



# NATURAL GAS AS A FLEXIBILITY PROVIDER

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Energy Transitions Workshop

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# Agenda

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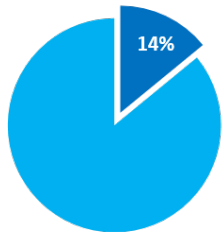
- Natural gas in Norway
- The natural gas value chain
  - Characteristics
  - Flexibility
- Modelling tools
- Opportunities and challenges

# NATURAL GAS IN NORWAY

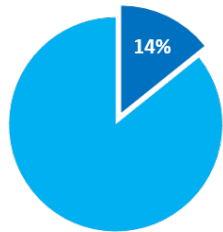


# The petroleum sector in Norway

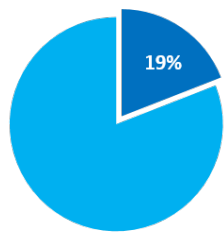
The oil and gas sector is Norway's largest measured in terms of value added, government revenues, investments and export value



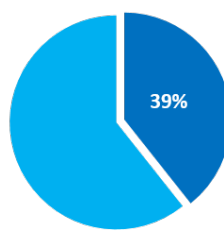
Share of GDP



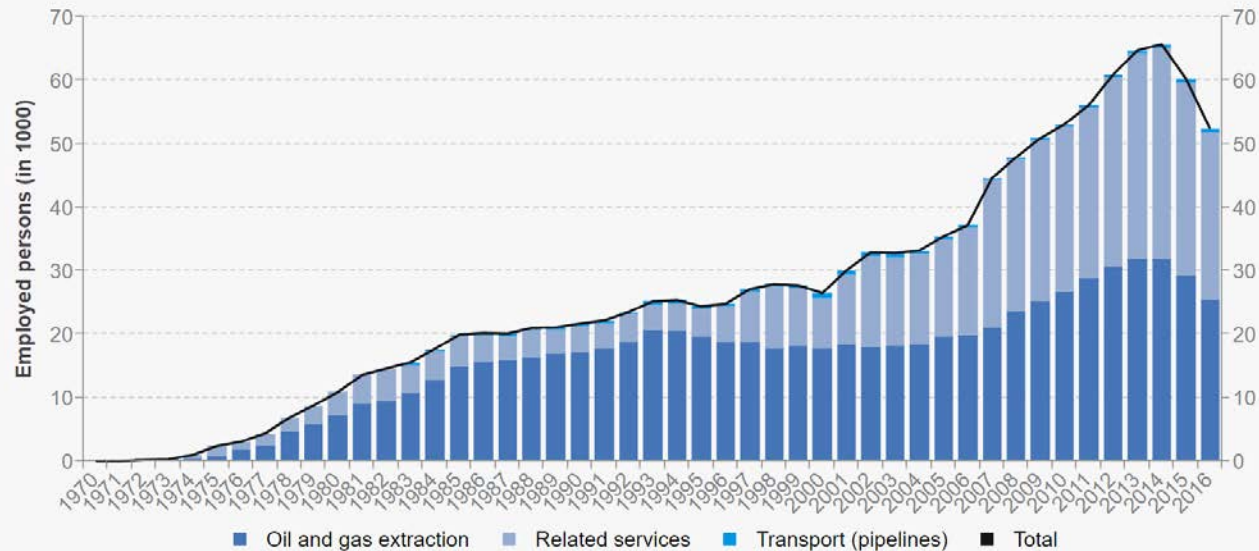
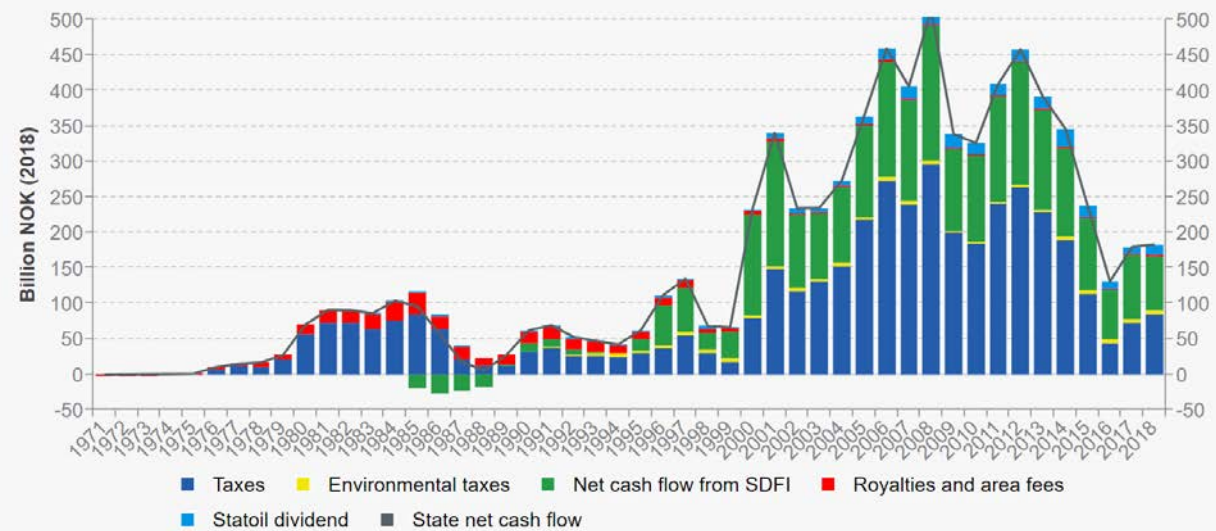
Share of the State's revenues



Share of total investments

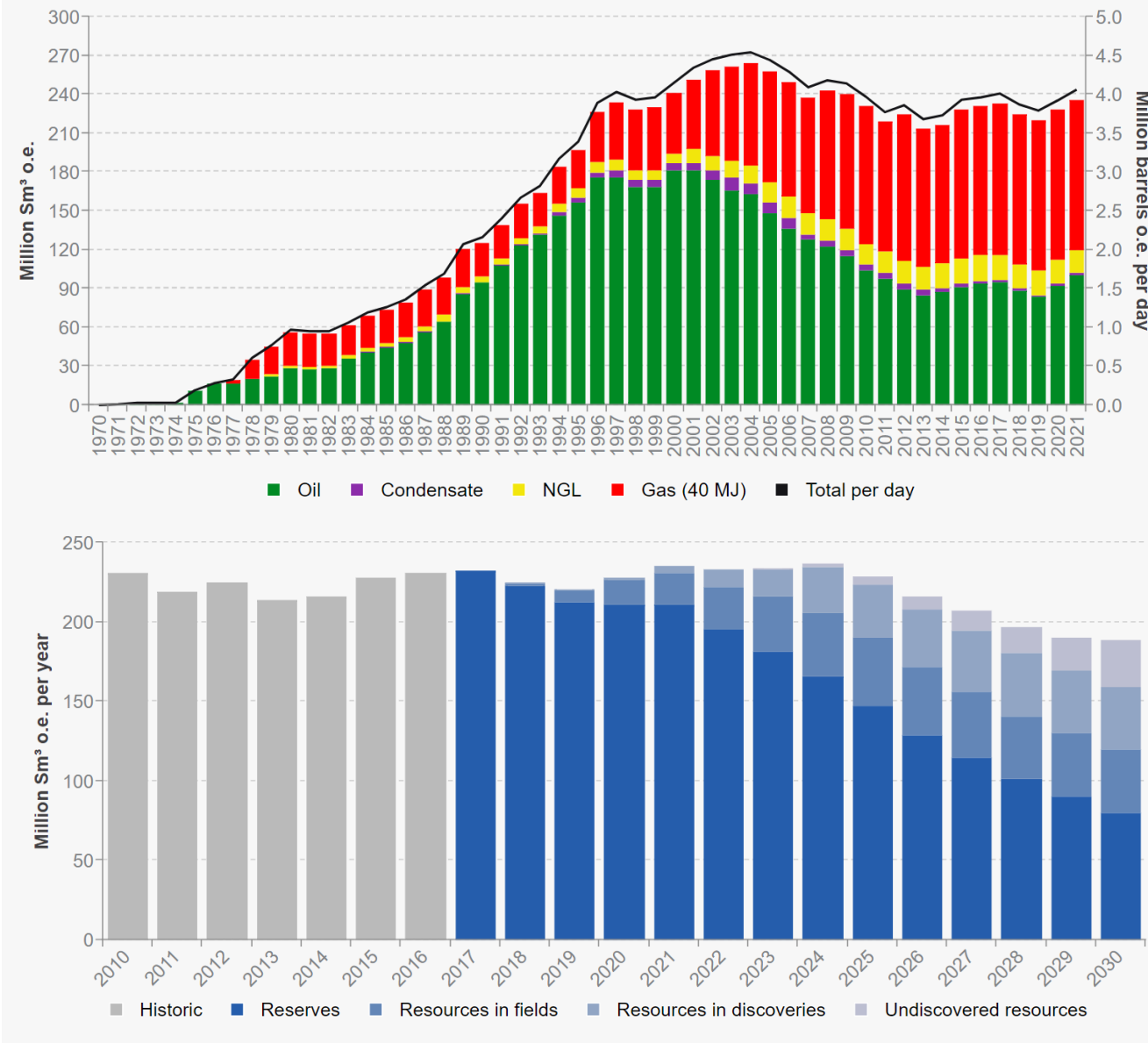


Share of total exports



# Natural gas in Norway

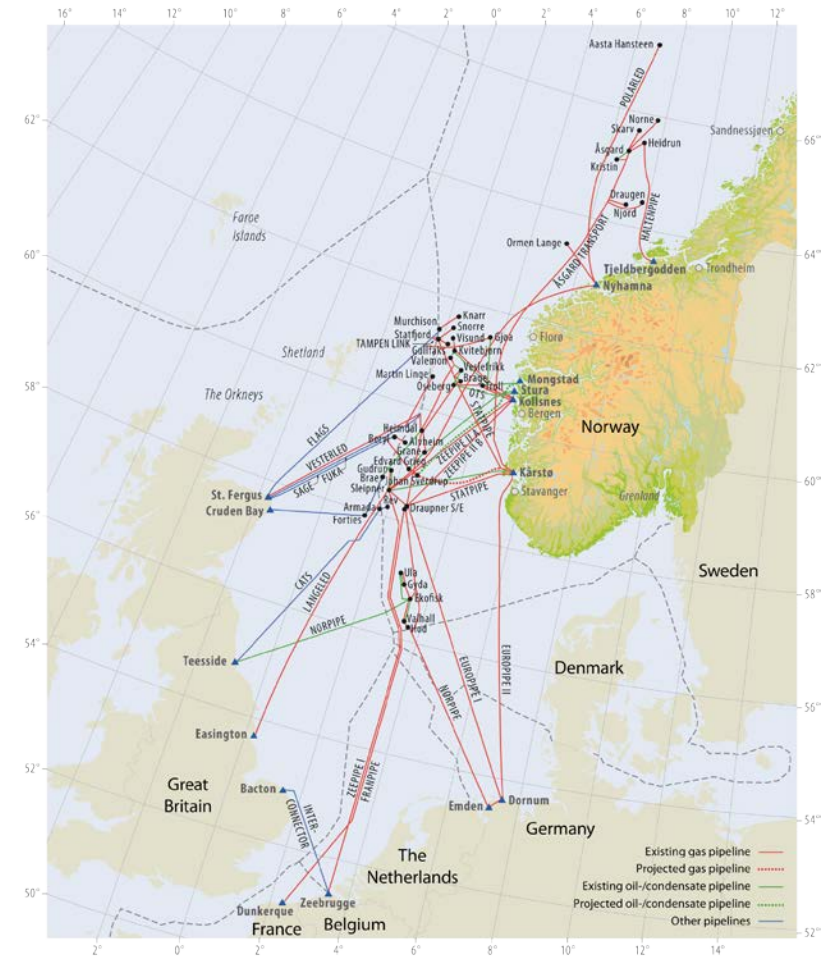
Almost half of the petroleum production (in oil equivalents) in 2016 was from natural gas



# THE NATURAL GAS VALUE CHAIN

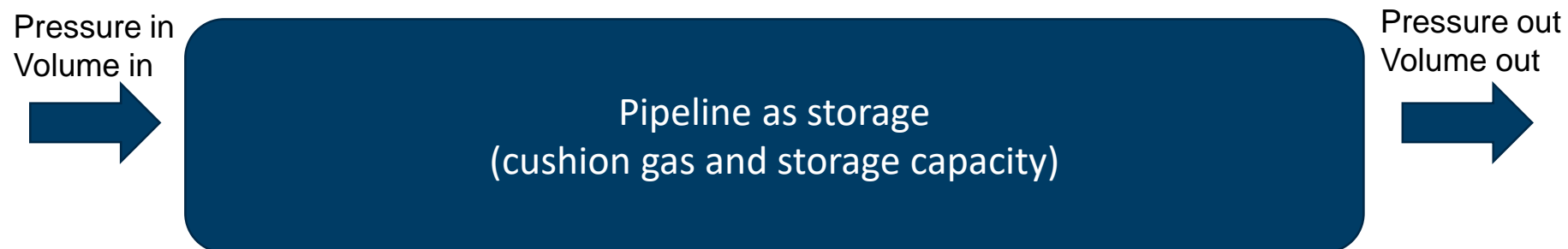
# The Norwegian natural gas value-chain

- The world's largest underwater natural gas transportation system (8800 km of pipelines)
- Capacity of approximately 120 billion Sm<sup>3</sup> dry gas per year
- High pressure
- Long pipelines
- Diversified fields and products
- System effects
- Quality requirements



# Pipelines as storage

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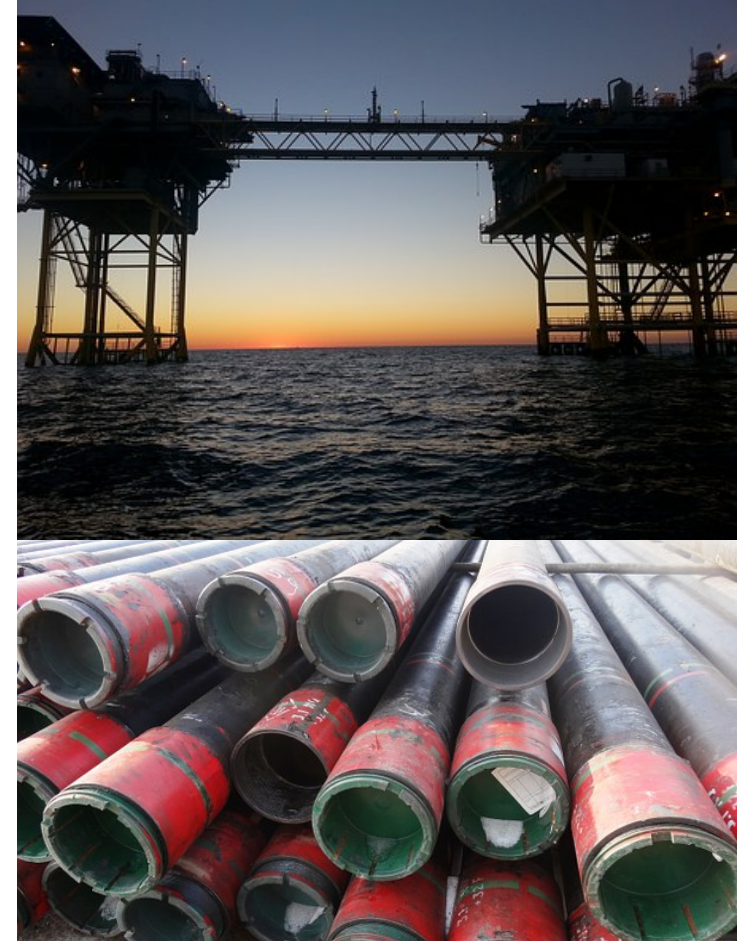
- Vary in- and outflow of the pipeline
- Influences both the inventory level, the storage capacity and the throughput of the pipeline
- Can be used as a storage facility to increase the flexibility in the transportation network
  - Handle foreseen and unforeseen network events
  - Exploit favorable market conditions
  - Offer new services (balancing services)



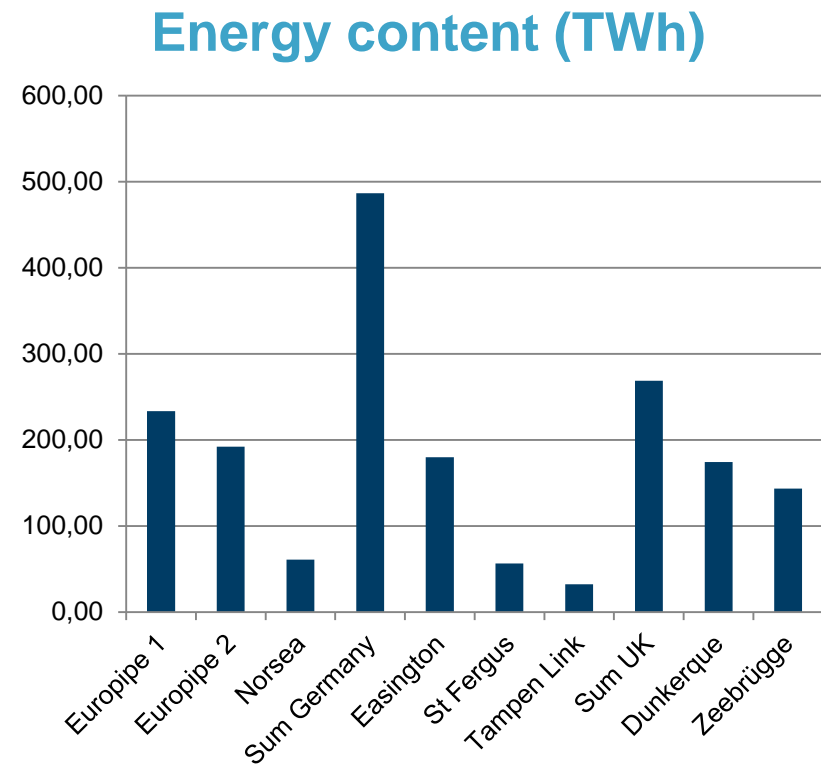
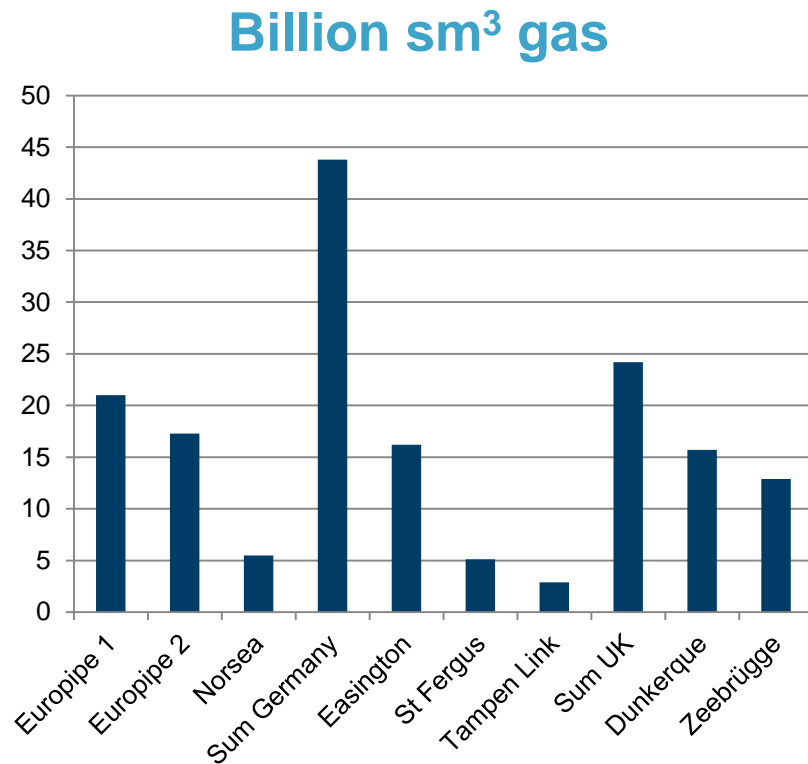
# Flexibility in the natural gas value-chain

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- Natural gas is flexible and easy to store
  - Reservoirs
    - Seasonal storage, weekly variations
  - Linepack / pipeline inventories
    - Daily to hourly storage
  - Conventional storages
  - LNG-storages



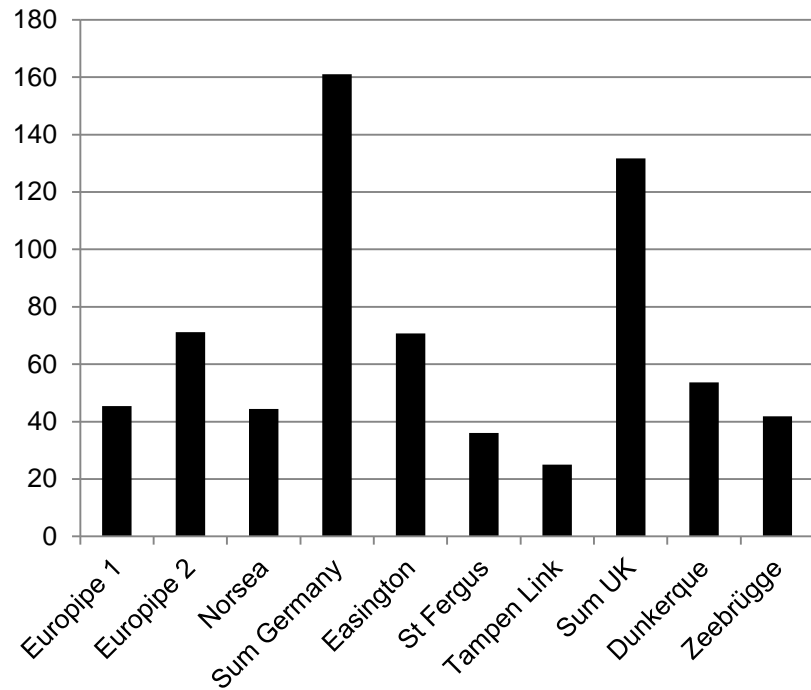
# Yearly natural gas deliveries from Norway to Europe



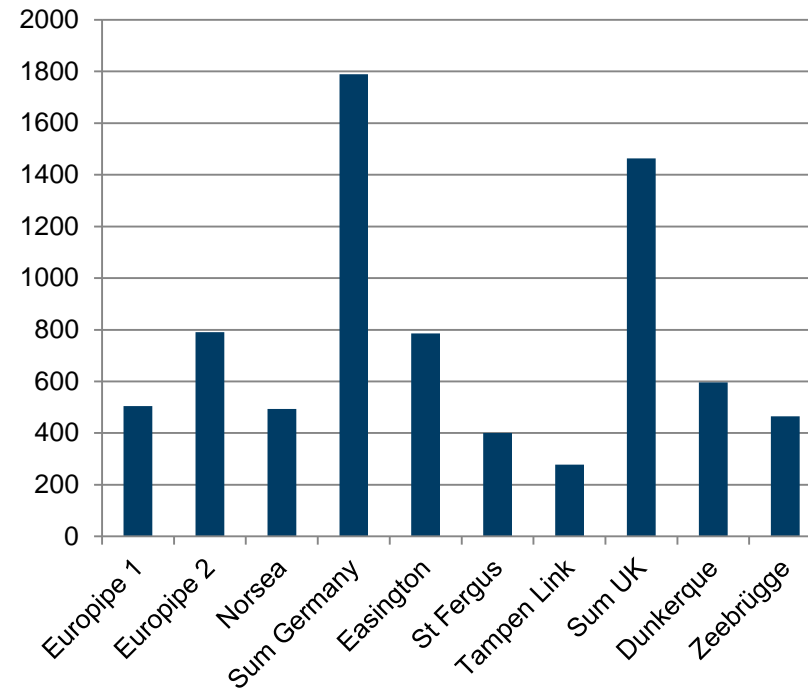
# Daily capacity

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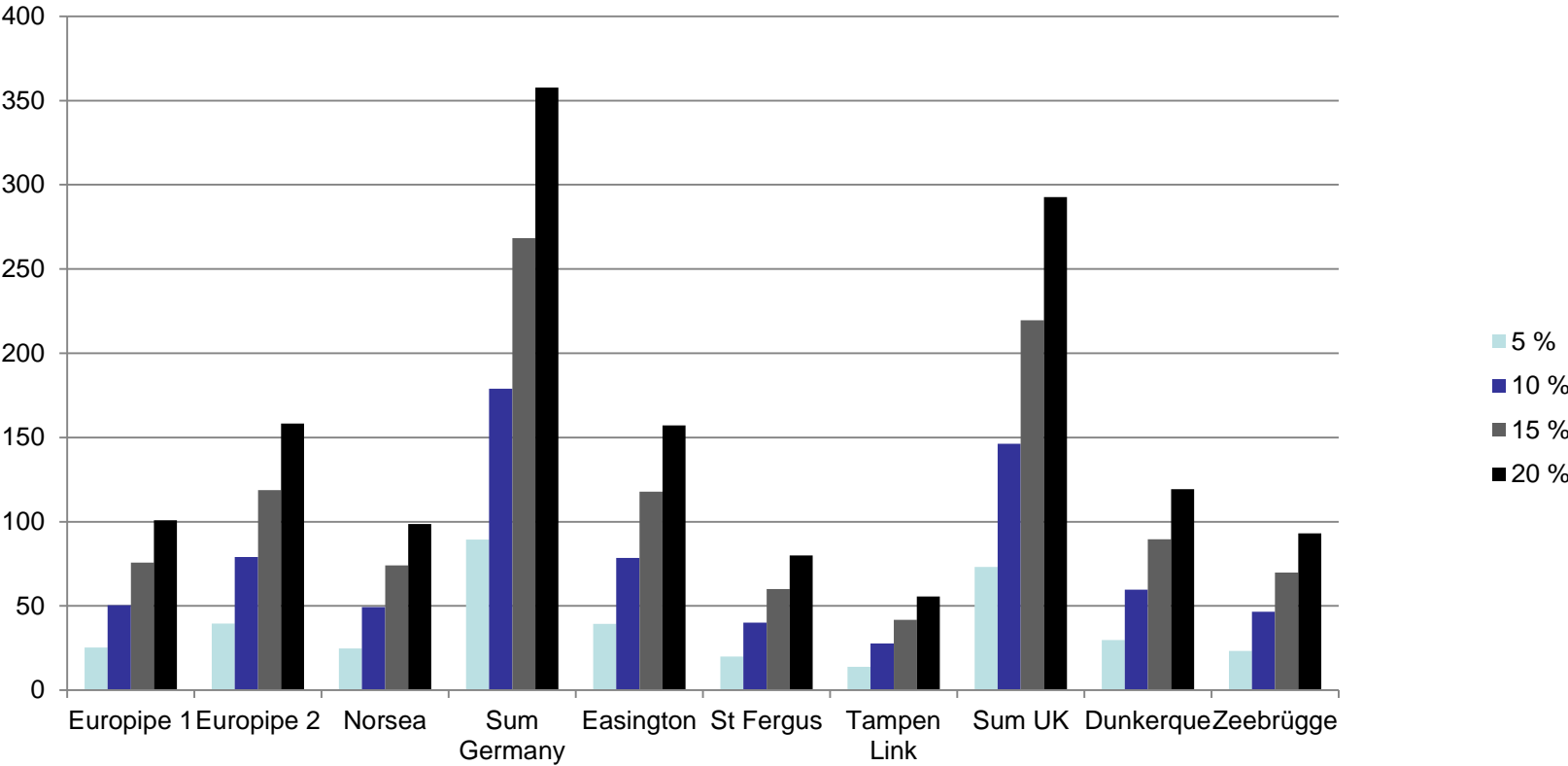
## Pipeline capacity (Msm<sup>3</sup>)



## Pipeline capacity (GWh)



# Potential linepack flexibility (GWh)



# MODELLING TOOLS



# SING Supply

- Portfolio optimization of the gas operations of Statoil
- Business focus
- Decision support system
- Optimization model linked to a database with live data feed
- Value of flexibility
- In daily use at Statoil

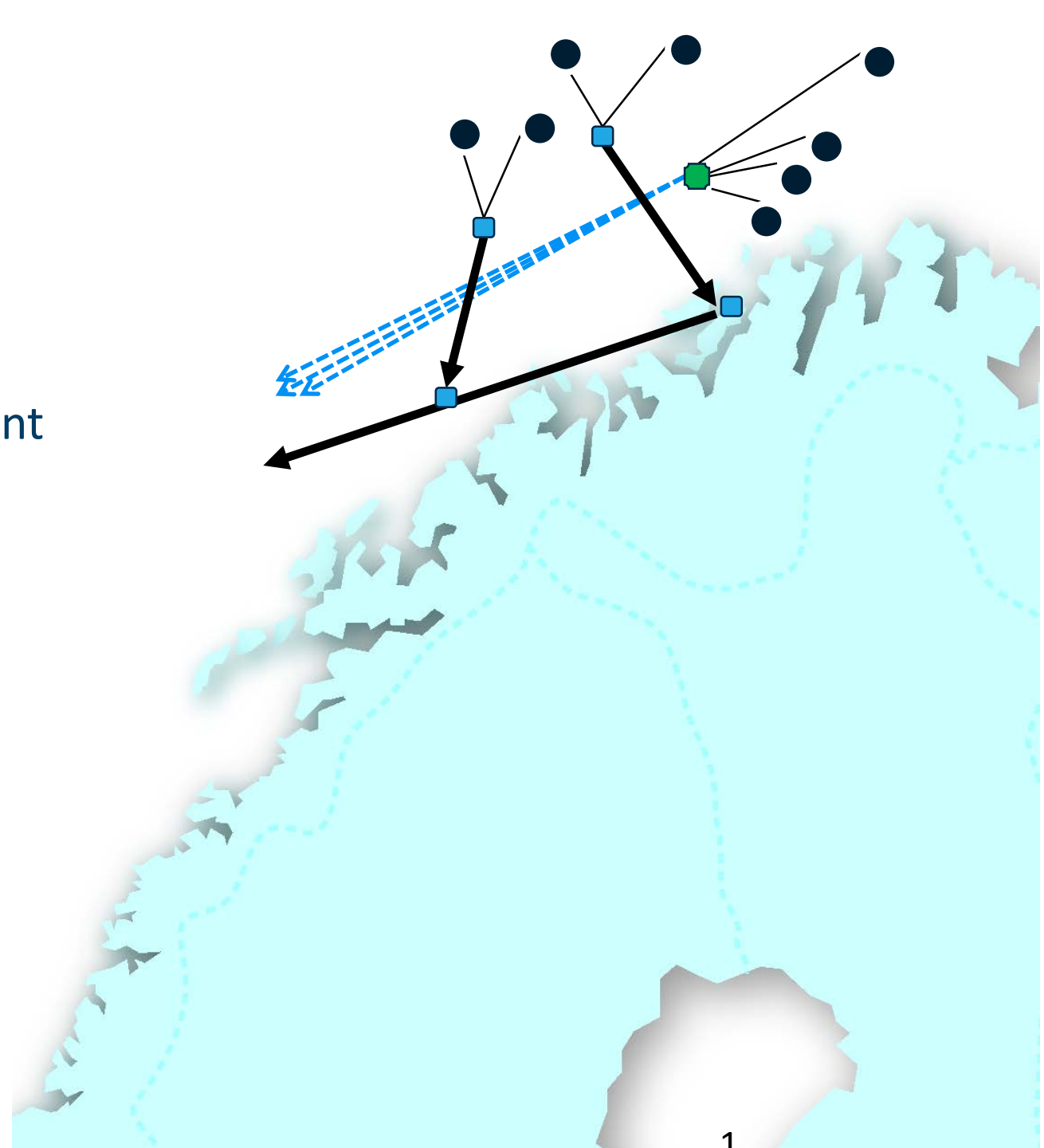
```
SQLexecute('SELECT TIME_ID FROM SUPPLY_TIME_PERIODS WHERE CASE_ID = ' & caseId +
  ' ORDER BY TIME_ID', TimeOriginal)
if RISK_AVERSE and LAST_POOR_PERIOD >= 0 then
  TimeOriginal = (LAST_POOR_PERIOD)
end-if
if TIME_AGGREGATION then
  lastTimeID:= max(t an TimeOriginal) t / Finding last timeID definition - model horizon
  sumOfTimeIDspecified:= getSize(TimeOriginal)
  SQLexecute('SELECT DISTINCT TIME_ID FROM SUPPLY_PROFILES WHERE CASE_ID = ' & caseId +
    ' ORDER BY TIME_ID', TimeProfileDB )
  SQLexecute('SELECT DISTINCT TIME_ID FROM SUPPLY_PRODUCT_PROFILES WHERE CASE_ID = ' & caseId +
    ' ORDER BY TIME_ID', TimeProductProfileDB )
  -- broker global average GasYears for 4 slippage models using
  TimeWithData = TimeProfileDB + TimeProductProfileDB + GasYears
  if FIELD_PURCHASE then
    SQLexecute('SELECT TIME_ID FROM SUPPLY_FIELD_PURCHASE WHERE CASE_ID = ' & caseId + ' ORDER BY 1', TimeFieldPurchaseDB)
  end-if
  / POOR - if fixed, then the fix-date must be included in model time indexes
  if POORFIX then
    StartID:= min(t in TimeWithData) t
    SQLexecute('SELECT P.TIME_ID, P.VAL FROM SUPPLY_INDEP_PROFILES P, SUPPLY_PROFILE_TYPES T *
      'WHERE T.TYPE = P.TYPE AND T.Name = 'Fixed POOR Period' AND P.CASE_ID = ' & caseId +
      ' ORDER BY 1', SetOfPoorFixed)
    /Also adds the time period just before and just after the POOR-TimeID
    TimeWithData = SetOfPoorFixed
    forall t in SetOfPoorFixed do
      TimeWithData = (t+)
      if (t- > StartID-) then
        TimeWithData = (t-)
      end-if
    end-do
  end-if
  if RISK_AVERSE then
    if LAST_POOR_PERIOD >= 0 and LAST_POOR_PERIOD not in TimeWithData then
      TimeWithData = (LAST_POOR_PERIOD)
    end-if
  end-if
end-if
```



# Ramona / Isted

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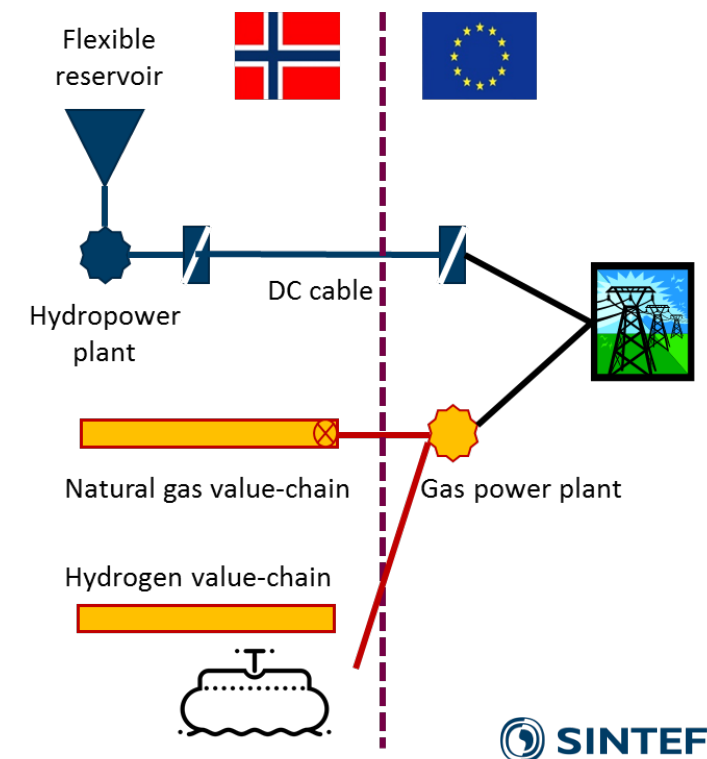
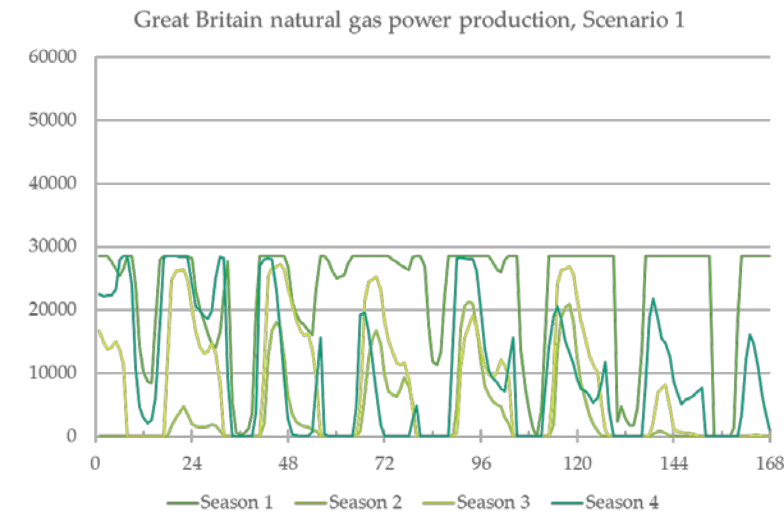
- Natural gas infrastructure development
- Investment analysis
- Portfolio perspective for
  - Sequencing of fields
  - Infrastructure design
  - Technology choices
- Multi-horizon to handle uncertainty



# OPPORTUNITIES AND CHALLENGES

# Norway as a flexibility provider

- Need to understand the role of natural gas in the European energy markets
  - What is the role of natural gas? Base load with CCS or for peak loads?
  - Which services can be offered?
- Supply and use of natural gas with minimal carbon footprint
- Interaction with the power markets and with the hydrogen value-chain
  - Requires a portfolio perspective for both investment analysis, service design and operational planning
- Capabilities of the pipeline system
- Capabilities of ramping (with CCS)
- Development of regulations and services (business models)





Teknologi for et bedre samfunn