FIFTH IEF-KAPSARC THOUGHT LEADERS' ROUNDTABLE
PLENARY SESSION 2

INTEGRATING LOW-CARBON ENERGY TECHNOLOGIES IN THE UPSTREAM AND MIDSTREAM

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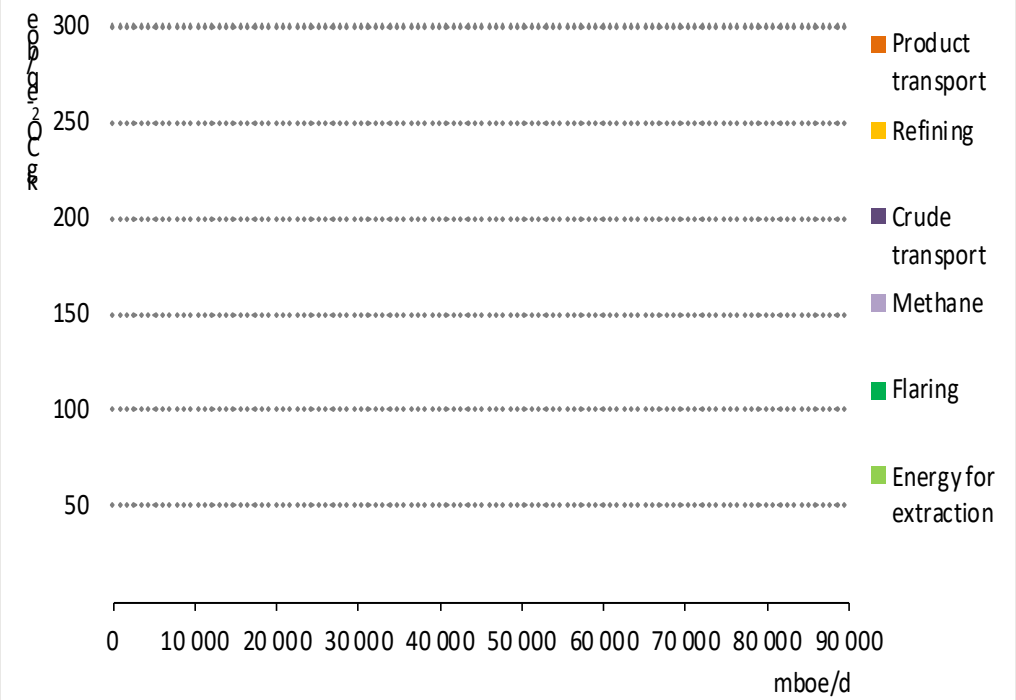
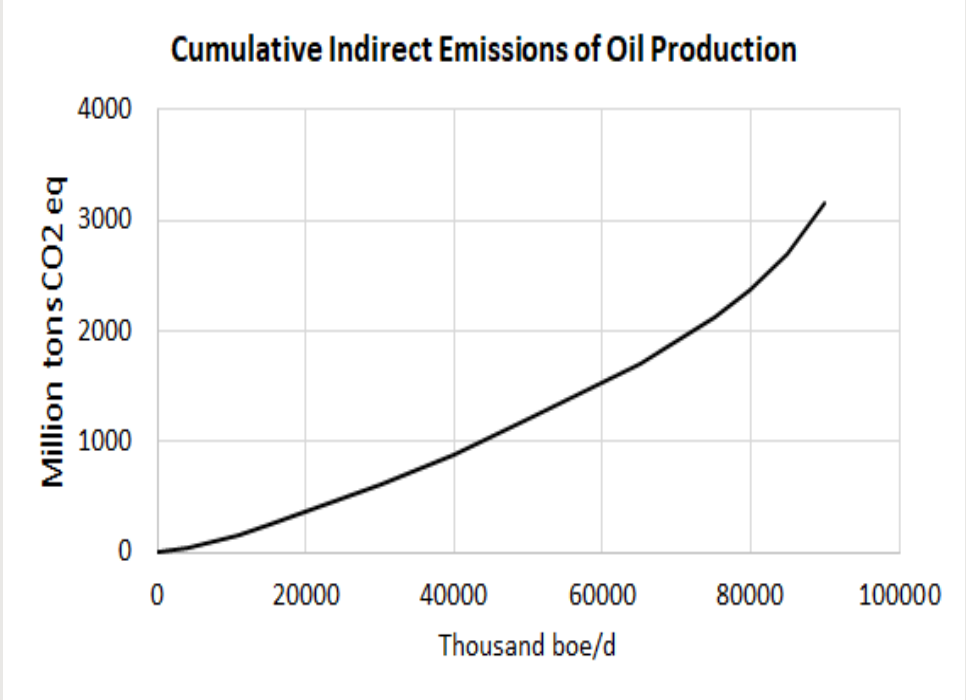
King Abdullah Petroleum Studies and Research Center

INDIRECT EMISSIONS INTENSITY (OIL PRODUCTION)





- Average indirect emissions intensity for oil is 95 kg CO2 eq./boe, but wide variation
- Most of the emissions related to methane and refining
- 2/3 of the emissions from less than ½ of the production

Source: IEA-WEO 2018, KAPSARC, Nomadia

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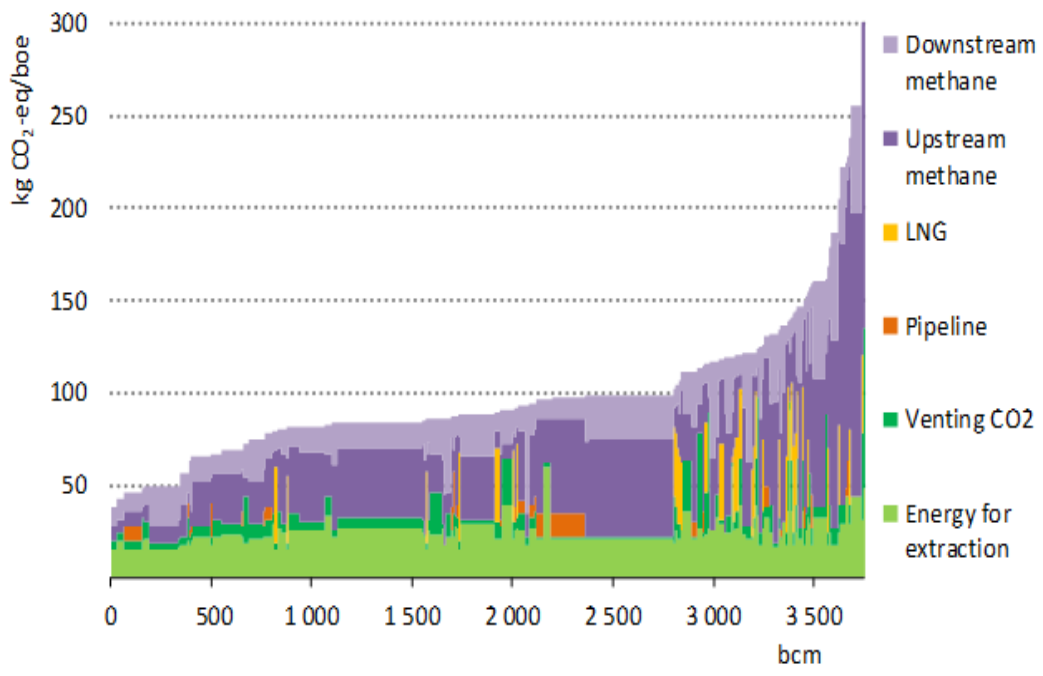
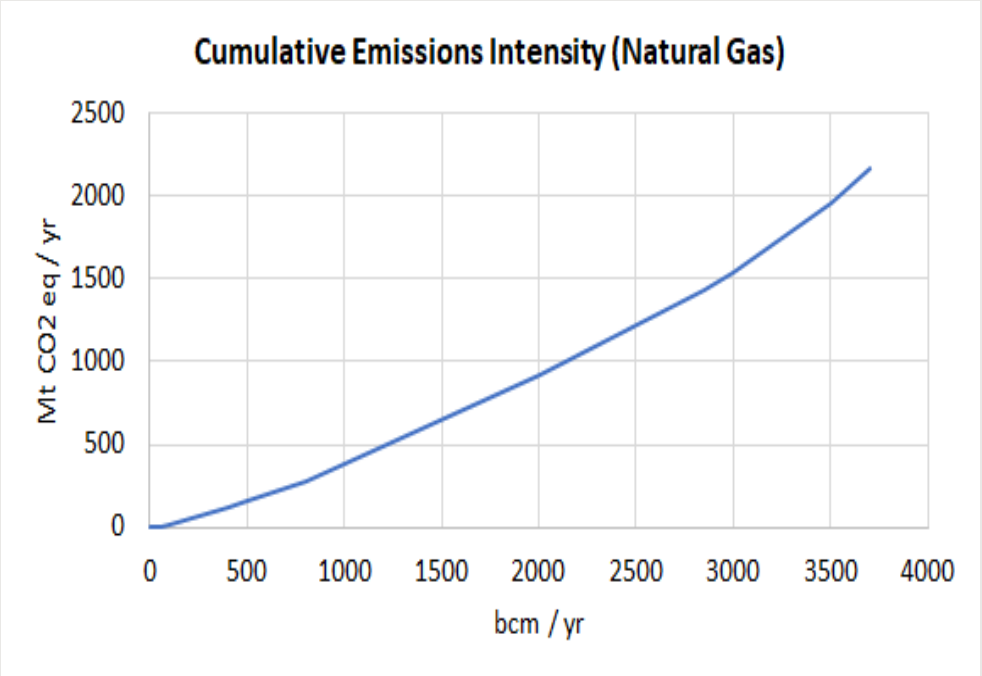
INDIRECT EMISSIONS INTENSITY (GAS PRODUCTION)





- Average indirect emissions intensity for gas is 100 kg CO2 eq/boe, but wide variation
- Most of the emissions related to methane (upstream and downstream)
- Energy for extraction is relatively uniform

Source: IEA-WEO 2018, Nomadia

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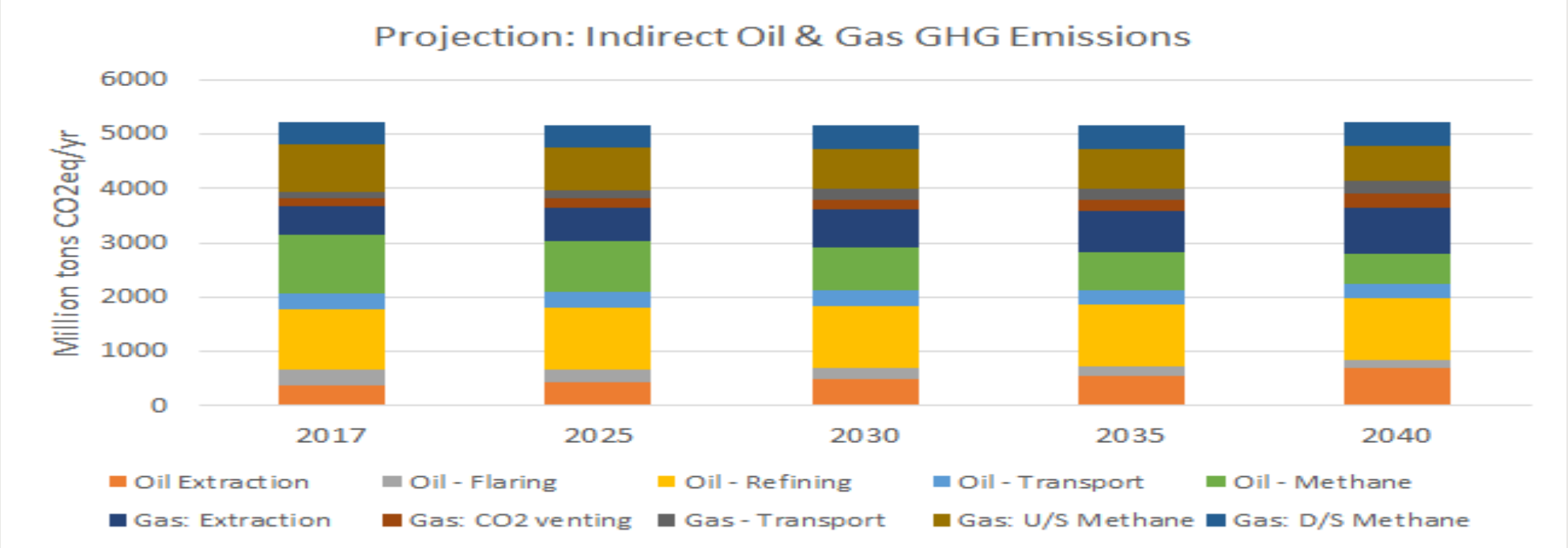
BETWEEN 2017 & 2040: GHG DECLINE FOR OIL COMPENSATED BY INCREASE WITH GAS



More energy/emissions intensive sources: heavy oil, shales, deepwater, higher water cut, sour/acid gas …

Source: IEA-WEO 2018, Nomadia

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COMMON TECHNOLOGIES FOR OIL & GAS

- Methane emissions:
  - Low hanging fruits: technology could avoid 75% of those emissions (IEA)
  - Marginal abatement cost varies from - $5/Mbtu to +$7/Mbtu
  - Leak detection and repair (LDAR) technologies
  - Replacement of existing devices: Pumps, electric motors, compressor components
  - New device installation: vapor recovery …

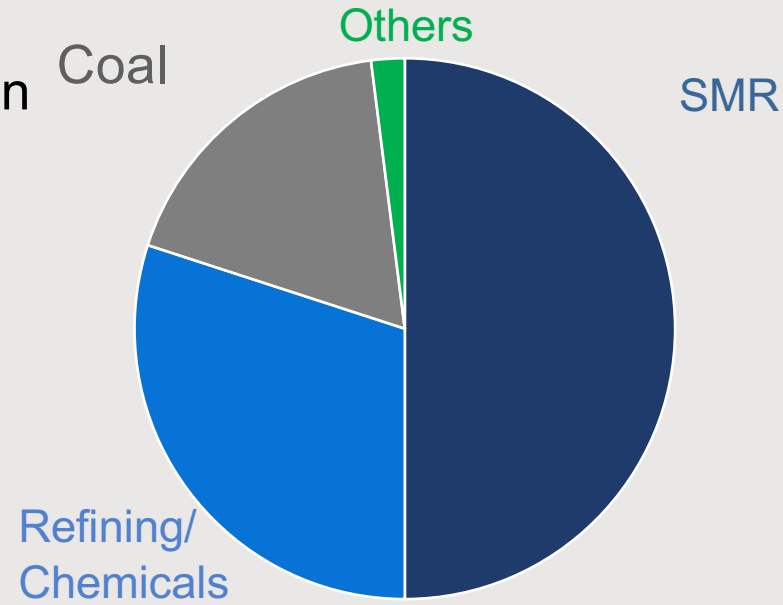
OIL RELATED TECHNOLOGIES

- Electrification
  - Improved efficiency
  - Emissions intensity varies regionally
  - Offshore/deepwater installations
- Digitalization
  - Improving recovery
  - Reducing energy use
- Enhanced Oil Recovery
  - Steam generation using solar power: Oman, Kuwait, California
  - CO2-EOR
  - Shifting to EOR+ (Storing CO2 through EOR)

HYDROGEN

- Significant potential for a clean energy transition
- IEA Report on H_2 for Japan's G20 presidency
- Challenges:
  - Emissions
  - Cost
  - Transport/Storage/Distribution
- Middle East Projects:
  - UAE: Green Hydrogen Project (DEWA/Siemens): Integrated MW-scale plant to generate H_2 from solar energy
  - Saudi: World-scale H_2 production at Yanbu

H_2 Production: 60 Mt today



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CO_2 CAPTURE, UTILIZATION AND STORAGE

- 17 major CCUs projects today capturing 30 million tons of CO_2 per year, with 70% from oil and gas operations
- IEA's ETP projects a potential of 6.8 billion tons by 2060 for the 2DS with 40% from the industry and fuel production / transformation
- At that scale, a major investment is requirement for a transport and storage network
- Amount of CO_2 indirect emissions from oil and gas-related operations depend on CO_2 price:

$ / t CO_2	Annual Oil & Gas-related CCUS potential (Mt CO_2)
50	250
100	450
150	690

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IN THE REGION: ADNOC ANNOUNCES 1.8 B$ IN EMISSIONS ABATEMENT PROJECTS TO 2023

- ADNOC is already one of the lowest GHG emitter per boe (less than half the industry average)
- Plan announced in February 2019 includes 1.8 B$ in further emissions abatement through:
  - Expanding CCUS from 0.8 Mt CO2 (al Reyyada) to 2.5 Mt by 2025
  - Increasing energy efficiency by 10%
  - Reducing gas consumption by 150 mmscf/d
  - Expanding use of AI / Big Data to enhance environment practices
  - Producing zero sulfur content bunker fuels
  - Installing low NOx burners in gas turbines, and installing solar panels at wellhead control panels
  - Avoiding the withdrawal of water from deep aquifers by using produced water for re-injection into oil reservoirs
  - Replacing inefficient diesel generators in drilling rigs to meet stringent air emission limits and reduce GHG emissions
  - Planting 250,000 mangrove seedlings in Al Dhabbia

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