"Capacity Building and Strengthening Institutional Arrangement"

Workshop: "Quantitative risk assessment of oil and gas plants"

Oil and gas IPCC (Intergovernmental Panel on Climate Change) implementation and emissions evaluation methodologies

Mr. Giovanni Pino

APAT

Agency for Environmental Protection and Technical Service

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- IPCC Implementation
- IPCC Emissions evaluation methodologies

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- Climate change is a major issue of international concern that is being addressed by companies throughout the Oil and Natural gas industry.

- The Oil and Natural gas industry is by its nature a global industry, operating in many markets and utilizing a variety of exchanges and trading apparatus in its daily dealings.

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- Calculation techniques and emission factors are available for developing GHG emissions inventories for Oil and gas industry operations.

- These techniques cover the calculation or estimation of emissions from the full range of industry operations, from exploration and production through refining to the marketing of products, as well as the emissions from the transportation of crude Oil, Natural gas and Petroleum products.

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- The most significant GHG, associated with the operations of Oil and Natural gas industries, are the emissions of Methane (CH4) and Carbon dioxide (CO2).

- A schematic depiction of the Operations and Major Emission Sources for an Integrated Oil Company is shown:

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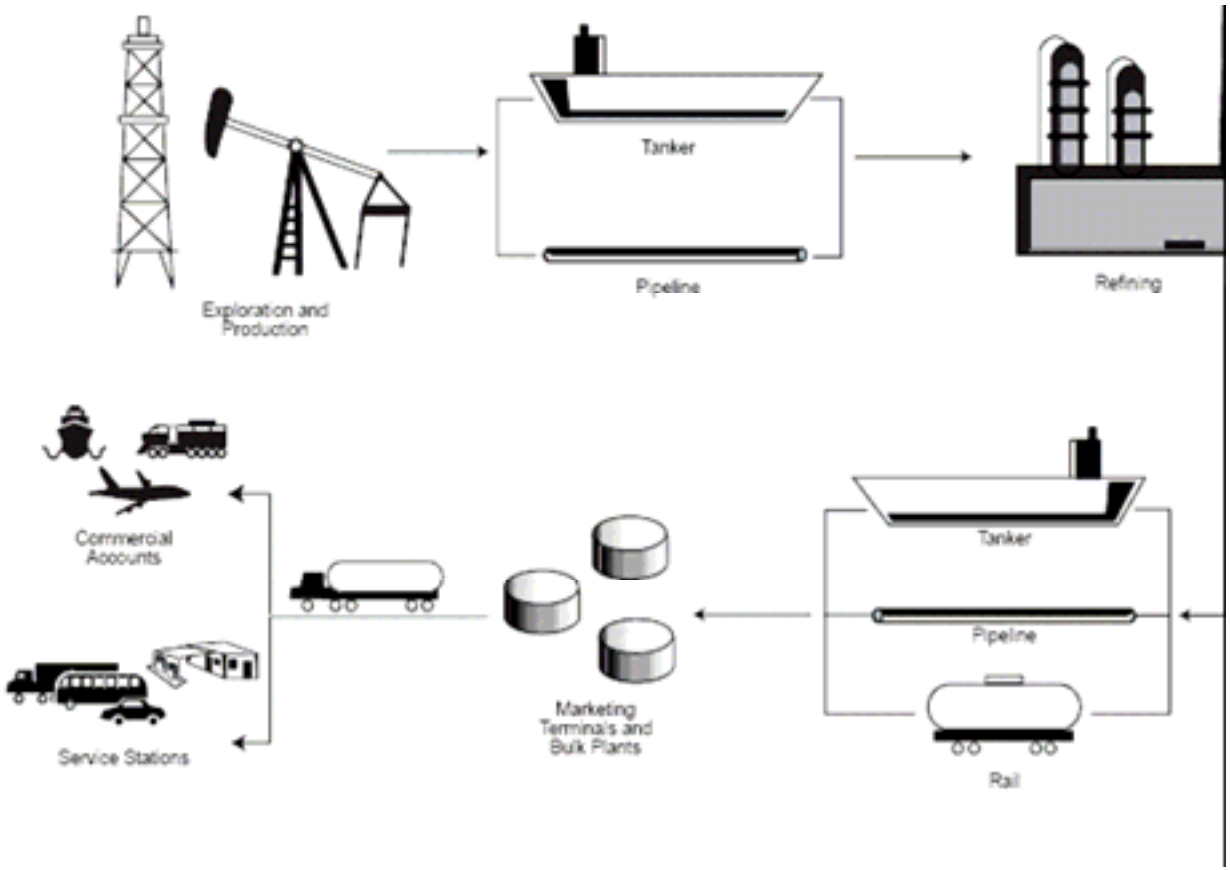

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- **Goal**: all the lessons learned from qualitative and quantitative comparisons of emission estimation methods are incorporated in the methodology;
- The **methods** compared are drawn from the most current GHG protocols available from the oil and gas industry, governmental, and non-governmental organizations;
- The **quantitative comparisons** are based on facilities representing the various sectors of the industry.

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Aims

- Cross check of emissions in developed and developing countries.
- Evaluation of three pollutants: CO2, CH4 and NMVOC, both for Natual gas and Oil.
- Natural gas: separate evaluations of extraction and distribution.
- Oil: separate evaluations extraction and refining, emissions in developed and developing countries

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Natural gas production and use: methane emissions

- Methane emissions can change by a factor of 1000.
- The weak point are the transmission and distribution lines

- Methane emissions

	Developing countries		Developed countries		Italy
	min	max	min	max	2004 aver.
gas prod.+processing	0.0005	0.0244	0.0005	0.0025	0.00002
gas transmission and distribution	1.9000	4.3400	0.0019	0.0019	0.0028

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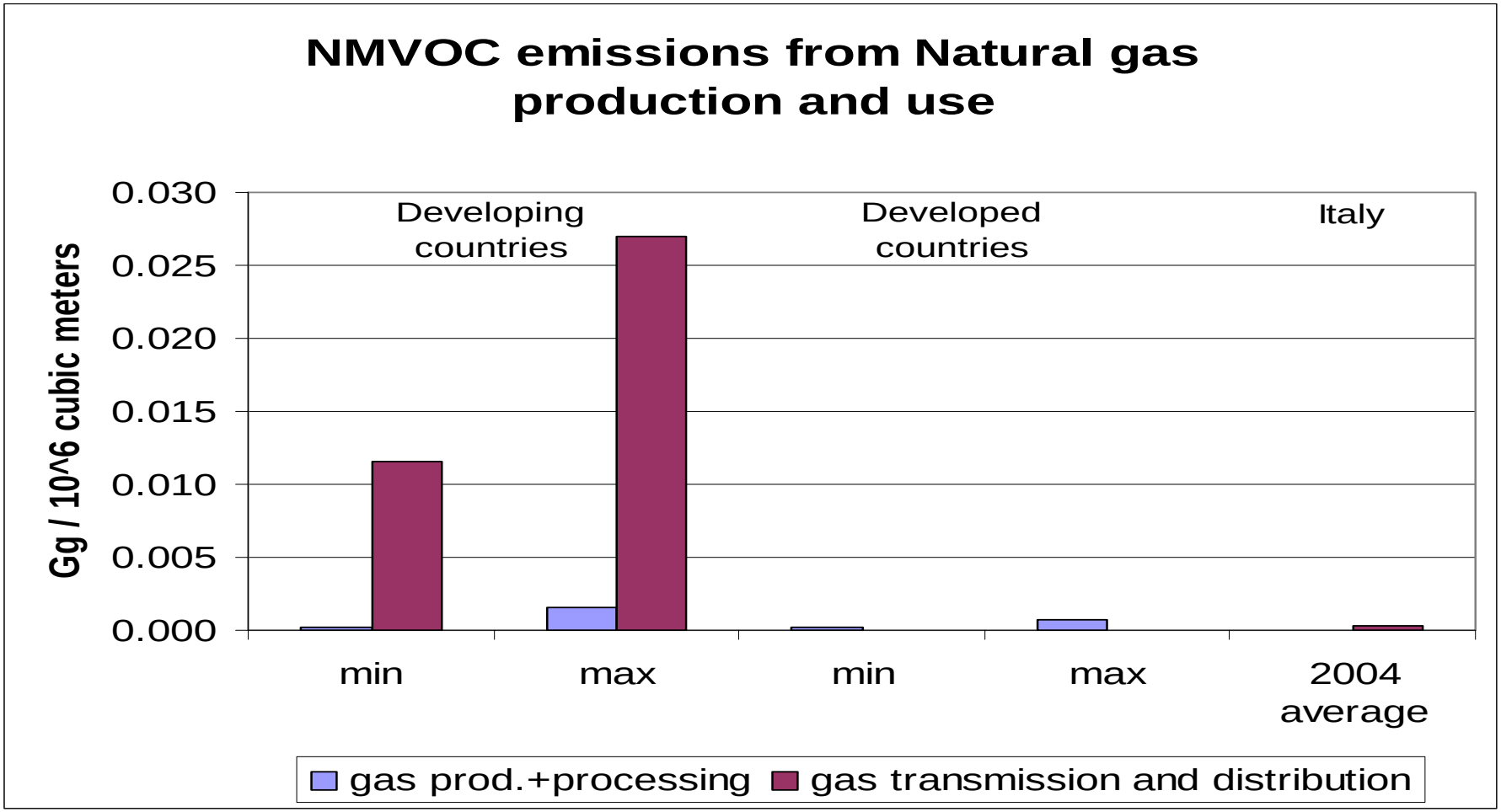
Natural gas production and use: NMVOC



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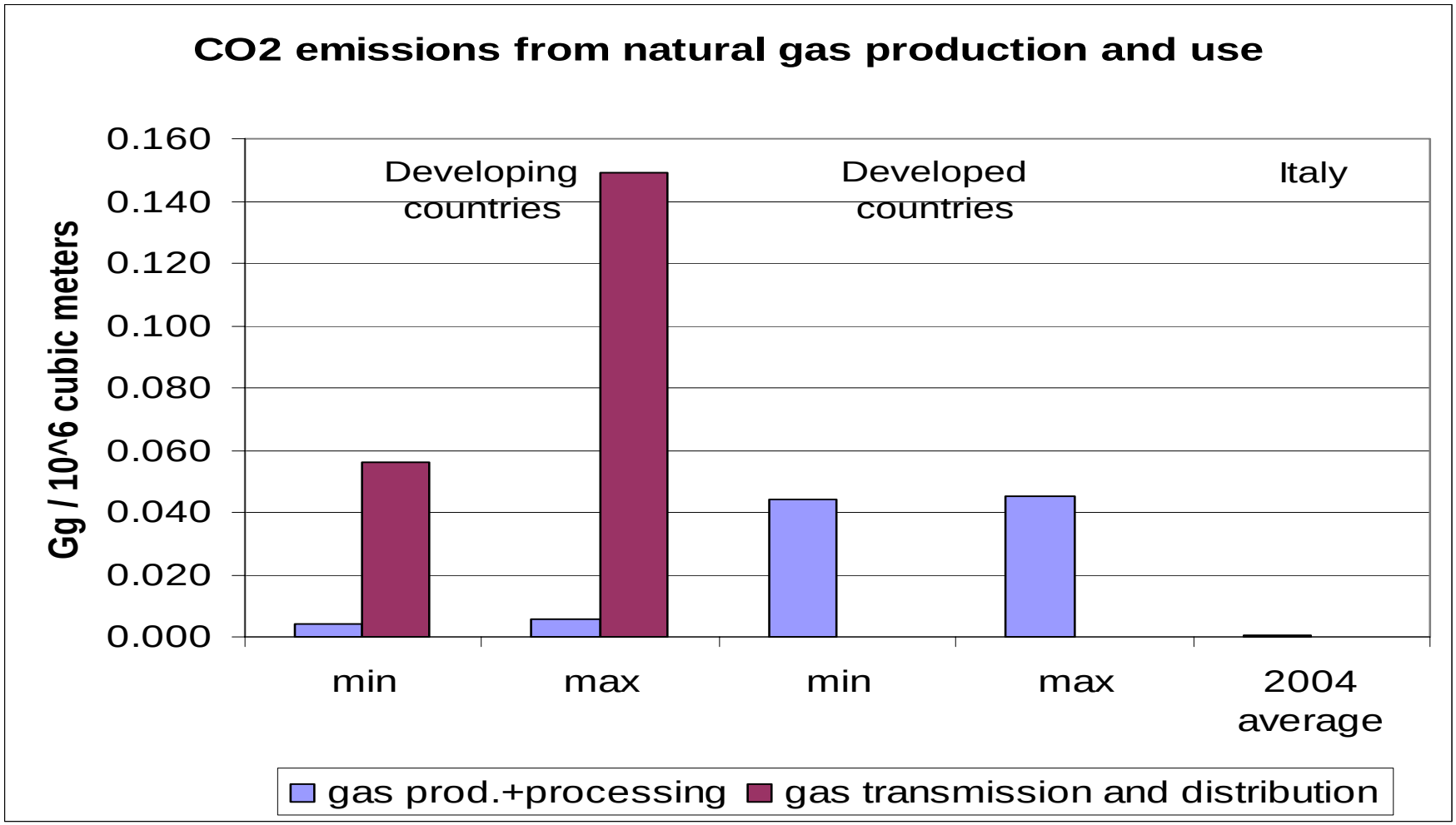
Natural gas production and use: CO2



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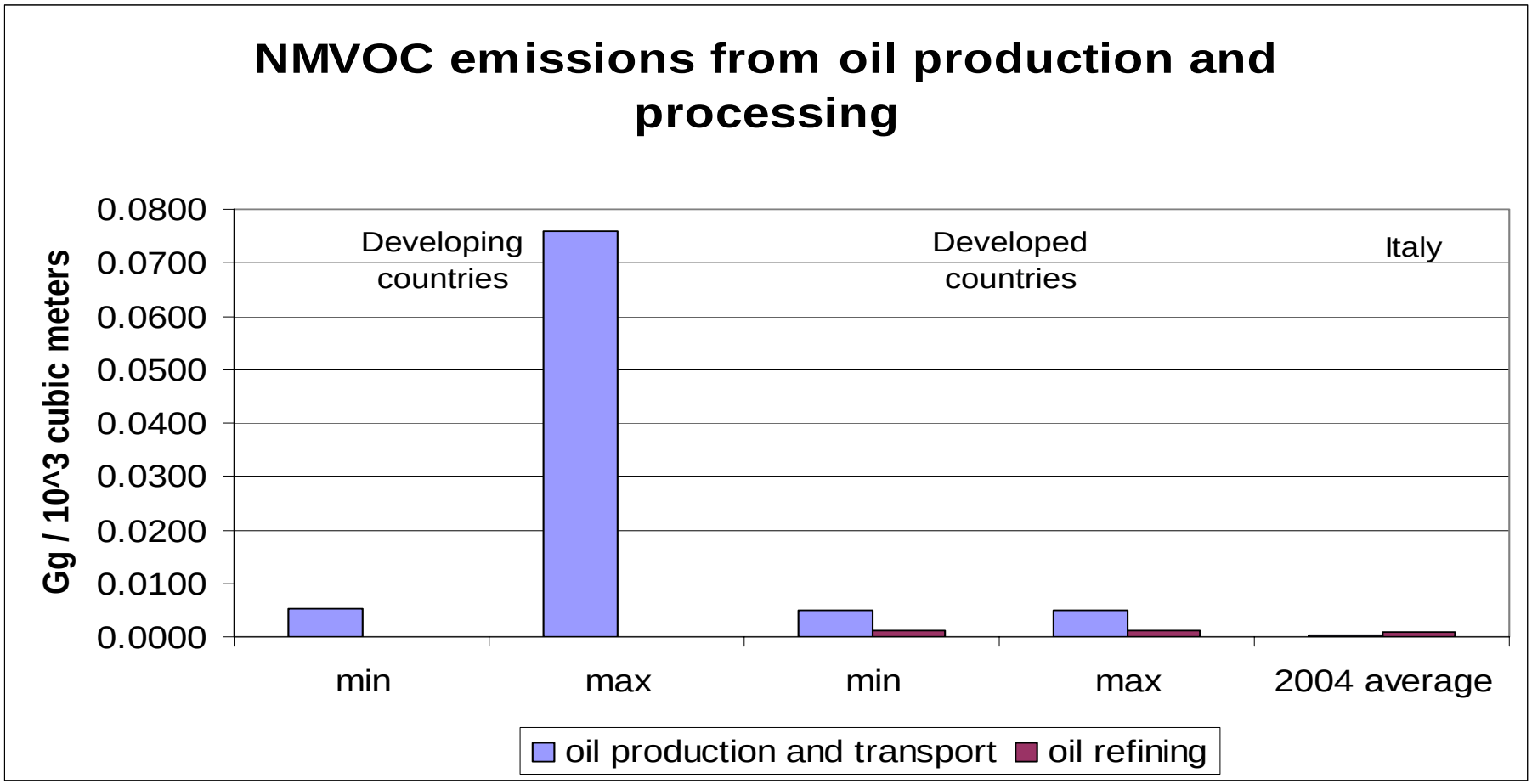
Oil production and processing: NMVOC emissions



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Oil production and processing: CO2 emissions

- Production efficiency seems to be quite similar around the word. The Italian value do indicate the potential for improvement.
- Oil refining is a complex process and the average value simply reflect the “complexity” of the refinery.

	Developing countries		Developed countries		Italy
	min	max	min	max	2004 aver.
oil production and transport	0.041	0.060	0.041	0.041	0.001
oil refining	ND	ND	0.0414	0.0414	0.0852

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Main findings

- The production and processing of fossil fuels is usually much more harmful than distribution and refining.
- Pollution control (and enhanced recovery) technologies do exist in this sector but they are seldom implemented in developing countries.
- Most of the great potential for emission reduction could be implemented at low cost, thank to the enhanced recovery of fossil fuels connected to the use of those technologies.

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Emission inventory practices

The design and harmonization of GHG inventorying and reporting practices include decisions on:

- Scope;
- Extent;
- Boundaries;
- Threshold;
- Technical issues of emission sources;
- Estimating methods;
- Data requirements.

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Elements of an Emissions Inventory

The key issues to be considered in developing a greenhouse gas emissions inventory, along with a recommended framework for addressing them are provided in Table:

Issues in Designing a GHG Emissions Inventory

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Issue	*Recommended Framework:*
Greenhouse Gases to be Included in inventory	Of the six potential compounds, or classes thereof, specified in the Kyoto Protocol, only 2 are highly relevant to Oil and Gas industry operations. Primary emphasis should be on CO_2 and CH_4.
Industry Sectors and Thresholds	Companies in the Oil & Gas Industry have a wide range of operations in all sectors from Oil and Gas exploration and production to refining, marketing, product distribution and retail. This mix of businesses differs in size and complexity. Applicable thresholds should be defined to establish relevance to the inventory being developed.
Reporting Scope and Geographical Coverage	The multitude of national and regional GHG estimation and reporting protocols fosters inconsistency in reporting for global companies. Industry guidance is needed to minimize redundancy in calculations, while allowing for regional and industry sector summaries.
GHG Emissions from JVs, non-wholly owned business units, contractors, and outsourcing	A growing portion of the oil and gas industry is operated through joint ventures and other forms of ownership. Most emission reporting practices entail estimating 100% of "operated emissions". In addition, for global GHG assessments, companies might also need to account for the full spectrum of emissions on an "Equity Basis". This will entail including joint ventures and other business units.
Accounting for emissions attributable to Indirect sources, e.g. utilities usage	The oil & gas industry's ability to operate depends to a large extent on the availability of electrical power and steam. For a variety of economic and local siting considerations, these utilities might be either on-site or imported. Emissions associated with such utilities are viewed as an enabler of the process, and thus might be taken into account when constructing a comprehensive inventory. Where indirect emissions are included in the inventory, they should be clearly identified to differentiate from direct emissions.

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Classification of Sources

- There are many GHGs, but oil and gas industry operations are significant emitters of only two: Carbon dioxide (CO2) and Methane (CH4).
- Oil and gas industry GHG ***emission sources*** are collected into five categories:

  - combustion devices;
  - point sources;
  - non-point sources;
  - non-routine activities;
  - indirect emissions.

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- *Combustion devices:* include both stationary sources, such as engines, burners, heaters, and flares; and fleet-type transportation devices, such as trucks and ships, where these sources are essential to operations (i.e. products or personnel transportation);
- *Point sources:* are part of normal operations, with releases occurring through stacks, vents, ducts, or other confined streams. They include hydrogen plants and glycol dehydrator vents along with venting from storage tanks and loading racks.

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- *Non-point sources:* include primarily CH4 emissions from equipment leaks (fugitive emissions), wastewater treatment facilities, and other sources that are part of waste handling.

- *Non-routine activities:* associated with maintenance or emergency operations may also generate GHG emissions.

- *Indirect emissions:* include emissions associated with company operations but physically occurring elsewhere.

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GHG Inventory Guidance

Protocol (Publication Date)	Scope	Root Data Source(s)	Other Details
IPCC's Guidelines for National Greenhouse Gas Inventories (IPCC, 1997). Non-combustion emissions are updated in IPCC uncertainty document (IPCC, 2001).	Energy chapter covers sources relevant to oil/ gas industry. Oil refining is not included in the uncertainty document.	For combustion, equipment based approach cites EPA AP-42 (1995). Fuel based approach uses International Energy Association (IEA) Statistics. IPCC, 2001 provides non-combustion emission factor ranges for broad source categories citing CAPP, 1999; GRI/ EPA, 1996; and EPA, 1999.	All energy data are expressed in net calorific values (i.e., lower heating value, LHV) converted from a higher heating value (HHV) basis.

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- An ***Emissions Factor*** is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant.
- These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g. kgs of particulate emitted per Mg of coal burned).
- Such factors facilitate estimation of emissions from various sources of air pollution.
- In most cases, these factors are simply averages of all available data of acceptable quality and are generally assumed to be representative of long-term averages for all facilities in the source category (i.e. a population average).
- The general equation for emissions estimation is:

$$E = A \times EF \times (1-ER/100)$$

where: E= emissions; A= activity rate; EF=***emission factor*** and ER= overall emission reduction efficiency, % .

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Emissions Factors Software and Tools (EPA)

- **Web*FIRE*** The FIRE database includes EPA's recommended emission estimation factors for criteria and hazardous air pollutants.

- **TANKS** TANKS estimates volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions from fixed- and floating-roof storage tanks.

- **SPECIATE** SPECIATE is EPA's repository of Total Organic Compound (TOC) and Particulate Matter (PM) speciated profiles for a variety of sources for use in source apportionment studies.

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- **LandGEM** The Landfill Gas Emissions Model (LandGEM) is an automated estimation tool with a Microsoft Excel interface that can be used to estimate emission rates for total landfill gas, methane, carbon dioxide, nonmethane organic compounds, and individual air pollutants from municipal solid waste landfills. It is available from the EPA's Clean Air Technology Center.
- **WATER9** WATER9, a wastewater treatment model, consists of analytical expressions for estimating air emissions of individual waste constituents in wastewater collection, storage, treatment, and disposal facilities; a database listing many of the organic compounds; and procedures for obtaining reports of constituent fates, including air emissions and treatment effectiveness.
- **PM Calculator** After receiving numerous inquiries regarding the removal of the PM Calculator, EPA has reposted the software. The software is here for your convenience, however, it is no longer supported by EPA. March 31, 2006.

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Comparison of CO2 Emission Factors for Fuel Combustion: Common Industry Fuel Types

Variability (%)	Fuel Types	Metric Tons of CO_2 / MMBTU (HHV)					
		API CO2 Emission Factor[1]	AGO Workbook 1.1 (Table 4)	IPCC Volume 3 (Table 1-1)	DEFRA, Protocol A1	WRI/ WBCSD[2]	CIEEDAC
3.6	Aviation Gas	0.0692	0.0717		0.0703	0.0693	
14.4	Bitumen	0.0810	0.0851	0.0808	0.0879	0.0931	
35.2	Coke (Coke Oven/Gas Coke)	0.1085	0.1260	0.1083	0.0879	0.1083	0.0893
6.4	Crude Oil	0.0743		0.0734	0.0703		
6.4	Distillate Fuel	0.0732	0.0718		0.0703	0.0732	0.0750
11.9	Electric Utility Coal	0.0994	0.0966		0.0879		
—	Ethanol	0.0700					
—	Flexi-Coker/ Low Btu Gas	0.113					
1.4	Gas/Diesel Oil	0.0742	0.0735	0.0742	0.0732	0.0732	
2.8	Jet Fuel	0.0723	0.0717		0.0703	0.0709	
4.4	Kerosene/Aviation Kerosene	0.0723	0.0735	0.0716	0.0703	0.0724	
3.8	Lignite	0.0976		0.1013		0.0977	
2.7	LPG	0.0629	0.0626	0.0632	0.0615	0.0631	
2.9	Butane	0.0668					0.0649
5.3	Ethane	0.0597		0.0617	0.0586		
11.6	Propane	0.0704				0.0631	0.0632
2.8	Misc. Petroleum Products and Crude	0.0721	0.0723		0.0703		
2.5	Motor Gasoline	0.0712		0.0694	0.0703	0.0710	
9.7	Naphtha (<104°F)	0.0665	0.0696	0.0734	0.0761		
0.0	Nat Gas Liquids	0.0632		0.0632			
6.8	Natural Gas	0.0531	0.0542	0.0532	0.0556	0.0531	0.0520
7.3	Other Bituminous Coal	0.0931		0.0947	0.0879	0.0931	
0.3	Other Oil (>104°F)	0.0732		0.0734			
—	Pentanes Plus	0.0669					
37.3	Petroleum Coke	0.102	0.1260	0.1010	0.0879	0.1021	0.0987
26.4	Refinery Fuel Gas	0.057	0.0718		0.0586		0.0566
11.0	Residual Fuel	0.0788	0.0718	0.0775	0.0703	0.0769	
—	Special Naphtha	0.0728					
—	Still Gas	0.0642					
8.9	Sub-bituminous Coal	0.0963		0.0962	0.0879	0.0965	
—	Unfinished Oils	0.0742					

Notes:
[1]Primarily taken from EIIP, 1999.
[2]Cites heating value and other fuel property conversion factors from EIA, *Annual Energy Review*, and U.S. Department of Energy, 2000.

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Emission Factors

- The principal source for the finding of the emission factors is the "Atmospheric Emission Inventory realized and modernized Guidebook“ from the European Agency of Atmosphere (EEA, 1999) that, for all the activities that involve emissions in atmosphere, propose specific factors of emission and procedures of calculation with degrees differentiates of complexity.

- These emission factors are connected to mainly used technologies and processes, so to guarantee the widest possibility in application.

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- The existence of a literature on the emission factors does not exclude however the possibility to develop here where necessary specific factors of emission more relating to the national or local situations.
- Other sources that can be consulted in the case in which the Guidebook it does not give exaustive indications are:

  - Guide to the Factors of Emission of EPA (EPA, 1995 and successive updatings), and

  - Guidelines for the realization of National Inventories of Emission for Greenhouse Gases of the IPCC, Intergovernmental Panel on Climate Change (IPCC, 1997).

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- ***Emission Factor (EF)*** *[**tCO2 / TJ** produced energy] (TJ=10^{12}J):*

  - ***Natural Gas:*** ***56,1 t_{CO2}/TJ***
  - ***Oil Fuel :*** ***77 t_{CO2}/TJ***
  - ***Coal bituminous:*** ***95 t_{CO2}/TJ***
  - ***Crude Oil :*** ***73 t_{CO2}/TJ***
  - ***Gasoline :*** ***69 t_{CO2}/TJ***
  - ***Diesel Fuel :*** ***74 t_{CO2}/TJ***

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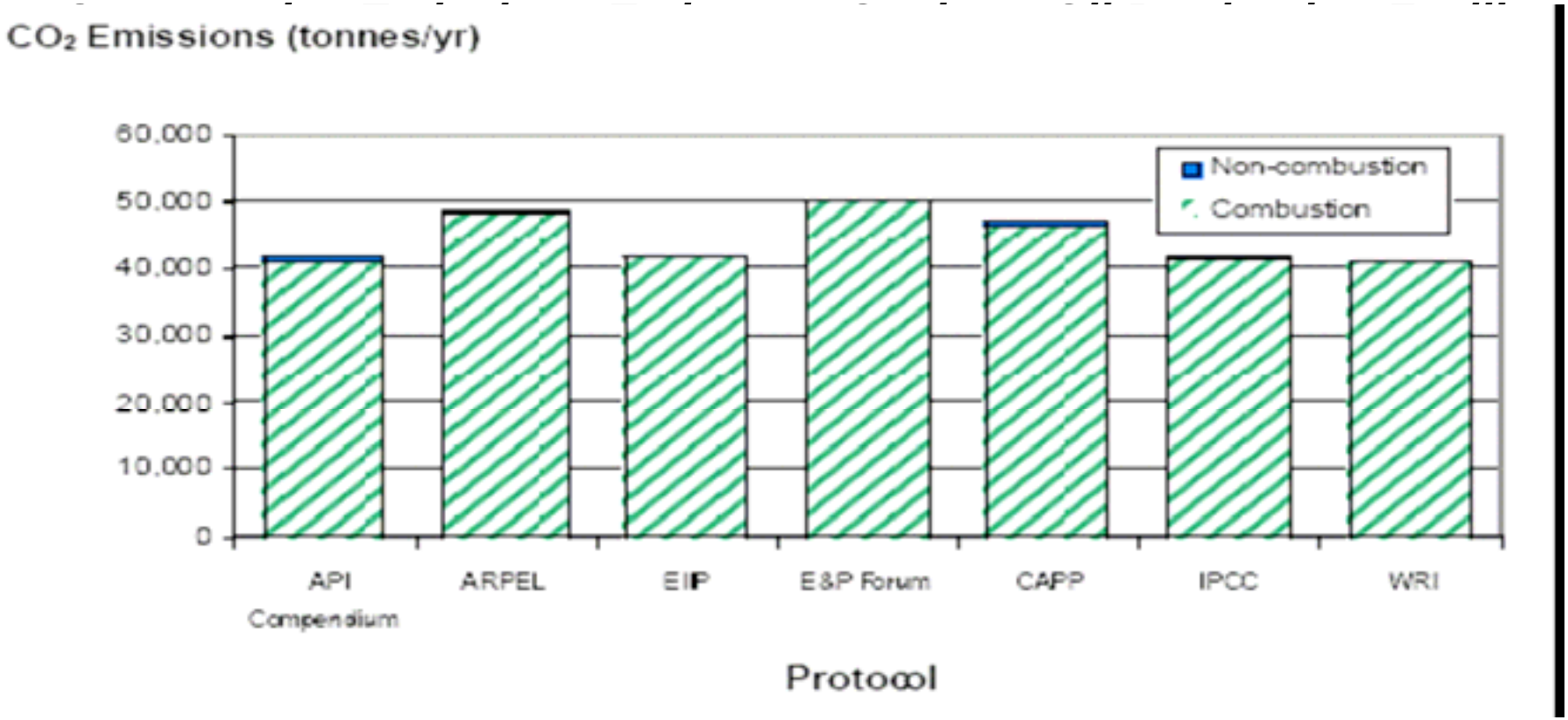
The figure presents graphically the results for CO2 and CH4 emissions estimates for the example facility when using the methodologies provided in the various protocol documents.



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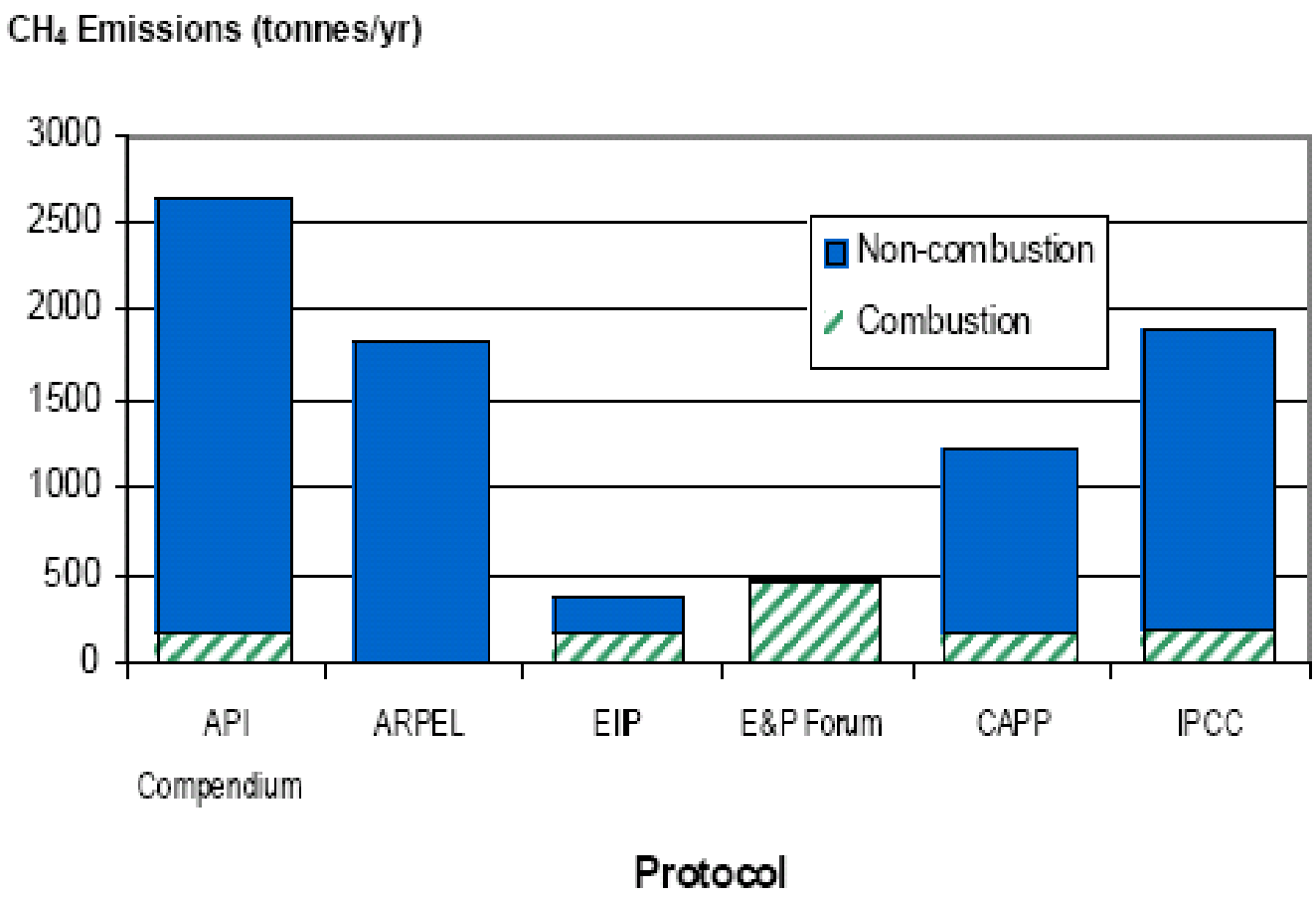

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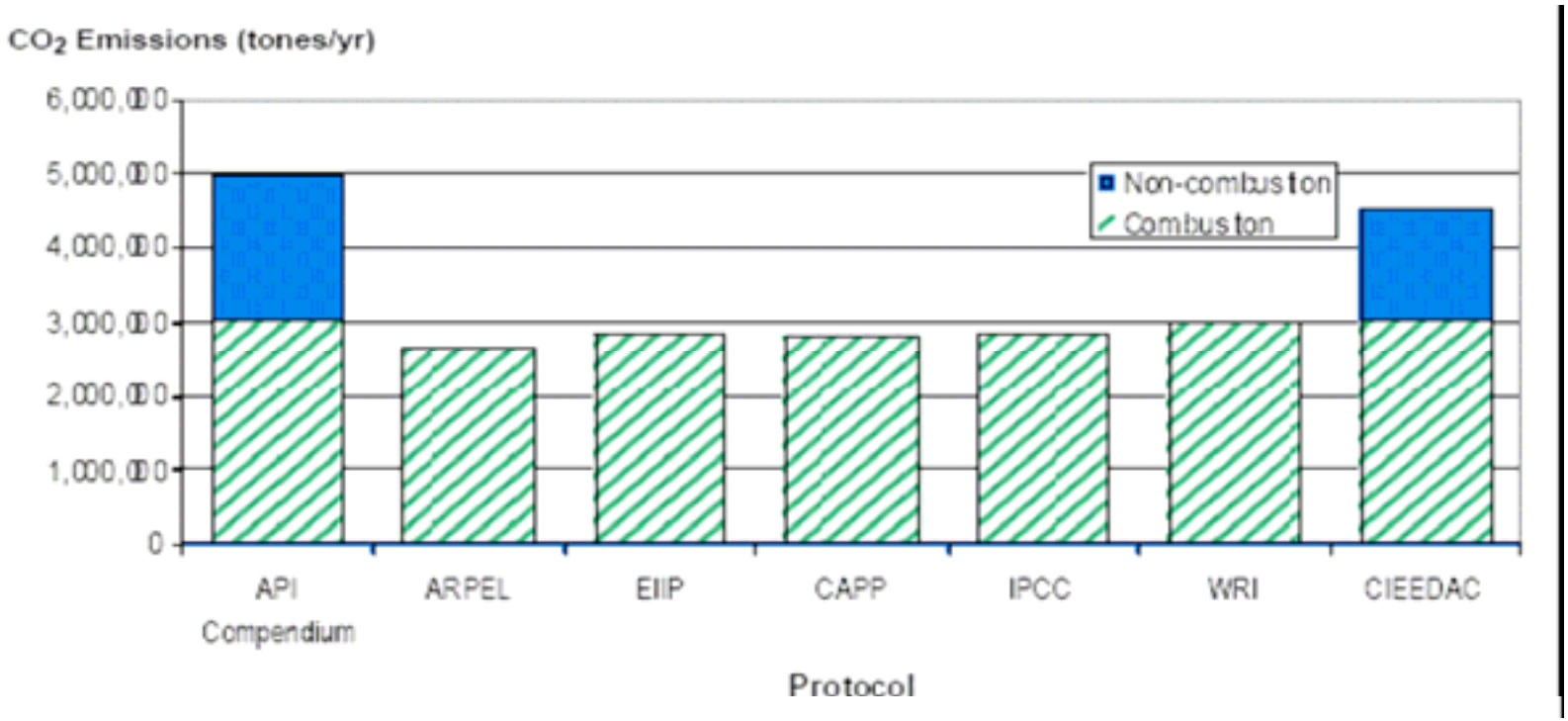
Next figure presents the estimated emissions from the example refinery when the various protocol documents are applied to the same set of sources and devices.

Comparative Emissions Estimate - Large Complex Refinery



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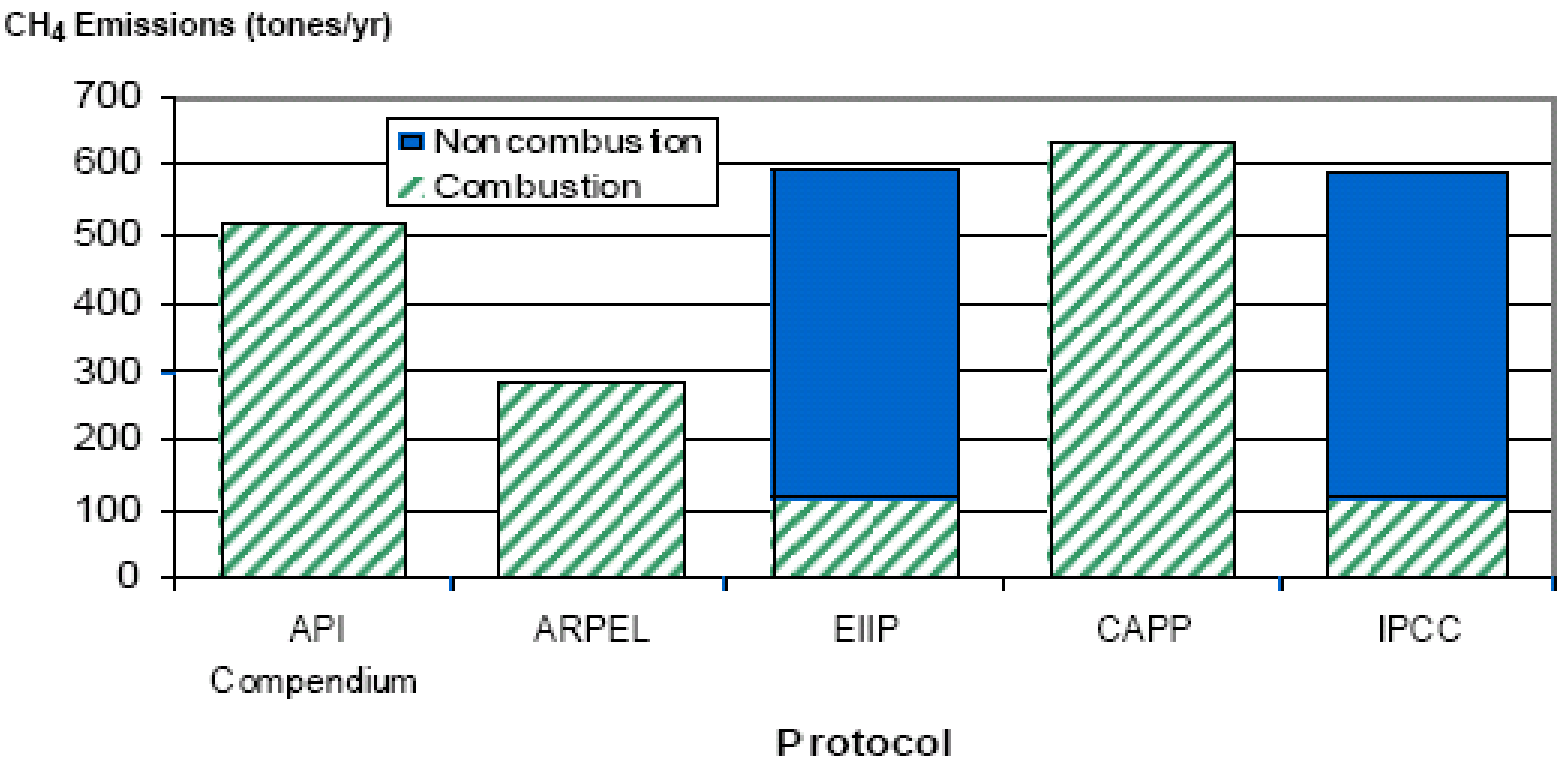

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- 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC 2006. Italian Greenhouse Gas Inventory 1990 – 2004, National Inventory report 2006, APAT 2006.