

## Annex H – CH<sub>4</sub> emissions analysis and scenarios

There have been numerous studies on methane emissions during the past 10 years, focused both on the measurement as well as quantifying global CH<sub>4</sub> emissions<sup>1</sup>. However, these studies neither characterize emissions in a way that allows for the application of a benchmark methodology (e.g. CH<sub>4</sub> emissions/energy produced) and nor distinguish between upstream, midstream and downstream emissions.

For that purpose, we have looked into the 2019 USA National Inventory Report (NIR, respecting to 2017 data), in particular to the Common Reporting Framework tables, to understand how USA CH<sub>4</sub> connected with oil & gas value chain would be distributed between the different oil & gas segments. This data is reported in Table 1.B.2, which is copied below for reference.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA <sup>(1)</sup>			IMPLIED EMISSION FACTORS			EMISSIONS			
	Description <sup>(1)</sup>	Unit <sup>(1)</sup>	Value	CO <sub>2</sub> <sup>(2)</sup>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>		CH <sub>4</sub> <sup>(4)</sup>	N <sub>2</sub> O
							Emissions <sup>(3)</sup>	Amount captured		
	(kg/unit) <sup>(5)</sup>						(kt)			
<b>1. B. 2. a. Oil<sup>(6)</sup></b>							23341.04	NA	1730.66	0.04
1. Exploration	Annual Domestic Production	10 <sup>6</sup> Bbl(oil US)	3414.58	485243.70	4198.02	0.74	1656.90	NA	14.33	0.00
2. Production <sup>(7)</sup>	Annual Domestic Production	10 <sup>6</sup> Bbl(oil US)	3414.58	5257036.02	426386.77		17950.54	NA	1455.93	
3. Transport	Refinery Feed	10 <sup>6</sup> Bbl(oil US)	6055.24	179.61	1263.29		1.09	NA	7.65	
4. Refining/storage	Refinery Feed	10 <sup>6</sup> Bbl(oil US)	6055.24	615657.44	4679.15	6.01	3727.95	NA	28.33	0.04
5. Distribution of oil products	Distribution	NA	NE	NE,NA	NE		NE	NA	NE	
6. Other	Abandoned Wells	abandoned wells	2598505.86	1.75	86.36		4.55	NA	224.42	
<b>1. B. 2. b. Natural gas</b>							26329.07	NA	6676.99	
1. Exploration	Annual Production	10 <sup>9</sup> ft <sup>3</sup>	27.29	17698963.55	1812155.80		483.02	NA	49.46	
2. Production <sup>(7)</sup>	Annual Production	10 <sup>9</sup> ft <sup>3</sup>	27.29	104254931.66	158902225.70		2845.22	NA	4336.60	
3. Processing	Annual Production	10 <sup>9</sup> ft <sup>3</sup>	27.29	822673044.08	17171591.48		22451.57	NA	468.63	
4. Transmission and storage	Consumption	10 <sup>9</sup> ft <sup>3</sup>	27.11	19659020.70	47758172.14		532.96	NA	1294.72	
5. Distribution	Consumption	10 <sup>9</sup> ft <sup>3</sup>	27.11	515420.20	17505544.40		13.97	NA	474.58	
6. Other	Abandoned Wells	abandoned wells	559411.14	4.15	94.74		2.32	NA	53.00	

<sup>1</sup> See for example the Environmental Defense Fund publication "[Methane Research: The 16 Study Series](#)"

In the USA NIR the emissions from Flaring and Venting are included within the different categories 1.B.2.a Oil and 1.B.2.a Gas. From this table, it is relatively straightforward to produce a partition of CH<sub>4</sub> emissions between Upstream, Midstream and downstream, for both Oil and Gas.

<b>Oil</b>	<b>Categories</b>	<b>CH<sub>4</sub> emissions (kt)</b>	<b>%</b>
Upstream	Exploration + production + other (abandoned Wells)	14.33 + 1455.93 +224.42 = 1694.68	98
Midstream	Transport + Refining/storage	7.65 + 28.33 = 35.98	2
Downstream	Distribution of oil products	-	
<b>Gas</b>	<b>Categories</b>	<b>CH<sub>4</sub> (kt)</b>	<b>%</b>
Upstream	Exploration + production + other (abandoned Wells)	49.46 + 4336.60+53.00 = 4439.06	66%
Midstream	Processing + Transmission and storage	468.63 +1294.72=1763.35	26%
Downstream	Distribution	474.58	7%

## CH<sub>4</sub> scenarios

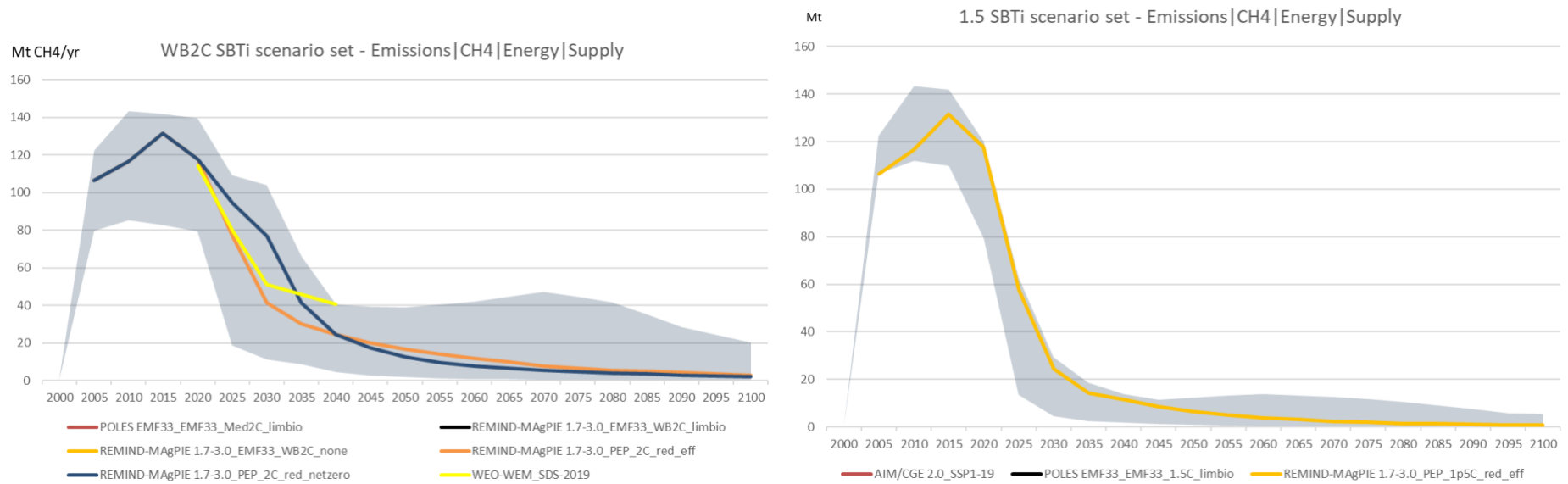
From the scenario set presented in Annex C only four have information on CH<sub>4</sub> for the energy supply side and they are:

- WB2C: REMIND-MAgPIE 1.7-3.0\_PEP\_2C\_red\_eff; REMIND-MAgPIE 1.7-3.0\_PEP\_2C\_red\_netzero and WEO-WEM\_SDS-2019;
- 1,5C: REMIND-MAgPIE 1.7-3.0\_PEP\_1p5\_red\_eff.

For scenarios in the IPCC database, according to the variables description, CH<sub>4</sub> emissions go well beyond emissions from oil production and refining, and include “CH<sub>4</sub> emissions from fuel combustion and fugitive emissions from fuels: electricity and heat production and distribution (IPCC category 1A1a), other energy conversions (e.g. refineries, synfuel production, solid fuel processing, IPCC category 1Ab, 1Ac), incl. pipeline transportation (IPCC category 1A3ei), fugitive emissions from fuels (IPCC category 1B)<sup>2</sup> and emissions from carbon dioxide transport and storage

<sup>2</sup> This includes all fugitive emissions from fuels, including coal, oil and gas.

(IPCC category 1C) (Mt CH<sub>4</sub>/yr)”. Only the IEA WEO 2019 (IEA, 2019), explicitly includes CH<sub>4</sub> emissions from oil and gas operations (see below pictures).



However, both the present levels of CH<sub>4</sub> emissions (~120 Mt CH<sub>4</sub>/year), as well as the reductions advanced in the scenarios, are quite similar, which raises the question if the variables in the IAM database are appropriately described or if the IEA emissions are overestimated. Given recent studies on methane that raise the issue that CH<sub>4</sub> emissions are likely to have been seriously underestimated for decades (Schwietzke *et al.*, 2016; Hmiel *et al.*, 2020), we have taken the approach that the IEA data is the most accurate approximation to CH<sub>4</sub> emissions of Oil & Gas Upstream and Midstream segments and that the IAM CH<sub>4</sub> scenarios can also be taken as Oil & Gas CH<sub>4</sub> scenarios only. The reduction levels advanced in any of the scenarios are, in all cases, commensurate with other initiatives proposing CH<sub>4</sub> reductions, namely the Climate & Clean Air Coalition (CCAC) 45% reduction by 2025 and 75% by 2030.

In principle, these curves can be used to compute a kgCH<sub>4</sub>/TJ of primary energy supplied, leading to a Scope1, CH<sub>4</sub> emissions intensity pathway. Using available data from the IEA WEO 2018 (IEA, 2018) on the GHG intensity of Oil and Gas, a global average carbon intensity due to methane emissions for oil (32.64 kgCO<sub>2</sub>e/boe) and gas (60.9 kgCO<sub>2</sub>e/boe) can be established.

Assuming that emissions contract according to the abatement potentials, it can be established a curve for the CH<sub>4</sub> emission intensity of Upstream oil and gas. This simplified approach, allows the application of the SDA and the recognition of differentiated starting positions from companies on important mitigation of upstream methane reductions.

## References

IEA (2018), World Energy Outlook 2018, IEA, Paris <https://www.iea.org/reports/world-energy-outlook-2018>

IEA (2019), World Energy Outlook 2019, IEA, Paris <https://www.iea.org/reports/world-energy-outlook-2019>

Hmiel, B., Petrenko, V.V., Dyonisius, M.N. et al. Preindustrial <sup>14</sup>CH<sub>4</sub> indicates greater anthropogenic fossil CH<sub>4</sub> emissions. Nature 578, 409–412 (2020). <https://doi.org/10.1038/s41586-020-1991-8>

Schwietzke, S., Sherwood, O., Bruhwiler, L. et al. Upward revision of global fossil fuel methane emissions based on isotope database. Nature 538, 88–91 (2016). <https://doi.org/10.1038/nature19797>