 MW	52.5 MWh/day	Small-scale hydroelectric plants can be considered along canals in the Lamai area and at Hin Lad waterfall.

6.5. Waste management approaches for Koh Samui

Waste is one of the significant environmental challenges in Koh Samui. Between 150 and 160 tonnes of waste are generated daily. Plastic waste accounts for 29.4 per cent of waste generated in Koh Samui, followed by organic waste at 27.4 per cent.[23] The remaining 43.2 per cent comprises other types of waste (not specified).

Currently, there are two main approaches to managing waste on the island: (a) waste is collected and sent to a landfill site and then packed into a cube shape (1 ton per cube), and are subsequently sent to Surat Thani mainland by ships (current capacity is around 100 cubes or 100 tonnes of waste per day; and (b) some waste which is not packed is used as landfill.

Leftover waste at the landfill site is around 300,000 tonnes. Koh Samui used to have a waste incinerator with a capacity of around 140 tonnes per day. However, this incinerator has been broken and out of operation since 2002. There are a few pathways that the province could explore, in collaboration with the citizens and/or private investors, in order to manage the waste:

(a) Promotion of 4R (reduce, reuse, recycle and recover) and waste segregation. Maximising recycling/reuse will minimise waste at the landfill while simultaneously optimising the economic value (recyclables are normally worth more). In addition. waste segregation at source is an effective way of keeping individual types of waste. For example, diversion of organic waste to composting reduces landfill inputs and potentially extends the life of the landfill;

(b) Rejuvenation of the incinerator facility. The existing incinerator facility might be restorable as a waste-to-energy facility. The municipal solid waste is treated to be used to heat water in a boiler to produce steam. The steam can then be used to generate electricity through steam-driven turbines. The LCOE for renewable municipal waste varies from 0.05 to 0.20 US$/KWh (IRENA, 2020);

(c) Generation of refuse-derived fuel (RDF). It is produced from combustible components of municipal solid waste. Such materials include non-recyclable plastics, paper and cardboard, and generally ‘corrugated’ materials These materials are treated to reduce the moisture content before they can be finally burnt in a co-firing plant to produce electricity. Segregation at source is useful in isolating the wastes that will provide a more suitable basis for RDF feedstock production.

23 Secondary data from the Samui Municipality Development Plan, B.E. 2566-2570.

7. Policy recommendations for a sustainable energy transition

Chapter 3 demonstrates how sustainable energy transition can be accelerated to progress Surat Than province's development in line with the national targets and commitment towards the Paris Agreement. Chapter 4 provides tangible low carbon transition pathways for Surat Thani, with the most ambitious pathway reaching a GHG emissions as low as 1.15 $MTCO_2$-e by 2030. This chapter presents several policy recommendations, which further elaborate on the interventions proposed.

7.1. Transitioning to industrial best practices to realise substantial energy savings in energy demand

The energy consumption of the industry sector is the highest – at around 47.6 per cent in 2018. This gives a substantial energy savings potential through a transitioning industry into a more energy-knowledgeable sector. As modelled in SET, the proposed energy efficiency interventions may allow an energy demand reduction of 232 ktoe (24.3 per cent).

Without further region-specific information, the suggested energy savings potential for several industries is based on the potential savings provided in the Energy Efficiency Development Plan (MOE, 2011). These are approximately assessed by comparing Thailand's average specific energy consumption (SEC) in 2009 with the best SEC in other countries or within Thailand. Nonetheless, potential savings may vary from site-to-site; hence in-depth energy audits and baseline studies on a production site basis should be conducted in order to understand the energy efficiency and fuel switching potential in the industrial sector. Box 4 provides a list of energy improvement measures that are generally applicable in the different subsectors.

Industrial companies in Surat Thani should be encouraged to perform regular energy audits to assess their energy efficiency improvement potential as well as implementation of energy savings measures (i.e., using more efficient appliances). However, the high cost of conducting an energy audit and subsequently implementing energy efficiency measures are often a barrier to widespread adoption, particularly for SMEs. The provincial government could consider providing financial incentives and subsidies to encourage such practices. Needless to say, energy conservation awareness among the industrial owners is imperative to ensuring a successful sustainable transition.

Box 4. Energy efficiency measures in the industrial sector

The areas of potential savings that are generally present in the different subsectors include (but are not limited to):

- Improvement in motor loading;
- Replacement of old and rewound motors;
- Installation of capacitor banks and increasing efficiency of existing capacitor banks;
- Improvement in combustion efficiency of boilers;
- Regular cleaning and maintenance of boiler equipment (i.e., condenser pipes);
- Installation of more efficient electric motors;
- Improvement of the steam distribution system, including leakage control and insulation improvement;
- Electricity load management;
- Minimization of energy losses by partition of cooling areas, with installation and effective use of air curtains;
- Minimization of heat losses from the boiler (or kilns for the cement sector);
- Condensate and waste heat recovery.

7.2. Sustainable transport strategies to realise a low-carbon transport sector

Surat Thani's transport sector accounted for about 40 per cent of the total energy demand and contributed about half of the province's GHG emissions in 2018. Hence, ambitious policy actions for the transport sector are critical for Surat Thani to realise substantial GHG emission reduction, aligning with the national NDC commitment – specifically through the adoption of transport electrification.

Electric vehicles have garnered great interest globally, growing exponentially during the past decade. Electric car sales passed 2 million globally in 2019, with a projected compound annual growth rate of 29 per cent through 2030 (Deloitte, 2020) . Various governmental policies have been introduced, which directly or indirectly promote the adoption of electric vehicles as a means of achieving environmental and climate objectives. Thailand similarly has a grand plan for e-mobility, targeting 50 per cent zero-emission vehicles (ZEVs) of its domestic vehicle production by 2030, and an ambitious target for the registration of new cars to be 100 per cent ZEVs by 2035 (Ministry of Foreign Affairs, 2021). The SET scenario targets a 15 per cent electric share for passenger cars and motorcycles, and a 50 per cent electric vehicle share for buses and minibuses by 2030. These, altogether, are projected to reach 57.3 ktoe of energy demand and 135 ktCO_2-e of GHG emissions reduction in 2030.

Promoting the use of public transport, specifically buses, can effectively reduce fuel consumption by the transport sector. It is also a means of reducing traffic congestion – a major problem in cities. With the urbanization rate expected to rise in the foreseeable future, traffic congestion is likely to worsen without intervention. In addition, air pollution can be substantially reduced by taking cars off the road. The impact of increased mass public transport adoption on GHG emissions and energy demand is further examined in the STS scenario, simultaneously with a higher ambition for transport electrification.

Several potential technical barriers to widespread adoption of electric vehicles include increased demand for grid electricity and the lack of charging facilities. Close collaboration between the province and power development agency should be fostered to carefully deliberate the potential impact on the power and grid infrastructure. In addition, the provincial government should take a lead in establishing an extensive charging infrastructure and expanding public transport infrastructure.

The total length of highways with four or more lanes in Surat Thani is approximately 507 km. It is assumed that installation of fast-charging points (> 55kW) at 7-km intervals, with each costing around 1 million baht (US$ 30,000 equivalent). The total number of charging points required are estimated to be 73 units, with a total investment cost of US$ 2.2 million. However, an in-depth study should be conducted to come up with implementation strategies and a workable business model, with the possibility of public-private partnerships

7.3. Pursuance of high renewable power share through cost-effective pathways

Renewable capacity has increased significantly across the globe amid climate change concerns. The decarbonization of the power sector is generally regarded as the low-hanging fruit, as the cost of renewable power technologies has decreased rapidly during the past decade. With electricity constituting around a quarter of the total fuel consumption and more than 42 per cent of the GHG emissions in 2018, decarbonizing the electricity supply provides a quick decarbonization pathway, reaching a substantial GHG emissions reduction, while providing financial benefits. NEXSTEP proposes four different pathways that may be considered in decarbonizing the electricity supply, as described in subsection 4.2.4. A combination of these four pathways can be adopted.

Renewable energy auctions may be the most cost-effective and efficient option, whereby contracts and agreements are awarded through competitive bidding. While the renewable energy auction mechanism and its associated standards are set at the national level, Surat Thani province can work with the central Government to implement RE auctions at the province level. Box 5 explains further the renewable energy auction in detail.

Box 5. Mechanism of renewable energy auction

A renewable energy auction, also known as a "demand auction" or "procurement auction", is essentially a call for tenders to procure a certain capacity or generation of renewables-based electricity. The auction participants submit a bid with a price per unit of electricity that they are able to realize with the project. The winner is selected on the basis of the price and other criteria, and a power purchase agreement is signed. The auctions have the ability to achieve deployment of renewable electricity in a well-planned, cost-efficient and transparent manner. Most importantly, it makes the achievement of targets more precise than would be possible by other means, such as a Feed-in-Tariff (FiT).

Auctions are flexible and they allow Governments to combine and tailor different design elements to meet deployment and development objectives. Unlike FiTs, where the Government decides on a price, auctions are an effective means of discovering the price appropriate to the industry, which is the key to attracting private sector investment. In addition, an auction provides greater certainty about future projects and is a fair and transparent procurement process. However, the administrative and logistic costs associated with auctions are very high unless multiple auctions are undertaken at regular intervals.

It is imperative that an auction be appropriately designed to (a) avoid the risk of underbuilding and project delays, and (b) allow sufficient competition among different levels of bidders in order to drive down the cost. IRENA suggests the following key design elements:

- Auction demand. Governments need to clearly indicate the scale or size of each auction, the preferred technology (technology neutral of a specific technology), auction frequency, and the upper and lower limits of project size and price;
- Pre-qualification. A strict or high pre-qualification for bidders will leave out the smaller entities, while a relaxed pre-qualification may undermine the quality of the project and increase the administrative costs. Governments need to make a trade-off, depending on the project size and other development objectives;
- Selection criteria. Commonly, two selection criteria are used: (a) the lowest bid where only the lowest bidder will win; and (b) lowest bids plus other objectives where, in addition to the price, other objectives such as local content and jobs are taken into consideration;
- Payment modalities. The pay-as-bid model is good for minimizing the cost; however, the marginal cost payment model, where the same price (selected based on the highest cost winner) is paid to all winners is also practised;
- Penalties for non-compliance. There could be cases where the developer either delays the project or fails to complete it. To avoid such cases, penalties should be put in place. There are two modes of penalty. In the monetary penalty, money will be deducted from bidder's "bond" or the price of energy will be reduced for a delayed completion. A form of non-monetary penalty can be the exclusion of the bidder from future auctions.

7.4. Moving towards net zero carbon

Limiting temperature rise to 1.5^{o}C requires a climate mitigation effort on an unprecedented scale and speed in order to reduce GHG emissions by about 45 per cent from 2010 levels by 2030, reaching net zero around 2050 (IPCC, 2018). Failing to act on the most pressing issue of this generation may lead to a catastrophic impact on human livelihoods. Thailand is highly vulnerable to the impacts of climate change, with the greatest impacts likely to come from flooding events. Thailand's agriculture sector could be significantly affected, whereby productivity decreases with the warming climate (World Bank and ADB, 2021).

The energy system of Surat Thani is well-positioned for an accelerated decarbonization effort as the required net-zero technologies in decarbonizing its energy systems are readily available and matured, i.e., electric vehicles, electric cooking stoves and renewable power technologies. As detailed in section 4.2, decarbonising its electricity supply is key for deep decarbonization as it contributes around 42 per cent of the total GHG emissions in 2018. A decarbonized electricity supply is also required to complement the hastened adoption of electricity-based technologies, such as electric vehicles and electric cooking stoves, in order to realise the greatest potential of electrification.

Efforts from all levels and sectors are imperative in the emission race to net zero. These include a clear and well-guided transition plan from the provincial and national governments, and citizen's participation. The latter is often a challenge due to barriers such as low climate consciousness and low purchasing power to transition to a more sustainable lifestyle. Thus, an energy conservation awareness programme and easier access to sustainable choices are the key to encourage widespread adoption of efficient technologies, such as electric vehicles. In addition, financial incentives can aid the transition, particularly at the early stage.

8. Conclusion

The 2030 Agenda for Sustainable Development and Paris Agreement provide a common goal in achieving sustainability and climate objectives. While achieving the SDG 7 targets is principally a national effort, it requires a combined contributions from stakeholders at various levels, such as subnational jurisdictions and cities. Recognising this, ESCAP and the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy further expanded the NEXSTEP initiative to develop a Sustainable Energy Transition (SET) road map for Surat Thani province, as part of DEDE's "Energy for ALL" programme focusing on sustainable energy planning for cities.

Surat Thani is the sixth largest province in Thailand and best recognised for its famous tourist islands and national parks. The GDP of Surat Thani is projected to grow at 3.99 per cent per annum, while the population is expected to increase by 0.42 per cent annually. Under the current policy settings, the overall energy demand is projected to rise, by an annual average rate of 3.8 per cent, to 1,964 ktoe. Considering the increasing renewable energy generation share as per the Thailand Power Development Plan, 2018-2037, GHG emissions are projected to be 3.86 $MTCO_2$-e, a reduction of 0.5 $MTCO_2$-e, compared to a business-as-usual baseline.

The SET scenario proposes an energy transition pathway that strategically allows Surat Thani to align its energy sector performance with the national development targets for the energy sector and the unconditional NDC target. It suggests several energy efficiency opportunities that would lead to energy savings and GHG emission reduction across different demand sectors. The industrial sector is the largest energy consuming sector and has a substantial energy savings potential. With an energy saving potential ranging from 11 per cent to 44 per cent across different subcategories, the energy demand reduction is projected to reach 232 ktoe, if best practices are adopted widely. This corresponds to about a 24 per cent reduction from the BAU/CPS baseline. Energy conservation awareness should be further strengthened among the industrial owners, while financial incentives may be provided to assist in overcoming financial hurdles for SMEs.

The electric vehicle adoption is critical to achieving a 20 per cent GHG emissions reduction, aligning with the national unconditional NDC commitment. The SET scenario explores a relatively conservative electric vehicle penetration, which realises an energy demand reduction and GHG emission reduction of 57.3 ktoe and 135 $ktCO_2$-e, respectively. More can be done, such as a greater adoption of public mass transport and electric vehicles, as further examined in the STS scenario. These, however, require concerted efforts from the public and private sectors, such as establishing an extensive network of charging stations and public transport routes.

Climate change is one of the most pressing issues of this century, requiring hastened and widespread climate mitigation by all sectors. Surat Thani may play its part by raising its decarbonization effort to realise a more rapidly declining GHG emissions trajectory particularly, through decarbonizing its electricity supply. This road map further explores several pathways that the province could undertake in decarbonizing its electricity supply. Renewable energy auctions stand out as the cheapest option, without the operational burden from the provincial government. In combination with a high transport electrification ambition and energy efficiency measures as already proposed for the SET and STS scenarios, GHG emissions are projected to be reduced to 1.15 $MTCO_2$-e in 2030, a 74 per cent reduction from the BAU baseline.

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Annexes

Annex I. Surat Thani's status against the SDG 7 indicators

Table 10 summarises Surat Thani's status against the SDG 7 indicator in 2018 and 2030. The projection for 2030 is based on the SET scenario. The following sections further describe the calculation methodologies in determining the (a) energy intensity, (b) energy efficiency improvement rate, and (c) renewable energy share in TFEC.

Annex table 1. Targets and indicators for SDG 7

Target	Indicators	2018	2030
7.1. By 2030, ensure universal access to affordable, reliable, and modern energy services.	7.1.1. Proportion of population with access to electricity.	100%	100%
	7.1.2. Proportion of population with primary reliance on clean fuels and technology for cooking.	97.3%	100%
7.2. By 2030, increase substantially the share of renewable energy in the global energy mix.	7.2.1. Renewable energy share in total final energy consumption.	42.0%	41.5%
7.3. By 2030, double the global rate of improvement in energy efficiency.	7.3.1. Energy intensity measured as a ratio of primary energy supply to gross domestic product.	3.31 MJ/US$ (2017) PPP	2.91 MJ/US$ (2017) PPP

SDG 7.3. Energy Efficiency. "By 2030, double the global rate of improvement in energy efficiency", as measured by the energy intensity of the economy. This is the ratio of the total primary energy supply (TPES) and GDP. Energy intensity is an indication of how much energy is used to produce one unit of economic output. As defined by IEA, TPES is made up of production plus net imports minus international marine and aviation bunkers plus stock changes. For comparison purposes, GDP is measured in constant terms at 2017 PPP.

Energy intensity (MJ/US$$_{2017}$) is calculated using the following formula:

$$Primary\ energy\ intensity = \frac{Total\ Primary\ Energy\ Supply\ (MJ)}{GDP\ (USD\ 2017\ PPP)}$$

Energy efficiency improvement rate is calculated with the following formula:

$$CAGR = \left(\frac{EI_{t2}}{EI_{t1}}\right)^{\frac{1}{(t2-t1)}} - 1$$

where EI_{t1} is energy intensity in year t1 and EI_{t2} is energy intensity in year t2. In the case of Surat Thani, t1 refers to the baseline year (2018) and t2 refers to the analysis end year (2030)

SDG 7.2. Renewable Energy. Share of renewable energy in TFEC is calculated using the following formula, where TFEC is total final energy consumption and ELEC is gross electricity production.

$$\%TFEC_{RES} = \frac{TFEC_{RES} + \left(TFEC_{ELEC} \times \frac{ELEC_{RES}}{ELEC_{TOTAL}}\right)}{TFEC_{TOTAL}}$$

Annex II. Key assumptions for NEXSTEP energy modelling

(a) General key assumptions

Annex table 2. GDP and GDP growth rate

Parameter	Value
GDP (2018, current Thai baht)	206.9 billion
GDP (2018, current US dollar)	6,402.9 million
PPP (2018, constant 2017 US dollar)[24]	15,871 million
GDP growth rate	3.99%

Annex table 3. Population, population growth rate and household size

Parameter	Value
Population (2018)	1,061,195
Population growth rate	0.42%
No. of Households (2018)	355,504
Household size (constant throughout the analysis period)	2.99

(b) Demand analysis and growth projections by sector

Residential:

- The residential sector is further divided into urban (43.6 per cent) and rural (56.4 per cent) households.
- The clean cooking access rate is estimated at 97.3 per cent for 2018. The cooking distribution and assumed energy intensities are as estimated in annex table 4.

24 The GDP in 2018 (in terms of local currency) is converted into PPP (current US dollar) with a conversion factor of 12.723 (https://data.worldbank.org/indicator/PA.NUS.PPP?locations=TH), and adjusted to 2017 US$ based on consumer price index (CPI) provided in https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator/consumer-price-index-1913-

Annex table 4. Cooking distribution for 2018

Stove type	Distribution [25]	Energy intensity (GJ/household)
LPG stove	86.7%	4.34
Electric stove	4.2%	3.65
No cooking	6.4%	-
Charcoal stove	2.6%	6.58

- The residential appliance ownership data are based on the ownership database of the National Statistical Office. The appliance ownership is projected to grow at a rate similar to the growth in GDP per capita, up until reaching saturation of 100 per cent.
- The average electrical intensities per owning household for the different appliances are as estimated based on assumed appliance wattage and operating hours/year, constrained by top-down measured residential electricity consumption data. The energy intensities are assumed constant throughout the analysis period.

Annex table 5. Residential appliance baseline assumptions for 2018

Category	Appliance	Ownership (%)	Electricity intensity (kWh/HH/year)
Lighting	Fluorescent	89.6	205.0
	Compact Fluorescent	45.9	181.3
	LED E27	8.9	136.5
-	Air conditioner	20.9	2824.3
-	Refrigerator	90.2	348.7
Television	LCD/LED/Plasma	49.8	87.03
	Common	46.1	104.43
-	Water heater	5.0	704.1
-	Electric stove	4.2	1015.0
-	Electric fan	98.9	308.8
Washing machines	Top Loading	64.4	37.0
	Front Loading	2.9	206.8
-	Water pump	21.2	357.9
-	Irons	83.8	251.5
	Others	100.0	587.6

25 Cooking distribution is based on a 2019 survey by the National Statistical Office – the percentage of households classified by type of fuel for cooking in the southern region.

Transport:

- Land transport sector consumption is estimated using the vehicle-km statistics and assumed fuel economy, as shown in annex table 6. The vehicle statistics and vehicle-km statistics are compiled by the local consultant, while fuel economy assumptions are based on numbers referenced in several studies conducted for Thailand.
- Transport activities in 2018 were an estimated 3.97 billion vehicle-kilometres for road passenger transport and 1.92 billion vehicle-kilometres for road freight transport. The growth both in passenger transport and freight transport activities is assumed to be growing at the same rate as the GDP, i.e., 3.99 per cent per annum.

Annex table 6. Transport sector baseline assumptions for 2018

Passenger transport	**% share of vehicles by fuel type**	**Travelled mileage in 2018 (million km)**	**Fuel consumption**	**% share of passenger-km**
Passenger car	Gasoline – 31.8%	2,938	12.5 km/l	74.0%
	Diesel – 66.3%		11.1 km/l	
	Hybrid – 0.4%		20 km/l	
	LPG – 1.2%		2.7 MJ/km	
	CNG – 0.4%		2.7 MJ/km	
	Electric – 0.004%		5 km/kWh	
Motorcycle	Gasoline – 100%	899	25.5 km/l	22.6%
Bus and minibus	Gasoline – 5.1%	132	5.15 km/l	3.3%
	Diesel – 71.3%		5.15 km/l	
	CNG – 3.5%		7.3 MJ/km	
	LPG – 20.1%		7.3 MJ/km	
Freight transport	Number of vehicles	Travelled mileage in 2018 (million km)	Fuel consumption	% share of tonne-km
Freight truck	Diesel – 99.1%	1,891	9.29 km/l	98.5%
	Gasoline – 0.1%		9.29 km/l	
Trailer	Diesel – 99.2%	29	3.00 km/l	1.5%
	Gasoline – 0.8%		3.00 km/l	

Industry:

- The industrial sector is further differentiated into seven sub-categories. The fuel consumption by industry sub-categories is as detailed in annex table 7, as provided by the local consultant.
- The industrial activities are assumed to be growing at an annual rate of 3.99 per cent, similar to the provincial GDP growth rate.

Annex table 7. Fuel consumption by industry sub-categories in 2018

Industry	Fuel consumption (ktoe)					
	Coal	Oil Products	Biomass	Electricity	Biogas	Total
Cement and non-metallic quarry products		-	-	3.64	-	3.64
Textile and leather		-	-	0.72	-	0.72
Iron and steel		-	-	0.26	-	0.26
Fertilizer, chemical, and rubber products		-	0.84	0.45	-	10.80
Food and beverages	0.31	6.25	172.83	31.61	3.49	237.57
Machinery and transportation tool	-	-	-	0.33	-	0.33
Wood and other products	-	8.84	180.07	56.80	-	253.97
Other industries	-	15.06	88.66	27.05	-	173.04

Commercial:

- The commercial sector is differentiated into designated buildings and non-designated buildings.
- The total commercial floorspace of the designated buildings is estimated to have been 3.68 million square metres in 2018. These buildings can be further distinguished into six sub-categories. This is projected to grow at an annual rate of 3.99 per cent, a rate similar to the projected growth in provincial GDP.
- There are no floorspace data available for non-designated buildings, but the fuel consumption is measured as 34.1 ktoe for 2018. NEXPSTEP assumes a 3.99 per cent annual growth in fuel consumption, a rate similar to the projected growth in provincial GDP.
- The fuel intensities and consumption data for 2018 are summarized in annex table 8.

Annex table 8. Commercial sector fuel intensities in 2018

Category	Sub-category	Floorspace (million m^2)	Electricity intensity (kWh/m^2)	Total (ktoe)
Designated buildings	Private office	0.036	13.80	0.04
	Others	2.897	8.31	2.07
	Shopping mall	0.219	285.13	5.36
	Hotel	0.175	192.97	2.90
	Hospital	0.054	72.75	0.34
	University	0.298	35.02	0.90
Non-designated buildings	-	-	-	34.12

Other sectors:

- The remaining demand sectors are (a) non-specified use and (b) agriculture. The estimated energy consumption for 2018 is detailed in annex table 9. The consumption growth is projected to grow at an annual rate of 3.99 per cent, the same as the provincial GDP growth rate.

Annex table 9. Consumption in other sectors in 2018

Sector	Electricity consumption (toe)
Agriculture	0.04
Non-specified use	1.91

Annex III. Power technologies assumptions

Cost assumptions used for calculating the levelized cost of electricity (LCOE) of solar PV systems and biomass power plant are listed in annex tables 10 and 11.

Annex table 10. Capital cost assumptions for solar PV and biomass plant

	Installation cost[26]	
	THB/W	US$/MW
Residential 5-10 kW	52	1,612,000
Small commercial 10-100 kW	47	1,457,000
Large commercial 100-250 kW	45	1,395,000
Industry >250kW	32	992,000
Small centralised PV (1-20MW)	30	930,000
Large centralised PV (> 20MW)	28	868,000
Biomass power plant	-	2,390,000

Annex table 11. Other assumptions

Other general assumptions	Value
Capacity factor[27]	16.5 per cent for solar PV 66.5 per cent for biomass power plant
Fixed O&M (US$/MW)[28]	1.2 per cent of CAPEX for solar PV 6.5 per cent of CAPEX for biomass power plant
Lifetime	30 years
Biomass fuel cost[29]	12.5 US$/ton

26 With reference to the National Survey Report of PV Power Applications in Thailand 2018.

27 Averaged capacity factor for Thailand quoted in Levelized Cost of Electricity of Selected Renewable Technologies in the ASEAN member States (2016).

28 Averaged O&M for Thailand quoted in Levelized Cost of Electricity of Selected Renewable Technologies in the ASEAN member States (2016).

29 Averaged fuel cost for Thailand quoted in Levelized Cost of Electricity of Selected Renewable Technologies in the ASEAN member States (2016).

Annex IV. Summary results for the scenarios

	BAU scenario	CPS scenario	SET scenario	Sustainable Transport Strategies	Towards NetZero
Universal access to electricity	Already achieved				
Universal access to clean cooking	100% by 2024				
TFEC in 2030	1,968 ktoe	1,964 ktoe	1,668 ktoe	1,494 ktoe	1,463 ktoe
Energy efficiency (in terms of TFEC)	6.69 ktoe/billion $baht_{2010}$	6.68 ktoe/billion $baht_{2010}$	5.67 ktoe/billion $baht_{2010}$	5.08 ktoe/billion $baht_{2010}$	4.98 ktoe/billion $baht_{2010}$
Energy efficiency (SDG 7.3)	3.25 MJ/USD_{2017}	3.24 MJ/USD_{2017}	2.75 MJ/USD_{2017}	2.46 MJ/USD_{2017}	2.41 MJ/USD_{2017}
Renewable energy share in TFEC	42.7%	44.9%	41.5%	45.9%	75.2%
GHG emissions	4.36 $MTCO_2$-e	3.86 $MTCO_2$-e	3.48 $MTCO_2$-e	3.08 $MTCO_2$-e	1.15 $MTCO_2$-e
RE share in electricity supply	17.8%	24.6%	24.6%	24.6%	100%

Annex V. Energy balance

Business as Usual (BAU) scenario, 2030

	Electricity	Gasoline	Diesel	LPG	Other oil products	Ethanol	Biodiesel	Biomass	Coal Unspecified	Biogas	Total
Unit	GWh	Thousand litres				ktoe					
Production	-	-	-	-	-	-	-	707	-	-	707
Imports	4,378	156,013	637,136	74,509	118,000	19	41	-	0.5	5.6	1,260
Exports	-	-	-	-	-	-	-	-	-	-	-
Total primary supply	**4,378**	**156,013**	**637,136**	**74,509**	**18,000**	**19**	**41**	**707**	**0.5**	**5.6**	**1,968**
Total transformation	-	-	-	-	-	-	-	-	-	-	-
Residential	1,246	-	-	56,640	-	-	-	-	-	-	142
Industry	2,246	-	-	-	57,709	-	-	707	0.5	5.6	955
Commercial	850	-	0	-	-	-	-	-	-	-	73
Agriculture	1	-	-	-	-	-	-	-	-	-	0
Non-specified	36	-	-	-	-	-	-	-	-	-	3
Transport	-	156,013	637,135	17,862	60,292	19	41	-	-	-	795
Total demand	**4,378**	**156,013**	**637,136**	**74,509**	**118,000**	**19**	**41**	**707**	**0.5**	**5.6**	**1,968**

Current policy (CP) scenario, 2030

	Electricity	Gasoline	Diesel	LPG	Other oil products	Ethanol	Biodiesel	Biomass	Coal Unspecified	Biogas	Total
Unit	GWh	Thousand litres				ktoe					
Production	-	-	-	-	-	-	-	707	-	-	707
Imports	4,330	155,977	617,658	74,571	117,816	19	59	-	0.5	5.6	1,256
Exports	-	-	-	-	-	-	-	-	-	-	-
Total primary supply	**4,330**	**155,977**	**617,658**	**74,571**	**117,816**	**19**	**59**	**707**	**0.5**	**5.6**	**1,964**
Total transformation	-	-	-	-	-	-	-	-	-	-	-
Residential	1,246	-	-	56,706	-	-	-	-	-	-	142
Industry	2,246	-	-	-	-	-	-	707	0.5	5.6	955
Commercial	803	-	-	-	-	-	-	-	-	-	69
Agriculture	1	-	-	-	-	-	-	-	-	-	0
Non-specified	36	-	-	-	-	-	-	-	-	-	3
Transport	-	155,977	617,658	17,864	60,098	19	59	-	-	-	795
Total demand	**4,330**	**155,977**	**617,658**	**74,571**	**117,816**	**19**	**59**	**707**	**0.5**	**5.6**	**1,964**

Sustainable Energy Transition (SET) scenario, 2030

	Electricity	Gasoline	Diesel	LPG	Other oil products	Ethanol	Biodiesel	Biomass	Coal Unspecified	Biogas	Total
Unit	GWh	Thousand litres				ktoe					
Production	-	-	-	-	-	-	-	535	-	-	535
Imports	3,958	131,966	566,870	67,589	98,537	16	54	-	0.4	4.0	1,134
Exports	-	-	-	-	-	-	-	-	-	-	-
Total primary supply	**3,958**	**131,966**	**566,870**	**67,589**	**98,537**	**16**	**54**	**535**	**0.4**	**4.0**	**1,668**
Total transformation	-	-	-	-	-	-	-	-	-	-	-
Residential	1,208	-	-	56,640	-	-	-	-	-	-	138
Industry	1,709	-	-	-	-	-	-	535	0.4	4.0	723
Commercial	766	-	0	-	-	-	-	-	-	-	66
Agriculture	1	-	-	-	-	-	-	-	-	-	0
Non-specified	36	-	-	-	-	-	-	-	-	-	3
Transport	238	131,966	566,870	10,942	98,537	16	54	-	-	-	738
Total demand	**3,958**	**131,966**	**566,870**	**67,589**	**98,537**	**16**	**54**	**535**	**0.4**	**4.0**	**1,668**

Sustainable Transport Strategies (STS) scenario, 2030

	Electricity	Gasoline	Diesel	LPG	Other oil products	Ethanol	Biodiesel	Biomass	Coal Unspecified	Biogas	Total
Unit	GWh	Thousand litres				ktoe					
Production	-	-	-	-	-	-	-	535	-	-	535
Imports	4,819	68,517	385,072	59,189	83,172	8	36	-	0.4	4.0	959
Exports	-	-	-	-	-	-	-	-	-	-	-
Total primary supply	**4,819**	**68,517**	**385,072**	**59,189**	**83,172**	**8**	**36**	**535**	**0.4**	**4.0**	**1,494**
Total transformation	-	-	-	-	-	-	-	-	-	-	-
Residential	1,208	-	-	56,640	-	-	-	-	-	-	138
Industry	1,709	-	-	-	-	-	-	535	0.4	4.0	723
Commercial	766	-	0	-	-	-	-	-	-	-	66
Agriculture	1	-	-	-	-	-	-	-	-	-	0
Non-specified	36	-	-	-	-	-	-	-	-	-	3
Transport	1099	68,517	385,072	2,541	83,172	8	36	-	-	-	563
Total demand	**4,819**	**68,517**	**385,072**	**59,189**	**83,172**	**8**	**36**	**535**	**0.4**	**4.0**	**1,494**

Towards Net Zero (TNZ) scenario, 2030

	Electricity	Gasoline	Diesel	LPG	Other oil products	Ethanol	Biodiesel	Biomass	Biogas	Total
Unit	GWh	Thousand litres				ktoe				
Production	-	-	-	-	-	-	-	572	-	572.1
Imports	5,688	68,414	297,670	32,241	33,610	8	27	-	4.0	891.3
Exports	-	-	-	-	-	-	-	-	-	-
Total primary supply	**5,688**	**68,414**	**297,670**	**32,241**	**33,610**	**8**	**27**	**572**	**4.0**	**1,463.5**
Total transformation	-	-	-	-	-	-	-	-	-	-
Residential	1,369	-	-	29,692	-	-	-	-	-	135.8
Industry	1,709	-	-	-	-	-	-	572	4.0	723.1
Commercial	766	-	0	-	-	-	-	-	-	65.9
Agriculture	1	-	-	-	-	-	-	-	-	0.1
Non-specified	36	-	-	-	-	-	-	-	-	3.1
Transport	1088	68,414	297,669	2,541	33,610	8	27	-	-	535.6
Total demand	**5,688**	**68,414**	**297,670**	**32,241**	**33,610**	**8**	**27**	**572**	**4.0**	**1,463.5**