The 22nd Workshop on GHG Inventories in Asia (WGIA22)
15th – 18th July 2025
Sofitel Phnom Penh Phokeethra (Cambodia)

Development of emission factors for Thailand's livestock sector

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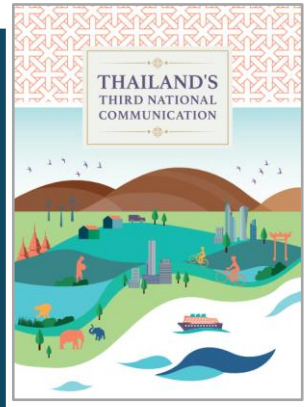
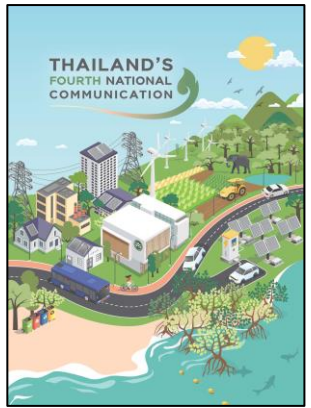
Thailand's National Communication and Mitigation

United Nations Framework Convention on Climate Change (UNFCCC)

- Thailand: Party to UNFCCC
- Commitment: Established a systematic and institutional arrangement; Responsible by permanent organization; Data must be accurate, consistent, up-to-date, continuous, and transparent; Measurement, Reporting, and Verification (MRV)



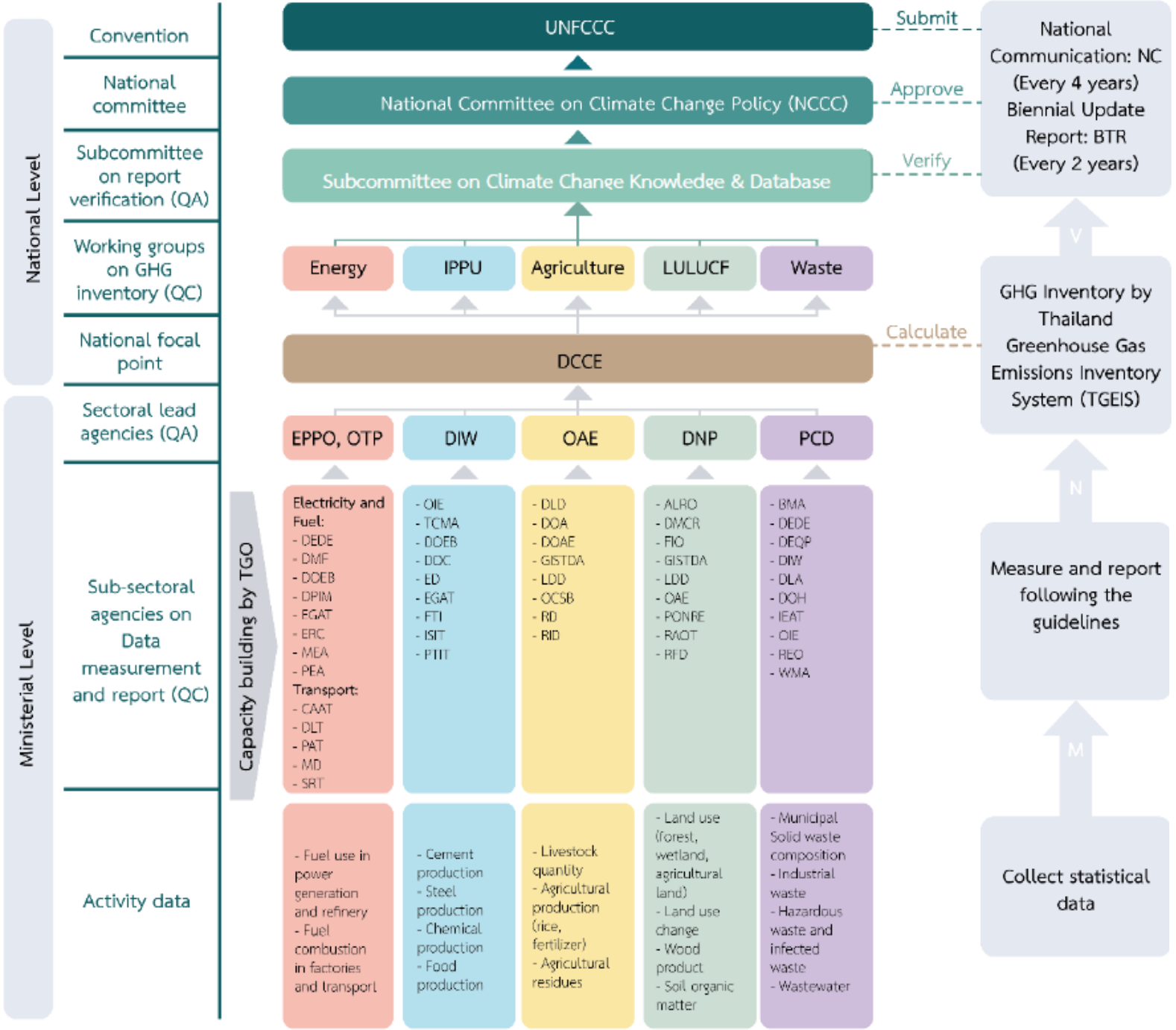


Submission to UNFCCC

- National Communication Report (NC)
- Biennial Updated Report (BUR)
- Biennial Transparency Report (BTR)
- Nationally Determined Contributions (NDCs)

Institutional Arrangement

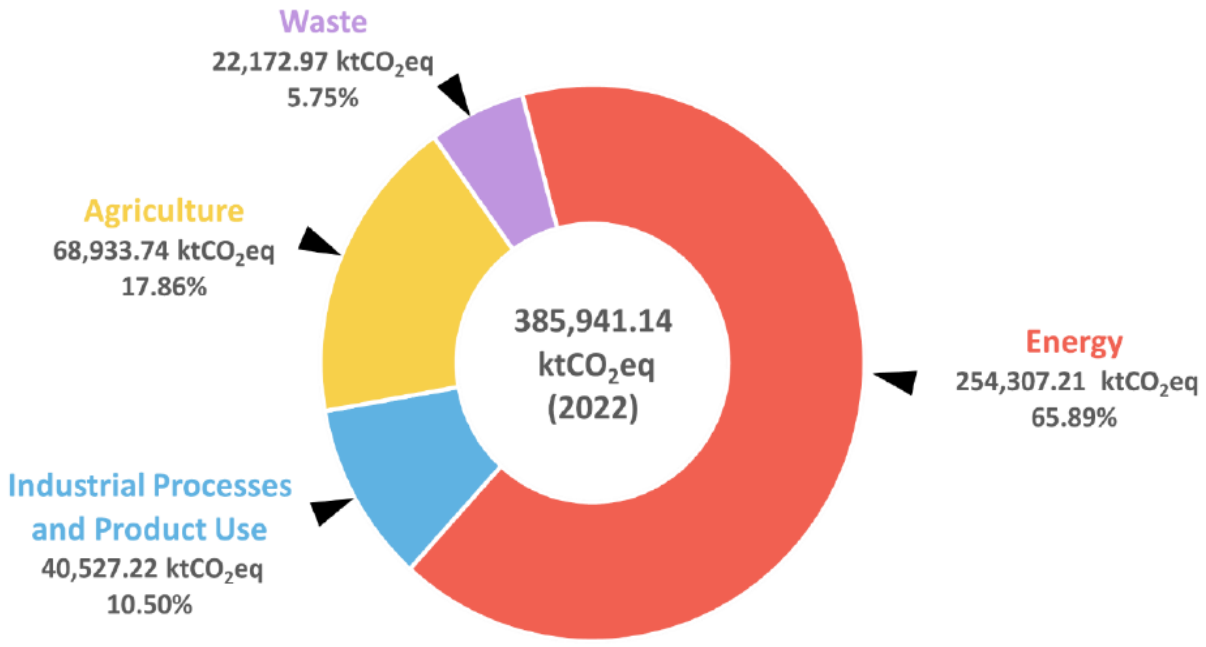
Thailand's First Biennial Transparency Report (BTR1)



FIO	Agricultural Land Reform Office
ALRO	Bangkok Metropolitan Administration
BMA	The Civil Aviation Authority of Thailand
CAAT	Department of Alternative Energy Development and Efficiency
DCCE	Department of Climate Change and Environment
DEDE	Department of Environmental Quality Promotion
DEQP	Department of Industrial Works
DIW	Department of Livestock Development
DLD	Department of Local Administration
DLA	Department of Land Transport
DLT	Department of Marine and Coastal Resources
DMCR	Department of Mineral Fuels
DMF	Department of National Parks, Wildlife and Plant Conservation
DNP	Department of Agriculture
DOA	Department of Customs
DOC	Department of Agricultural Extension
DOAE	Department of Energy Business
DOEB	Department of Health
DOH	The Excise Department
ED	Electricity Generating Authority of Thailand
EGAT	Energy Policy and Planning Office
EPPO	Energy Regulatory Commission
ERC	Forest Industry Organization
FTI	The Federation of Thai Industries
GISTDA	Geo-Informatics and Space Technology Development Agency
ISIT	Iron and Steel Institute of Thailand
LDD	Land Development Department
MD	Marine Department
MEA	Metropolitan Electricity Authority
OAE	Office of Agricultural Economics
OCSB	Office of the Cane and Sugar Board
OIE	The Office of Industrial Economics
OTP	The Office of Transport and Traffic Policy and Planning
PAT	Port Authority of Thailand
PCD	Pollution Control Department
PEA	Provincial Electricity Authority
PONRE	Provincial Offices of Natural Resources and Environment
PTIT	Petroleum Institute of Thailand
RAOT	Rubber Authority of Thailand
RD	Rice Department
REO	Regional Environment Office
RID	Royal Irrigation Department
RFD	Royal Forest Department
SRT	State Railway of Thailand
TCMA	Thai Cement Manufacturers Association
WMA	Wastewater Management Authority

Figure 1-32: Structure of Thailand's Greenhouse Gas Inventory process

Thailand's First BTR



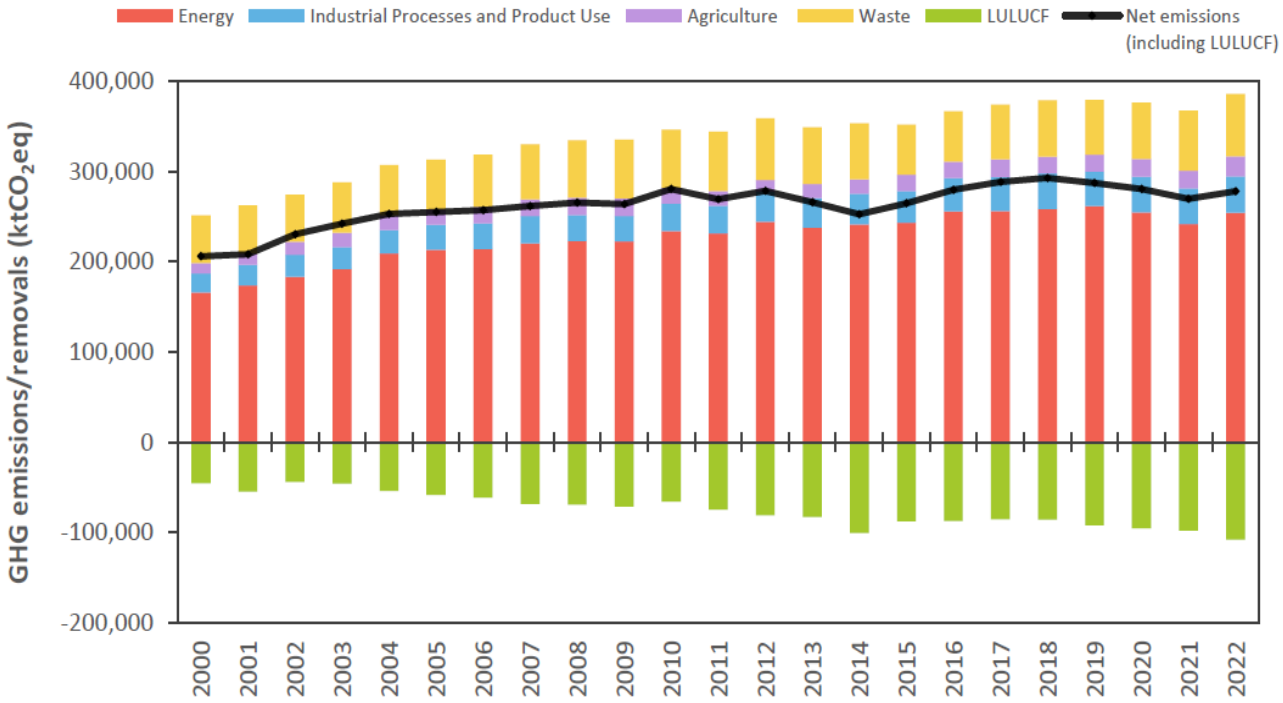
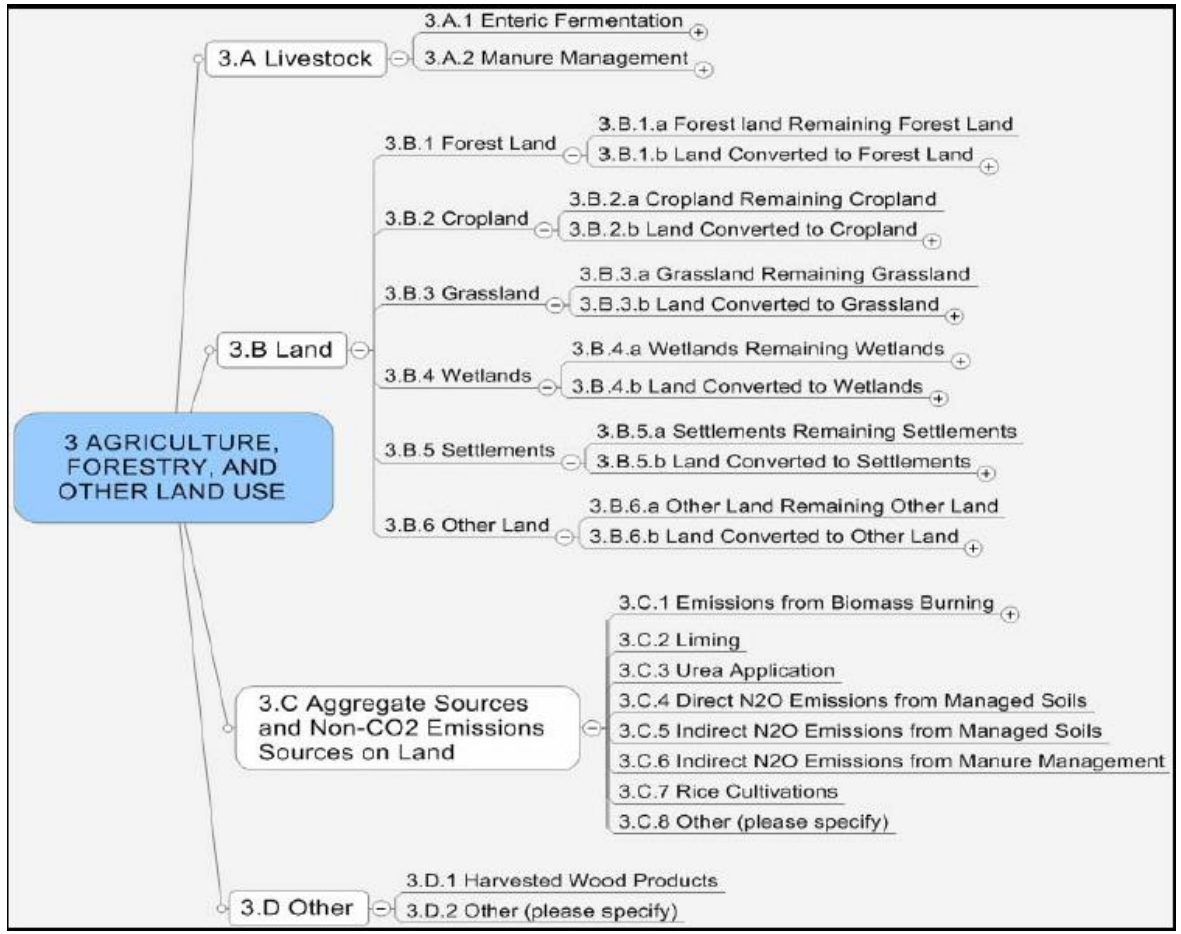


Figure 2-2: Trend of national GHG emissions/removals by sector for 2000-2022

IPCC methodology for Thailand's First BTR



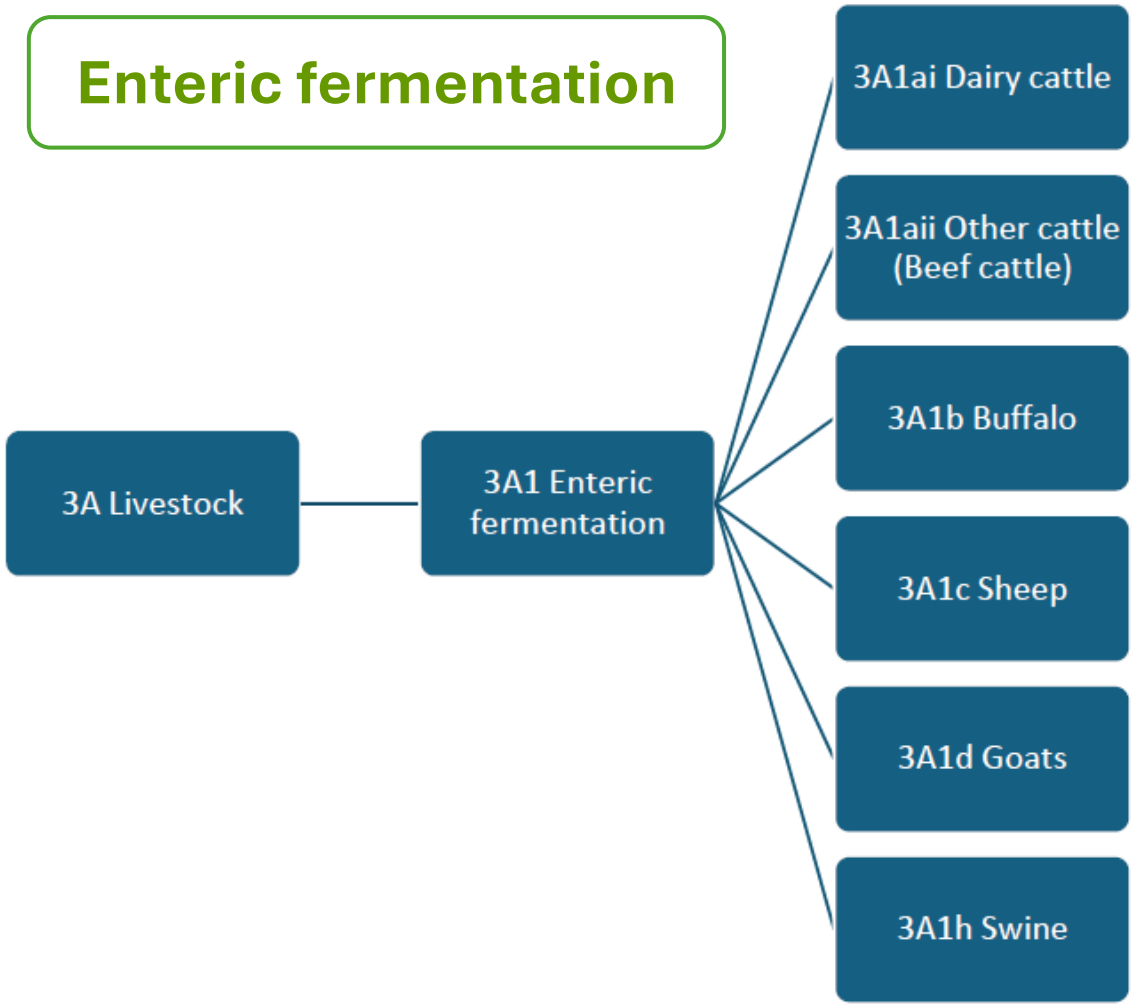
- Methodology currently used in Thailand's BTR was adopted **the 2006 IPCC Guidelines**.
- 3A Livestock:
  - 3A1 Enteric fermentation
  - 3A2 Manure management
- The methodology decisions were determined by the **decision tree** (according to the 2006 IPCC GLs) for selecting the method for estimate of GHG emissions for Livestock's sector:
  - Manure management (CH_4)
  - Manure management (N_2O)
- For GHG estimations from enteric fermentation and manure management, the **Tier 1 and Tier 2** methods were applied.

2006 IPCC Guidelines for National Greenhouse Gas Inventories

IPCC methodology for Thailand's First BTR

- For key livestock groups that have high CH_4 emissions, such as dairy cattle, beef cattle, and buffalo, a Tier 2 assessment can be conducted.
- Information was gathered from research and experts within the Department of Livestock
- Development to calculate country-specific emission factors using equations provided by 2006 IPCC GLs.

- For other species, such as pigs, poultry, sheep, and goats, which have lower CH_4 emissions, a Tier 1 assessment was utilized.



IPCC methodology for Thailand's First BTR

$$EF = \frac{GE \times (\frac{Y_m}{100}) \times 365}{55.65}$$

Where:

EF	=	emission factor (kg CH_4/head/year)
GE	=	gross energy intake (MJ/head/day)
Y_m	=	methane conversion factor (%)
365	=	time conversion (days/year)
55.65	=	energy content of methane

NE_{work} = net Energy for Work (MJ/day):
$NE_{work} = 0.10 \times NE_m \times$ Hours (note: Hours = number of hours of work per

NE_p = net Energy for Pregnancy (MJ/day):
NE_p for cattle and buffalo = $0.10 \times NE_m$

NE_g = net Energy for Growth (MJ/day):

NE_g for cattle and buffalo = $22.02 \times \left(\frac{BW}{C \times MW}\right)^{0.75} \times WG^{1.097}$

note: C = 0.8 for females, 1.0 for castrates and 1.2 for bulls
BW = the average live body weight of the animals in the population (kg)
MW = the mature live body weight of an adult female in moderate body condition (kg)
WG = the average daily weight gain of the animals in the population (kg/day)

$$GE = \left(\frac{NE_m + NE_a + NE_l + NE_{work} + NE_p}{REM} + \left(\frac{NE_g + NE_{wool}}{REG}\right)\right) \times \left(\frac{100}{DE\%}\right)$$

Where:

NE_m = net energy required by the animal for maintenance (MJ/day):
NE_m for cattle/buffalo (non-lactating cows) = $0.322 \times (\text{weight})^{0.75}$
NE_m for cattle/buffalo (lactating cows) = $0.386 \times (\text{weight})^{0.75}$
NE_m for cattle/buffalo (bull) = $0.370 \times (\text{weight})^{0.75}$
Note: weight = live-weight of animal (kg)

NE_a = net Energy for Animal Activity (MJ/day):
NE_a for cattle/buffalo (stall) = $0 \times NE_m$
NE_a for cattle/buffalo (pasture) = $0.17 \times NE_m$
NE_a for cattle/buffalo (grazing large areas) = $0.36 \times NE_m$

NE_l = net Energy for Lactation (MJ/day):
NE_l for beef cattle, dairy cattle and buffalo = milk × (1.47 + 0.40 × fat)
note: milk = amount of milk produced (kg of milk/day)
fat = fat content of milk (% by weight)

NE_{wool} = net Energy to Produce Wool (for sheep) (MJ/day)

REM = ratio of net energy available in a diet for maintenance to digestible energy consumed
$REM = 1.123 - (4.092 \times 10^{-3} \times DE\%) + (1.126 \times 10^{-5} \times DE\%^2) - (25.4/DE\%)$

REG = ratio of net energy available for growth in a diet to digestible energy consumed
$REG = 1.164 - (5.160 \times 10^{-3} \times DE\%) + (1.308 \times 10^{-5} \times DE\%^2) - (37.4/DE\%)$

DE% = digestible energy expressed as a percentage of gross energy

2006 IPCC Guidelines for National Greenhouse Gas Inventories

IPCC methodology for Thailand's First BTR

Table 2-104: Emission factors for CH_4 emissions (enteric fermentation) for 2020-2022

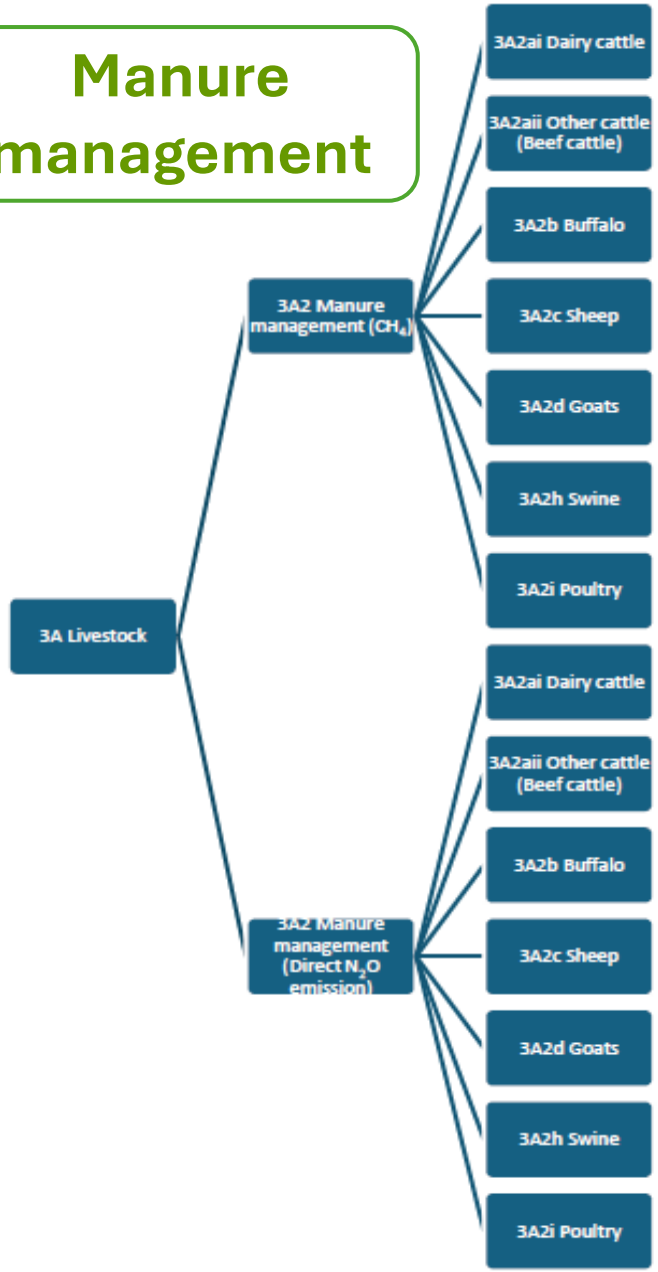
Livestock				EF (kg CH_4/head/year)
Dairy cattle	Male			18.89
	Female	Heifers	<1 year	29.21
			1 year to 1st pregnancy	43.52
		Milking cows	Lactating cows	92.86
			Dry cows	45.62
Beef cattle	Native	Male		44.63
		Female	<1 year	20.79
			Heifer >1 year	46.76
			From 1st pregnancy	47.18
	Pure/crossed breed	Male		64.96
		Female	<1 year	31.81
			Heifer >1 year	69.83
			From 1st pregnancy	62.02
	Fattening			55.72
Buffalo		Male		68.38
		Female	Young	52.25
			From 1st pregnancy	83.81
Swine				1.5
Goat and sheep				5
Poultry				-

Emission factors of Enteric Fermentation (3A1)

- The supporting data for estimating Tier 2 emission factor for dairy cattle, beef cattle and buffalo are animal and feed characteristics.
- These data were obtained from literature reviews (>15 national journal articles and handbooks), and expert judgement, mainly from the Department of Livestock Development, and IPCC defaults.
- Tier 1 emission factors of CH_4 for developing countries and/or warm climate were adopted for enteric fermentation for poultry, sheep and goats, while the Tier 1 emission factor for swine was applied from developed countries.

IPCC methodology for Thailand's First BTR

Manure management



$$EF_{(T)} = (VS_{(T)} \times 365) \times [B_{o(T)} \times 0.67 \times \sum \frac{MCF_{(S,k)}}{100} \times MS_{(T,S,k)}]$$

Where:

$EF_{(T)}$ = annual CH_4 emission factor for livestock category T (kg CH_4/year)

$VS_{(T)}$ = daily volatile solid excreted for livestock category T (kg dry matter/head/day)

$$VS = [GE \times (1 - \frac{DE\%}{100}) + (UE \times GE)] \times (\frac{1 - ASH}{18.45})$$

VS = volatile solid excretion per day on a dry-organic matter basis (kg VS/day)

GE = gross energy intake, MJ day-1

DE% = digestibility of the feed in percent (%)

(UE • GE) = urinary energy expressed as fraction of GE

Typically, 0.04GE can be considered urinary energy excretion by most ruminants (reduce to 0.02 for ruminants fed with 85% or more grain in the diet or for swine).

ASH = the ash content of manure calculated as a fraction of the dry matter feed intake (0.08 for cattle)

18.45 = conversion factor for dietary GE per kg of dry matter (MJ/kg)

$B_{o(T)}$ = maximum methane producing capacity for manure produced by livestock category T (m^3 CH_4/kg VS)

0.67 = conversion factor of m^3 CH_4 to kg CH_4 (kg/m^3)

$MCF_{(S,k)}$ = methane conversion factors for each manure management system S by climate region k (%)

$MS_{(T,S,k)}$ = fraction of livestock category T's manure handled using manure management system S in climate region k (%)

IPCC methodology for Thailand's First BTR

$$N_2O_{D(mm)} = \left[\sum_S \left[\sum_T \left(N_{(T)} \times Nex_{(T)} \times MS_{(T,S)}\right)\right] \times EF_{3(S)}\right] \times \frac{44}{28} \quad (3B\text{-}3)$$

$$Nex_{(T)} = N_{rate(T)} \times \frac{TAM}{1000} \times 365 \quad (3B\text{-}4)$$

Where:

$N_2O_{D(mm)}$	=	direct N_2O emissions from manure management in the country (kg N_2O/year)
$N_{(T)}$	=	number of head of livestock species/category T in the country (head)
$Nex_{(T)}$	=	annual average N excretion per head of species/category T in the country (kg N/head/year)
$MS_{(T,S)}$	=	fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country
$EF_{3(S)}$	=	emission factor for direct N_2O emissions from manure management system S in the country (kg N_2O-N/kg N) in manure management system S
S	=	manure management system
T	=	species/category of livestock

Activity Data of Manure Management (3A2)

- The primary activity data for assessing GHG emissions in this category is livestock population.
- Additionally, the assessment of GHG emissions from manure management utilizes the following supporting activity data:
  - Nitrogen excretion rate for each species (calculated using equations from the 2006 IPCC GLs)
  - Proportion of manure or nitrogen excreted by animals according to different manure management systems (MS)
- In this assessment, country-specific values were applied based on evaluations from experts and practitioners with relevant experience.

IPCC methodology for Thailand's First BTR

Table 2-106: IPCC defaults for N_{rate}, TAM and N_{ex}

Livestock				$N_{ex(T)}$ (kg N/head/year)
Dairy cattle	Male			12.77
	Female	Heifers	<1 year	23.94
			1 year to 1st	50.82
		Milking cows	Lactating cows	77.35
			Dry cows	77.35
Beef cattle	Native	Male		22.65
		Female	<1 year	9.76
			1 year to heifers	22.39
			From 1st pregnancy	32.54
	Pure/crossed breed	Male		34.70
		Female	<1 year	15.48
			1 year to heifers	34.09
			From 1st pregnancy	48.33
	Fattening			40.35

Table 2-108: Manure CH_4 emission factors

Livestock				Manure CH_4 (kg CH_4/head/year)
Dairy cattle	Male			4.39
	Female	Heifers	<1 year	6.79
			1 year to 1st pregnancy	10.11
		Milking cows	Lactating cows	21.57
			Dry cows	10.60
Beef cattle	Native	Male		5.12
		Female	<1 year	2.32
			1 year to heifers	5.37
			From 1st pregnancy	5.42
	Pure/crossed breed	Male		7.46
		Female	<1 year	3.55
			1 year to heifers	8.01
			From 1st pregnancy	7.12
	Fattening			6.22

IPCC methodology for Thailand's First BTR

Emission factors of Manure Managemet (3A2)

- For the Tier 1 assessment, recommended values from the 2006 IPCC GLs were applied, while the Tier 2 assessment utilized country-specific emission factors.
- This required the collection of necessary domestic data to calculate emissions according to the equations in 2006 IPCC GLs, such as the total energy intake of the animals, the energy used for digestion, the conversion rate of manure to CH_4, and the proportion of manure based on different manure management systems.
- In this assessment, country-specific emission factors (Tier 2) were used for dairy cattle, beef cattle, buffalo, and swine, while recommended values (Tier 1) were applied for goats, sheep, and poultry.

IPCC methodology for Thailand's First BTR

Emission factors of Manure Management (3A2)

- For the Tier 1 assessment, recommended values from the 2006 IPCC GLs were applied, while the Tier 2 assessment utilized country-specific emission factors.
- This required the collection of necessary domestic data to calculate emissions according to the equations in 2006 IPCC GLs, such as the total energy intake of the animals, the energy used for digestion, the conversion rate of manure to CH_4, and the proportion of manure based on different manure management systems.
- In this assessment, country-specific emission factors (Tier 2) were used for dairy cattle, beef cattle, buffalo, and swine, while recommended values (Tier 1) were applied for goats, sheep, and poultry.

Table 2-109: Manure N_2O emission factors

MS		EF_3 (kg N_2O-N/kg N excreted)
Pasture/range/paddock		0.02
Daily spread		0
Solid storage		0.005
Dry lot		0.02
Poultry litter	With bedding	0.001
	Without bedding	0.001
Uncovered anaerobic lagoon		0
Anaerobic digestion		0
Deep bedding		0.01
Composting-intensive windrow		0.1
Others		0

- The emission factor used is the N_2O emissions from manure in various manure management systems (EF_3). For the Tier 1 assessment, recommended values from the 2006 IPCC GLs were applied.
- In the Tier 2 assessment, either recommended values or country-specific values may be used.
- However, a review of domestic data revealed no reported emission factors, so this assessment relies on the recommended values from the 2006 IPCC GLs.

Area for improvement

- Some data are limited
  - Availability, accessibility and variability, e.g., net energy and gross energy, MMS, N_{ex}. Data gap filling is required.

- To be more accurate and updated, higher tiers should be adopted for some animals, e.g.:
  - VS, MCF, B_o, %MS, N_{ex}, N_2O EFs

- Data collection system and MRV system should be updated.

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