ライフサイクルアセスメント
生命週期評估
전 과정 평가
வாழ்க்கை வட்டப் பகுப்பாய்வு
ارزیابی چرخه عمر
Evaluarea Ciclului de Viață
Posuzování Životního Cyklu
Bizi zikloaren analisi
Olelusringi hindamine
Lífsferilsgreining
Levenscyclusanalyse
Livscyklusvurdering

LCI of methane emissions linked to oil and gas production

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Presentation for Plastics Europe

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Who are we?

Dr Niels Jungbluth

Karen Muir

Christoph Meili

Maresa Bussa

Over 25 years of experience in life cycle assessment

Clients from industry, NGOs, administration, universities

Founded 1998 as an ETHZ spin-off

Company LCA database with more than 8‘000 datasets

Update 2018-21 on behalf of the Swiss Federal Offices for the Environment & of Energy and the Swiss Gas & Oil Associations

All reports and data are available on https://esu-services.ch/data/public-lci-reports/, SimaPro library provided on demand

LIFE CYCLE INVENTORY OF OIL AND GAS PRODUCTS

Project outline

- Partial update of data for crude oil and natural gas extraction and transportation
- Reference year 2019
- Documentation of harmonized Life Cycle Inventories
  in SimaPro and EcoSpold v1 format
- Global data sources used where possible
  → consistency, simplification of data collection
- Validation by IFEU
- Basis for update of LCI databases used by Swiss authorities (UVEK/KBOB)

Extraction: Updates 2021

- Focus on most relevant specific data sources
- Country specific data for flaring and methane emissions
- Updated resource, water and energy uses and direct emissions (mainly reported by IOGP)
- Adjusted energy content for allocation

Sources of natural gas emissions

- Release of unburned natural gas to the atmosphere, due to production and processing of crude oil & natural gas.
- In industry: Unwanted release of natural gas in technical process chain, e.g. due to insufficient flaring, accidents or leakage.
- However, it may also occur due to forced changes in geological structures (e.g. due to fracking).

➢ Satellite measurements show that emissions are more diffuse and less connected to the flaring rate than expected by industry

Flaring, venting and fugitive emissions

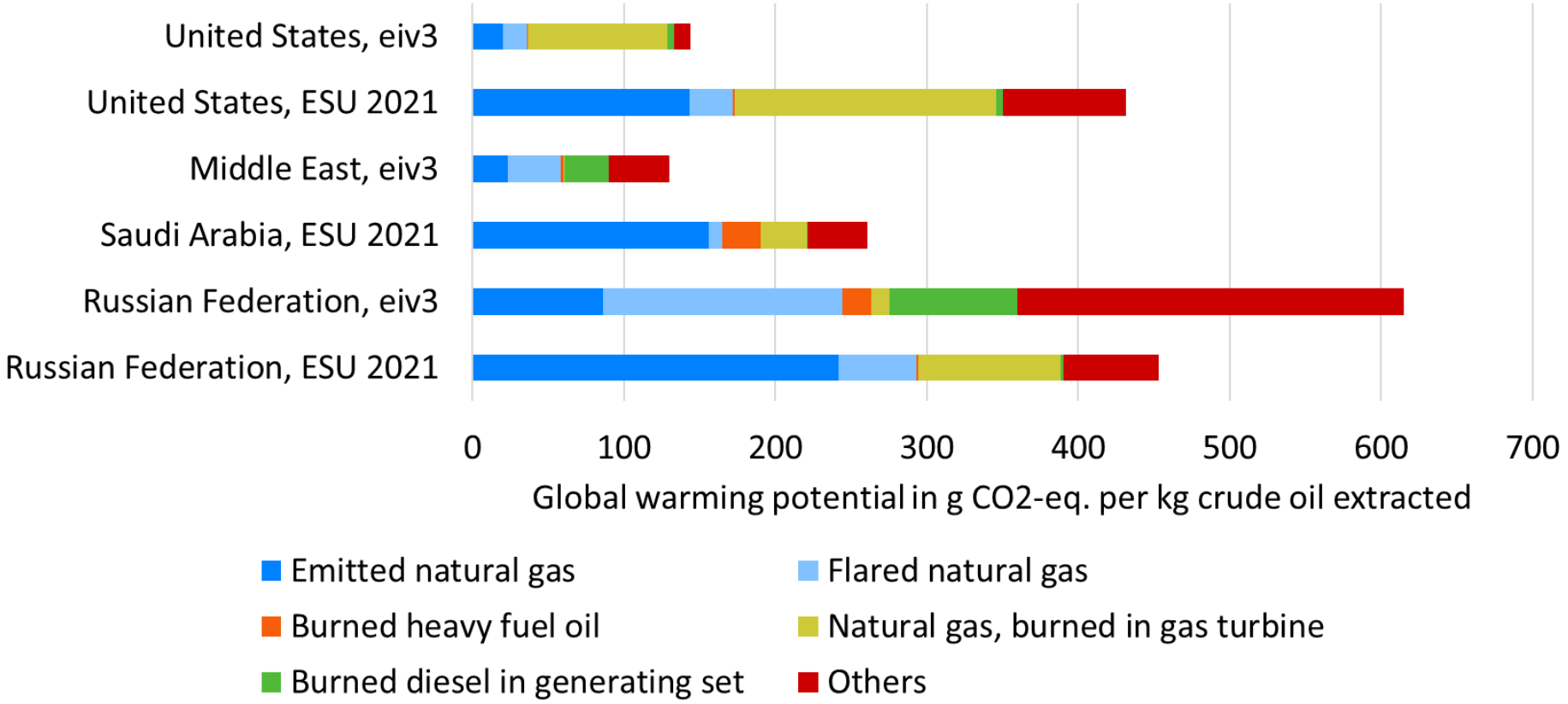
- Country-specific satellite data are available for all emission sources
- Flaring for oil and gas combined (Worldbank & Skytruth 2020)
- Venting and fugitive emissions (IEA 2020) distinguished for
  - oil & gas
  - on- & offshore
  - up- & downstream
  - conventional & unconventional

Methane emission: consulted and used sources of information (Examples for biggest extracting countries)

Source	Crippa et al. 2019, data from EDGAR, up- & downstream (2012)	IOGP 2020, upstream only (2019)	UNFCCC 2020, up- & downstream (2018)	UNFCCC 2020, up- & downstream (2018); Production: BP (2018)	IEA 2020, up- & downstream (2019); Production: BP (2019)	**IEA 2020, upstream (2019); Production: BP (2019)**	IEA 2020, downstream (2019); Production: BP (2019)
Unit	kg/kgOE	kg/kgOE	kg/kgOE	kg/kgOE	kg/kgOE	kg/kgOE	kg/kgOE
Russian Federation	8.76E-03	1.12E-03	6.37E-03	6.16E-03	1.09E-02	9.13E-03	1.80E-03
Saudi Arabia	4.45E-03	1.00E-04	n.a.	n.a.	5.26E-03	4.85E-03	4.08E-04
United States	8.26E-03	1.25E-03	1.37E-02	5.58E-03	7.53E-03	6.04E-03	1.50E-03
Global	1.01E-02	6.01E-04	7.58E-03	4.14E-03	1.05E-02	8.47E-03	1.99E-03

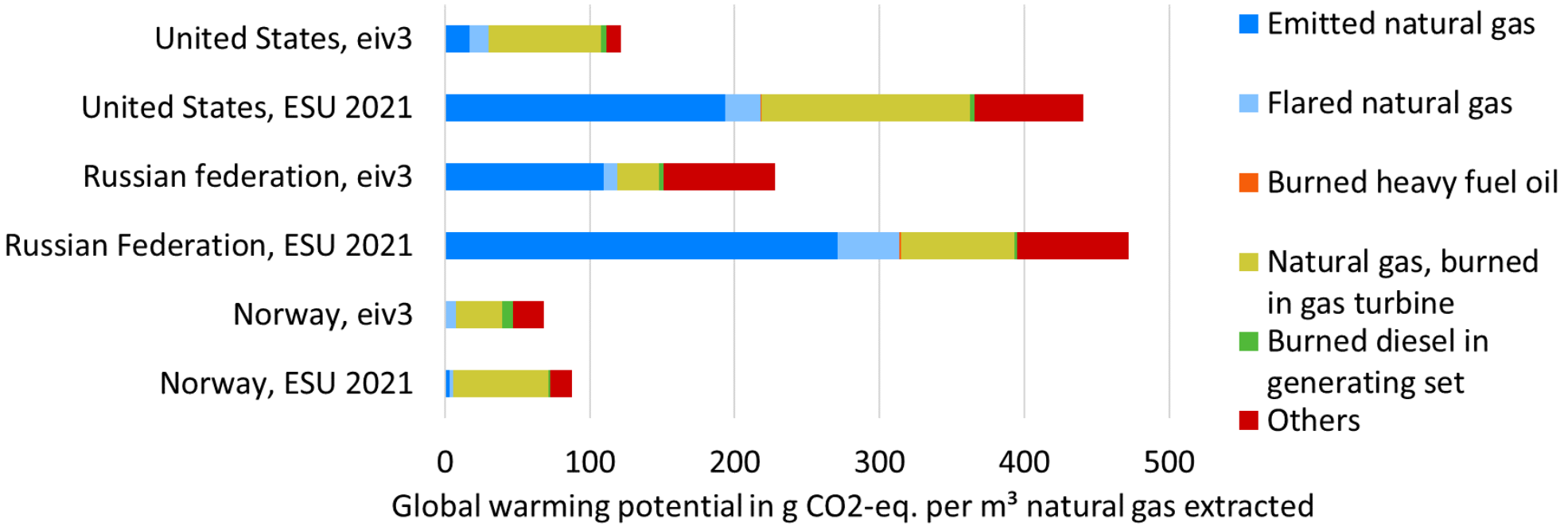
- Methane emissions reported by IOGP is order of magnitude lower than calculated from national and global emissions in relation to national and global production data

Crude oil from important extracting countries 2019: GWP 100a in ecoinvent v3 compared to our study



- New data for methane emissions are significantly higher than bottom-up estimates in former LCI

Natural gas from important extracting countries 2019: GWP 100a in ecoinvent v3 compared to our study



- Same findings as for crude oil

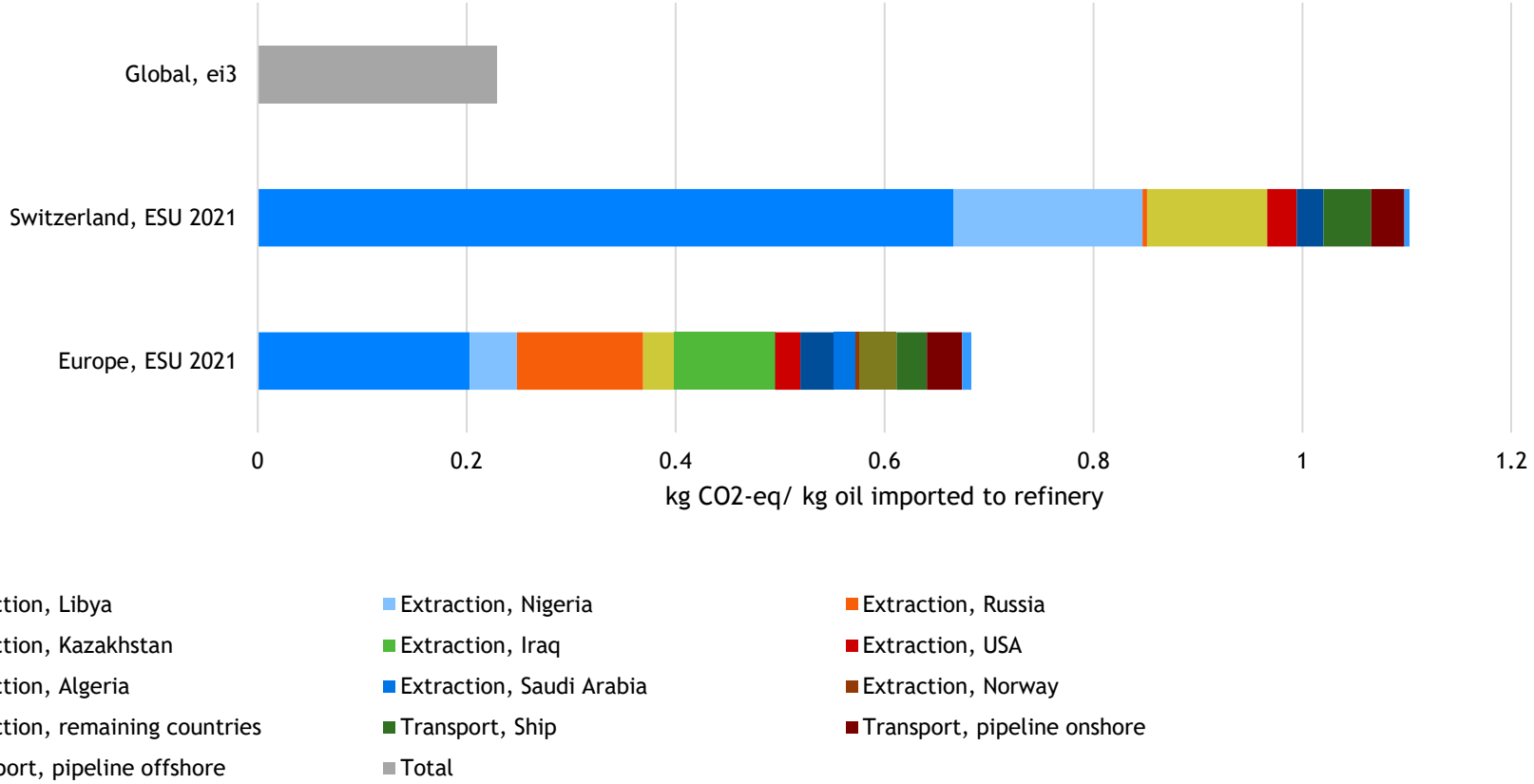
Extraction: GWP Results

- Wide variety of emissions depending on origin
- Main differences due to methane emissions and flaring
- GWP due to direct methane emissions about 10-times higher than reported in ecoinvent v3.6
- Global average about 2.5-times higher than reported in ecoinvent v3.6

Crude oil transport: Updates

- Supply mixes for European & Swiss refinery
- Same port of origin and destination independent of journey
- Extrapolation from shares of analysed countries to model 100% of the mix
- No updates for infrastructure and direct emissions

Crude oil transported to refinery: Results GWP 100a



- Updated LCI about factor 3 higher GWP than bottom-up in ecoinvent v3

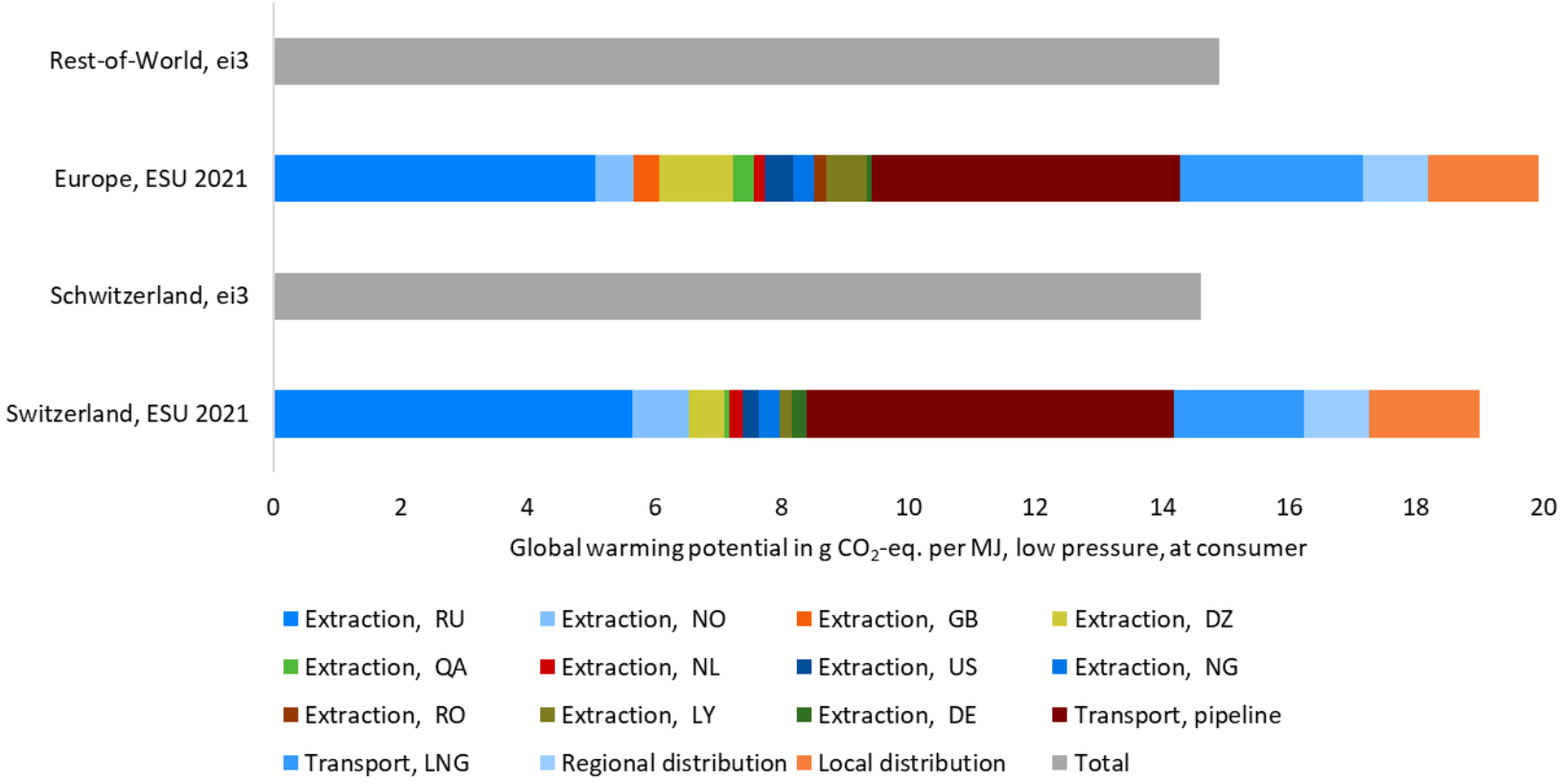
Crude oil transported to refinery: Results

- New datasets have higher GWP due to…
  - Higher shares from high-emitters like Libya, Algeria and Iraq
- Transport itself has small relevance (~2% of GWP)
- Compared to the global average in ecoinvent v3.6, GWP of the updated import mix to Europe and Switzerland is about 3 to 4.8-times higher, respectively

Natural gas transport: Updates in LCI

- Supply mixes for RER, CH, DE, FR, IT, NL
- Energy demand and leakage rates of pipeline transport
- Offshore pipeline from RU (North Stream 1)
- Energy demand and emissions of liquefaction and evaporation
- Fuel consumption and emissions of LNG carriers
- Energy demand and leakage rates of regional and local distribution

Natural gas transport to low pressure: Results GWP 100a



- New LCI about 30% higher than ecoinvent v3
- Downstream emissions more relevant and less different

Methane release downstream

Origin	Methane emission factor downstream (Crude oil)	Methane emission factor downstream (Natural gas)
Unit	kg/MJ crude oil	kg/MJ natural gas
Literature	IEA 2020, upstream (2019)	IEA 2020b
Global	**1.14E-06**	**1.07E-04**
LCI data available for this study	UVEK 2021	UVEK 2021
Natural gas, burned in gas turbine/CH		7.30E-05
Natural gas, burned in gas turbine/MJ/RER		6.90E-05
Light fuel oil, burned in industrial furnace 1MW, non-modulating/MJ/CH	6.00E-06	
Light fuel oil, burned in industrial furnace 1MW, non-modulating/MJ/RER	7.00E-06	

- IEA has only downstream data for countries of origin (no consumer perspective)
- Confirmation for the order of magnitude
- Downstream emissions for European natural gas use are below and emissions for oil over global average according to IEA 2020

Natural gas transport: Results

- New datasets have higher environmental impacts
  - Country-specific venting data
  - Higher imports from Russia and lower imports from the Netherlands
- European datasets have higher environmental impacts
  - Higher share of LNG imports
  - Greater importance of Libya and Algeria

Key messages natural gas transport

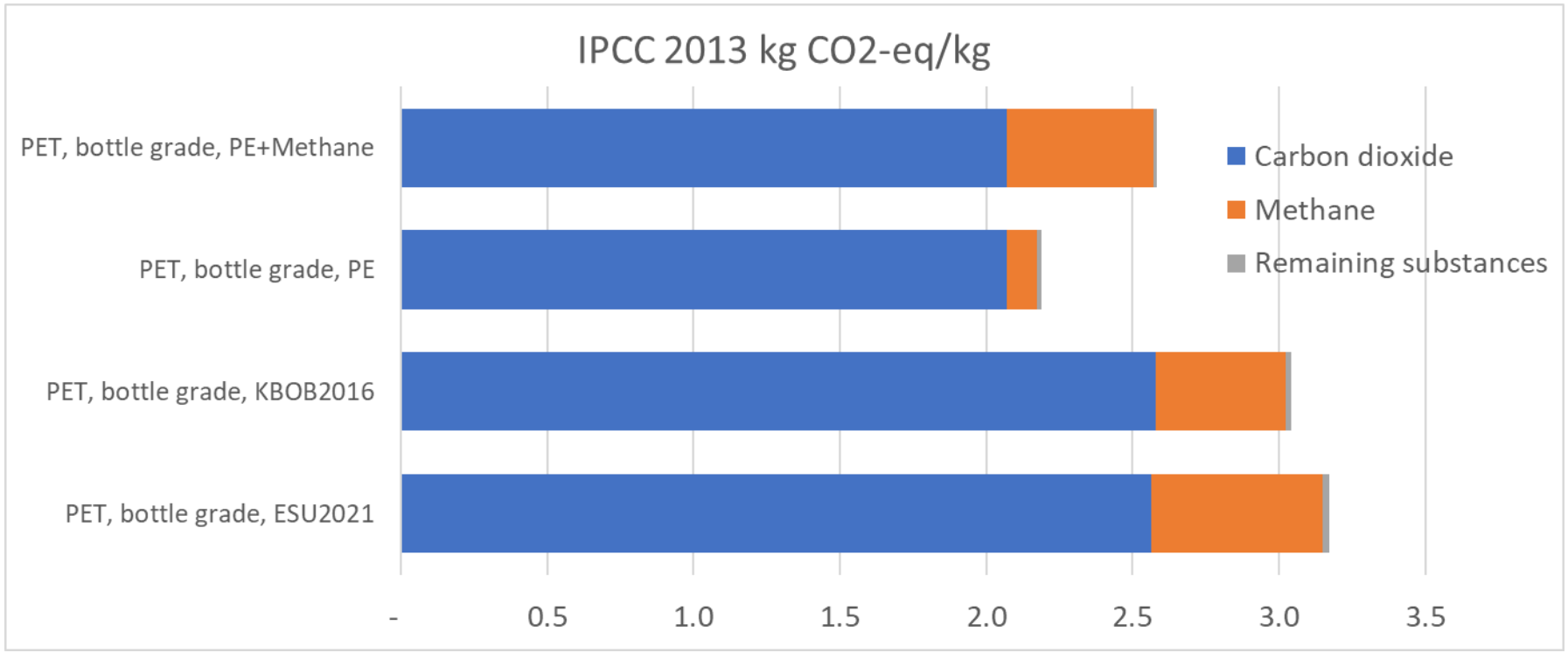
1. Consumption mix plays important role
2. Differentiation between Pipeline and LNG-imports matters
3. Effect of methane from extraction less pronounced than for crude oil due to higher downstream emissions

INFLUENCE ON PLASTICS EUROPE DATA

What is the contribution for plastics?

- Bias for system processes needs to be avoided
- Estimation of surplus methane release based on LCI for crude oil and natural gas resource use
  - methane, fossil/kg = oil, crude in ground/kg * 0.0135 kg/kg + gas, natural/m^3 * 0.0089 kg/m^3
- Integrated in system processes provided by Plastics Europe and imported to ESU-database 2021

Results for plastics, example PET

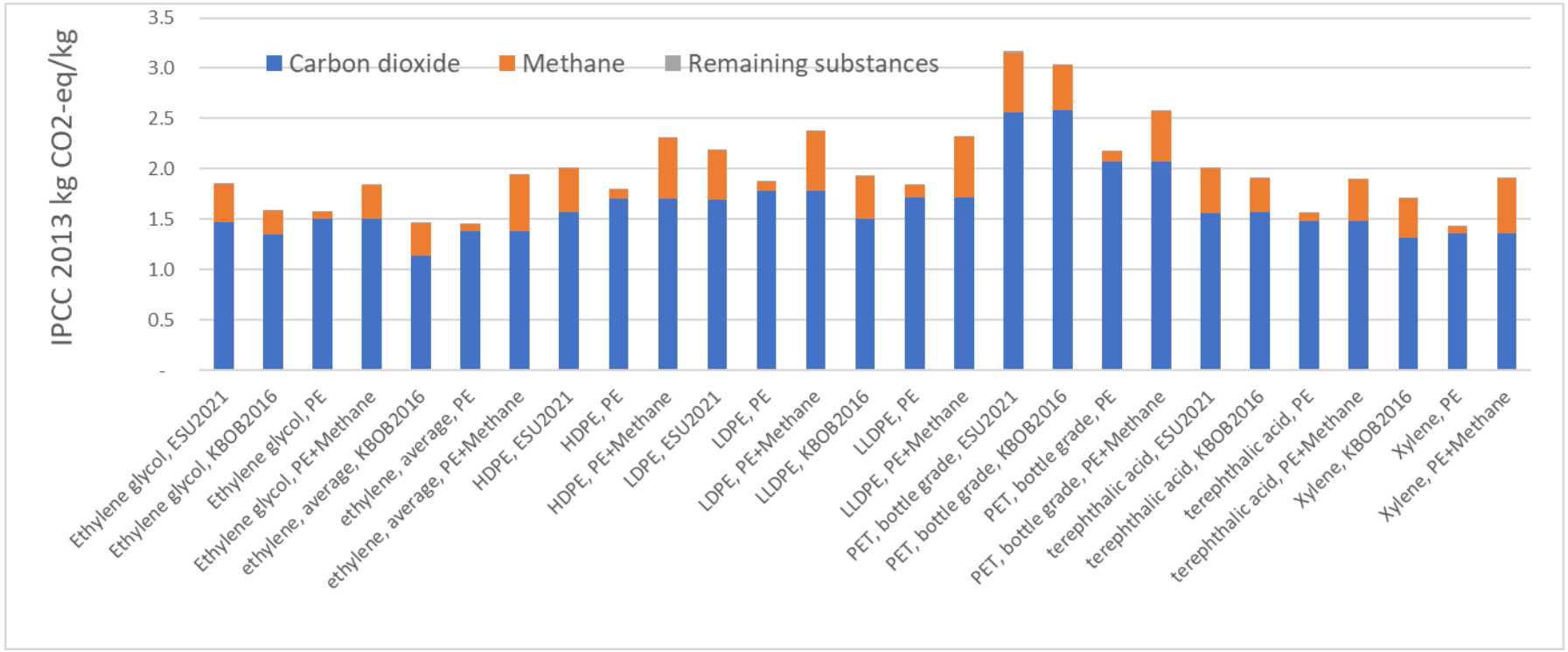


ESU 2021 – Unit processes with CH4
PE – system processes

KBOB 2016 – Unit processes without CH4
PE+Methane – including methane

- Increase due to methane 15-30%
- Effect of methane less pronounced due to further CO2 emission from fossil fuels
- Data for several plastics integrated in ESU database 2021

Results all plastics



ESU 2021 – Unit processes with CH4
PE – system processes

KBOB 2016 – Unit processes without CH4
PE+Methane – including methane

Outlook/Suggestion

- Regular updates of oil/gas mixes, e.g. every 2-3 years
- Harmonize and update data for coal
  (effect seems to be of low relevance)
- Link PlasticsEurope and other industry data to up-to-date LCI
- Include future emissions due to abandoned oil and gas fields

Thank you very much for your attention!

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Funding by several institutions

Here we present our own personal conclusions

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