2021

THE BRIDGE TANK

In collaboration with the
Institut des mobilités durables
(IMD)

Energy trajectories in main markets

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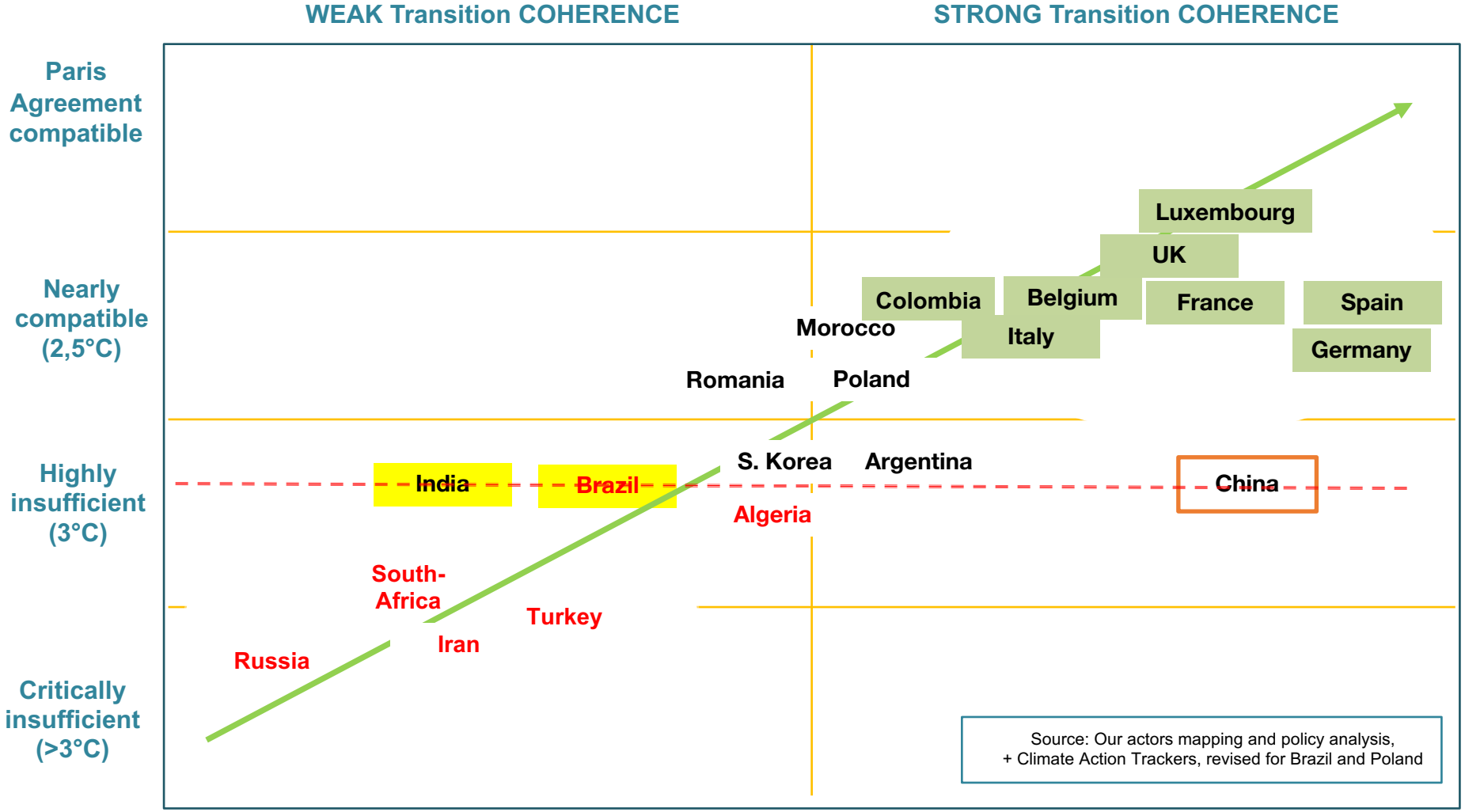
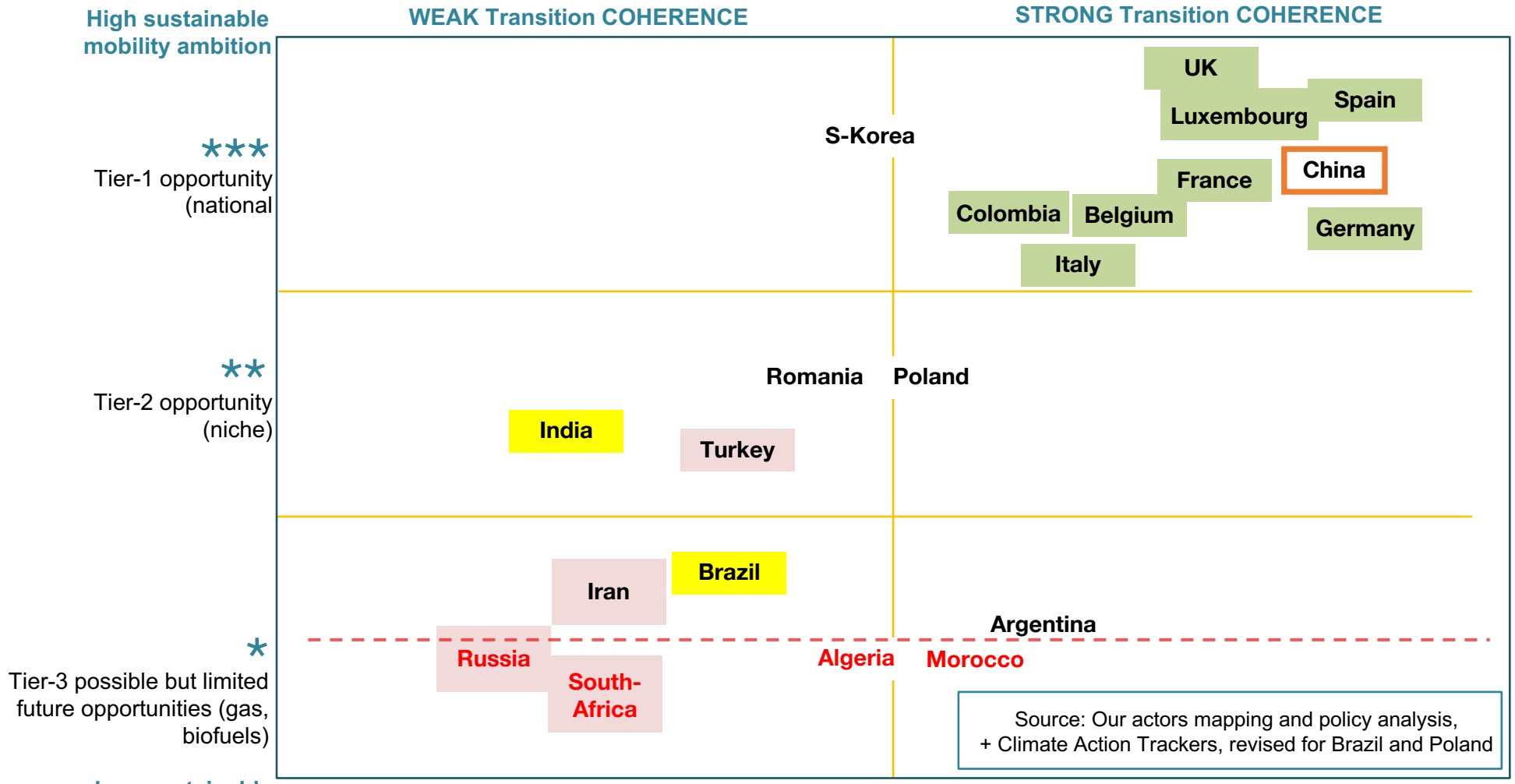
Analysis of Transition Coherence vs. INDC assessment (ambition + credibility)- Typology of countries



Financial and extra-financial risks on TCFD and ESR regulations for over exposure in climate off-track markets.

Transition Coherence vs. Sustainable mobility ambition- clean mobility market opportunities and risks



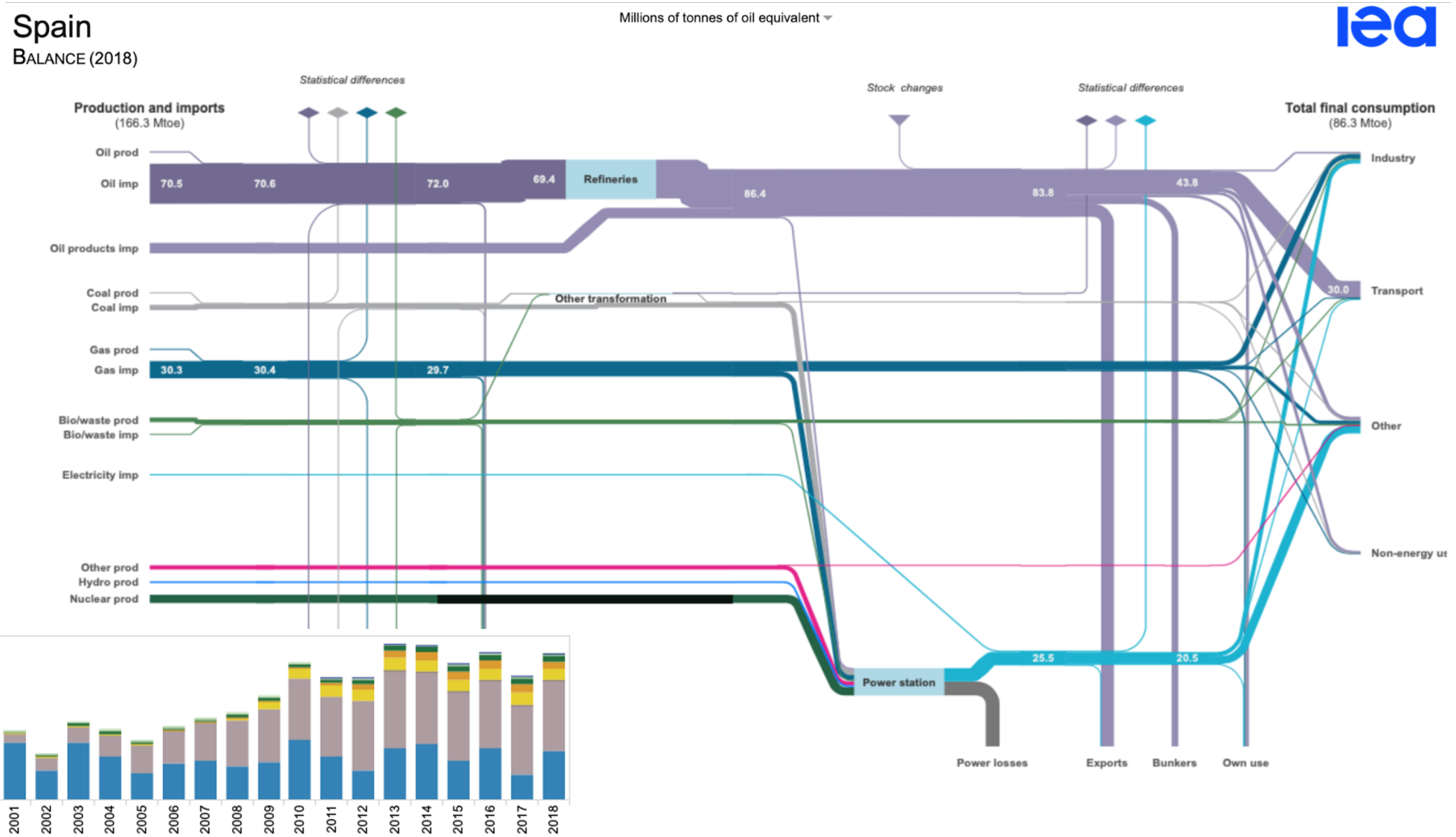
Risk that one star countries don't support overall company strategy towards low carbon mobility

I) European countries (+ Colombia & US) offer a coherent energy transition

Clear and structured climate ambitions for energy policies impact industrial decisions. Despite disparate inherited energy mixes, these countries offer a successful energy transition by the 2050 horizon, with ambitious 2030 milestones and KPIs to follow. Overall, they are consistent with the 2050 target.

Germany, Spain, Italy, France, United Kingdom, Luxembourg, Belgium, Colombia, US

1.1 Energy system picture : key system realities

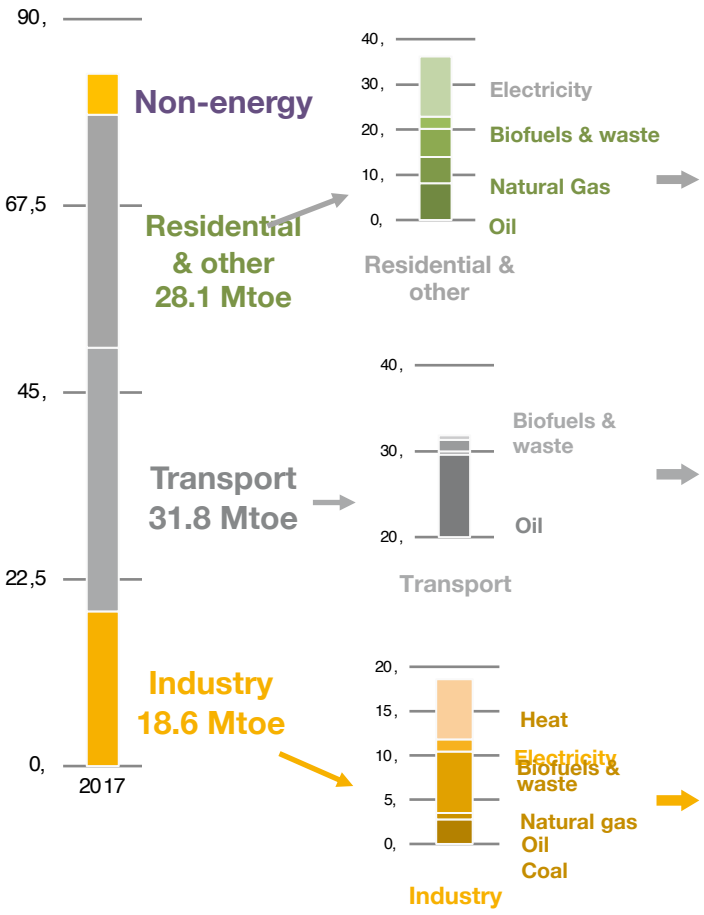


Electric generation from renewables (Irena 2017 data, GWh)

Spain's energy mix relies on hydrocarbon imports. Nuclear energy is key in the electricity mix but a strong commitment to renewable energies' development has risen during the last decade.

1.2 System inertias & policy drivers

Spain final energy consumption 2018 : 86.1 Mtoe



Inertias
(by sectors)

Inertia1: electricity dominance

- Residential: 53.7% (15.1 Mtoe)
  - Electricity (40%), gas (25%), oil (17%), biofuels (17%)
- Commerce & public: 35.9% (10.1 Mtoe)
  - Electricity (61%), gas (24%), oil (13%)
- Agriculture: (2.4Mtoe) Oil (71%)

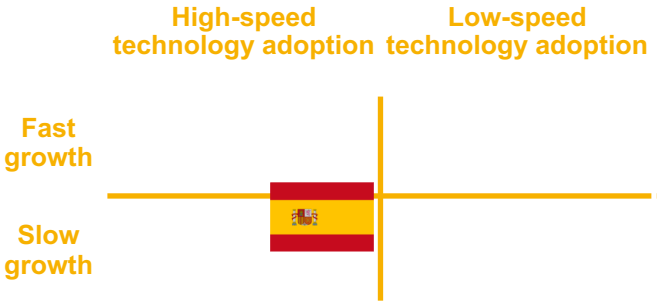
Inertia2: relatively high share of biofuels

- Road : 88% (28 Mtoe)
  - Oil (94%), **biofuels** (4%), gas
- Domestic aviation (2.1 Mtoe)

Inertia3: oil & gas equipment dominance

- Non-metallic minerals: 17.7% (3.3 Mtoe)
  - oil (42%), gas (15%), electricity (15%), biofuels (6%)
- Chemicals: 15.6% (2.9 Mtoe)
  - gas (66%), electricity (28%)
- Iron & Steel: 13.4% (2.5 Mtoe)
  - Electricity (48%), coal (24%), gas (24%)

Policy drivers
(on energy and/or sector)



Objectives: climate neutrality by 2050, 70% of RE in electricity mix by 2030
Our view: ambitious objectives that guarantee international commitments
Timeframe: 2030-2050
Governance type: central government with autonomous regions

Driver 1: RE Investment

- Total share mix concerned: 7% (6.2 Mtoe)
- Objectives: 70% RE in electricity mix by 2030 and 100% by 2050

Driver 2: Coal and nuclear phase-out

- Total share mix concerned: 27% (23.1 Mtoe)
- Objectives: all coal plants closed in 2035; half of the nuclear reactors closed in 2030

Driver 3: "Energy efficiency"

- Total share mix concerned: 22% (18.9 Mtoe)
- Objectives: reduction of primary energy by at least 35%; improvement in the efficiency of the electrical system by 39.5%

Minor driver 4: sustainable car fleet

- Objective: new passenger cars and light commercial vehicles 100% sustainable by 2050

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)	Coupling (dynamics on energy-to-energy, energy-to-use and use-to-use)
Residential - Inertia1: electricity dominance	**RE Investment** **Energy efficiency** **Coal and nuclear phase-out**	**Coupling1: inter-energy substitution in electricity** • *Double substitution from nuclear & coal to gas & renewables* • *Gas will mechanically rise while waiting for renewables' infrastructures to be built* • *Share of these energies in total supply: nuclear 14.5 + coal 9.2 + gas 9.0 + RE 12.3 = 45 Mtoe (32%)*
Transport – Inertia2: relatively high share of biofuels	**Sustainable car fleet**	**Coupling2: inter-use competition for electricity demand** • *Power generation will rise and mobility will electrify, in conflict with current uses* • *Weight of electricity on total energy consumption: 20.5 Mtoe (23.8%)*
Industry- Inertia3: oil and gas equipment dominance	**Energy efficiency** **Coal and nuclear phase-out** **RE Development**	**Coupling3: possible substitution of oil & coal supply by new equipment in some industries** • *Cement factories will probably have to shift equipment from coal to unknown sources* • *Weight of coal in industry: 0.6 Mtoe (3%)* • *Weight of oil in industry: 2.9 Mtoe (14%)*

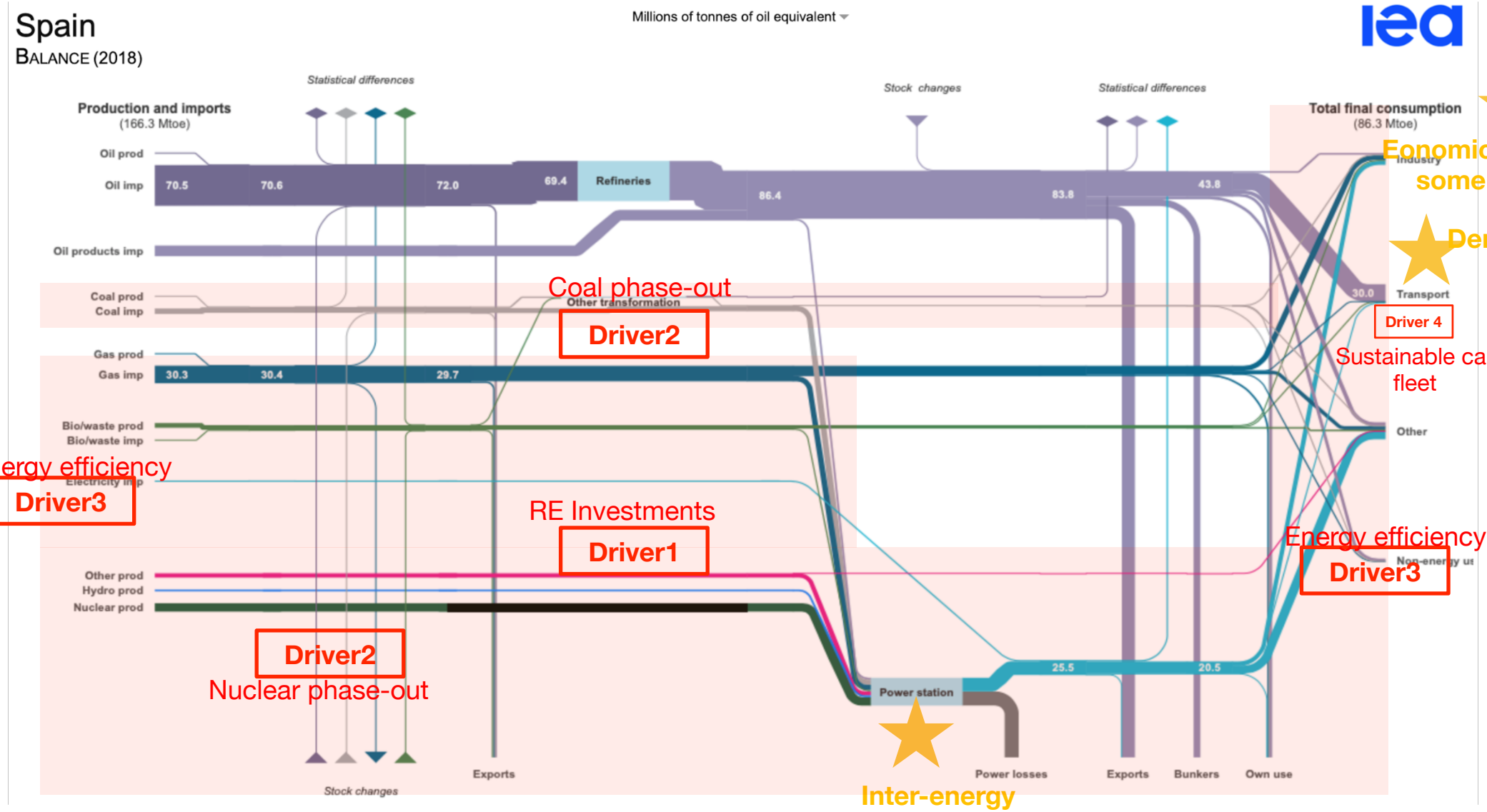
Structuring issues

Issue1: Pressure on electricity supply due to electrification
- *Weight on total energy supply: 14% (23.4 Mtoe)*
- Coupling with other energies
- Sector concerned: industry, residential and other

Issue2: Energy efficiency to relieve pressure on the electric system
- Sectors concerned: power industry, coal plants
- *Weight of these sectors on total energy supply: 27% (45 Mtoe)*

Issue3: Road mobility and car industry
- *Weight on total use: 28% (64 Mtoe)*
- Coupling with other energies: biofuels, possibly electricity and gas
- Sector concerned: transport, industry

1.4 Pressure on RE and gas to compensate coal and nuclaer phase-out



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Spain is committed to phase-out nuclear and coal before 2025 and phase-out new ICE LDVs. Biofuels capacity will be declining as climate changes.

2. RE investment is historically high with high territorial capacities and integration.

3. Gas combustion will increase to support e-mobility. Ambitious electric efficiency and interconnexion plan may soften the gas peak by 2025.

4. Carbon intensive industries (cement) rely on old oil equipment. It can push towards NG or H2 infrastructure investment.

Fuel, mobility & LCA policy

2040 - ICE phase-out for LDVs

3,000 vehicles/year concerned.

There is no specific measure for the secondary market.

Life-cycle scheme

EU Circular Economy Action Plan (section 3.2 Vehicles and batteries)

- Revision of the Battery Directives
  - Ban on non-rechargeable batteries
  - Recycling rates for all batteries (target still undefined)
- End-of-life vehicles package to promote material reuse

Messages

Electric Mobility for LDVs.

Car production in the EU will be ambitious with real climate objectives.

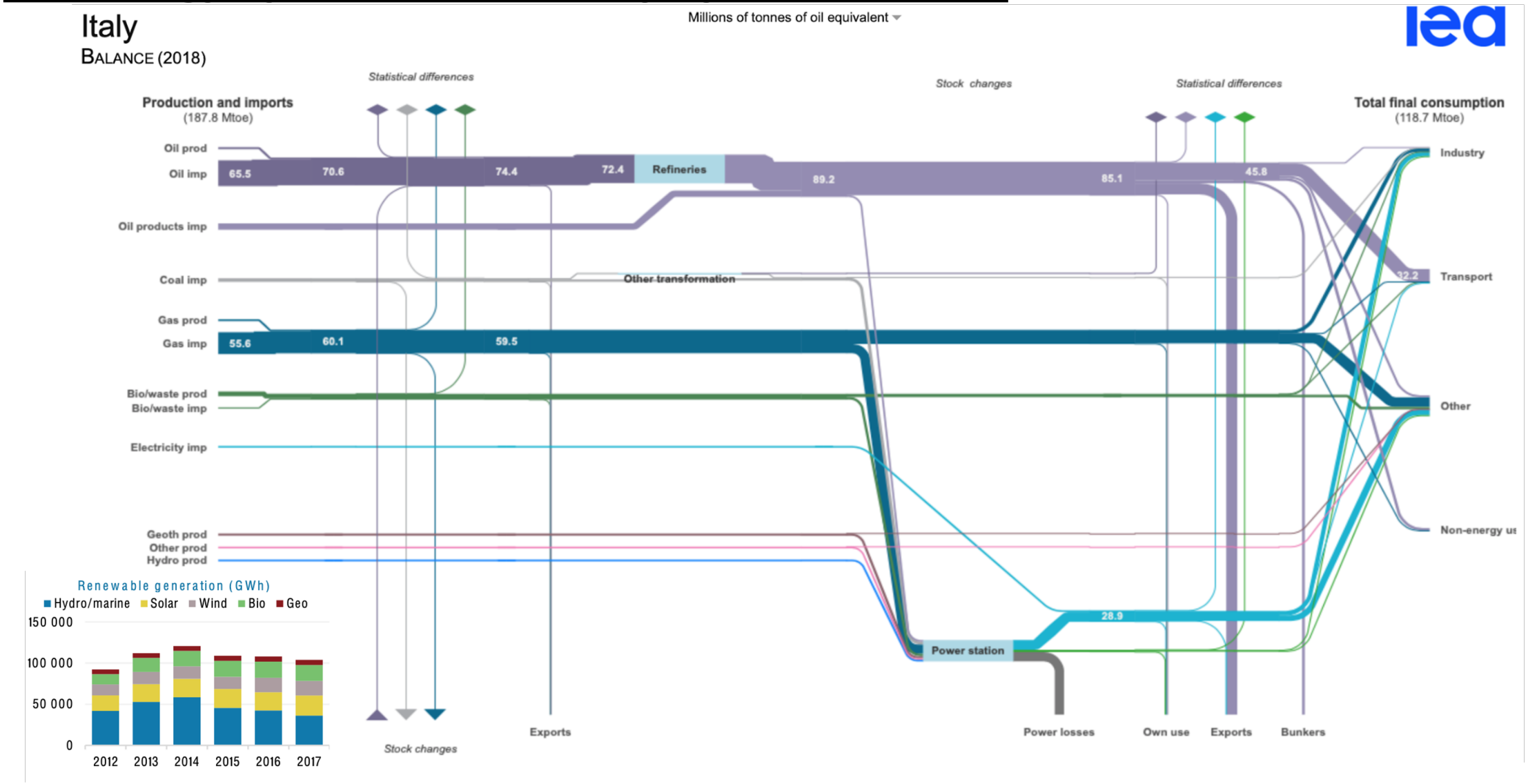
Actualized mobility BAU scenario

1. 2040 ICE LDV primary market will be forbidden. HDVs and especially trucks will remain the same.

2. No shift for road freight even though H2/gas powered engine will be promoted in the EU.

3. Urban policies may support shared mobility to support LDV objectives despite high electricity prices. This would result in LDV fleet reduction for households.

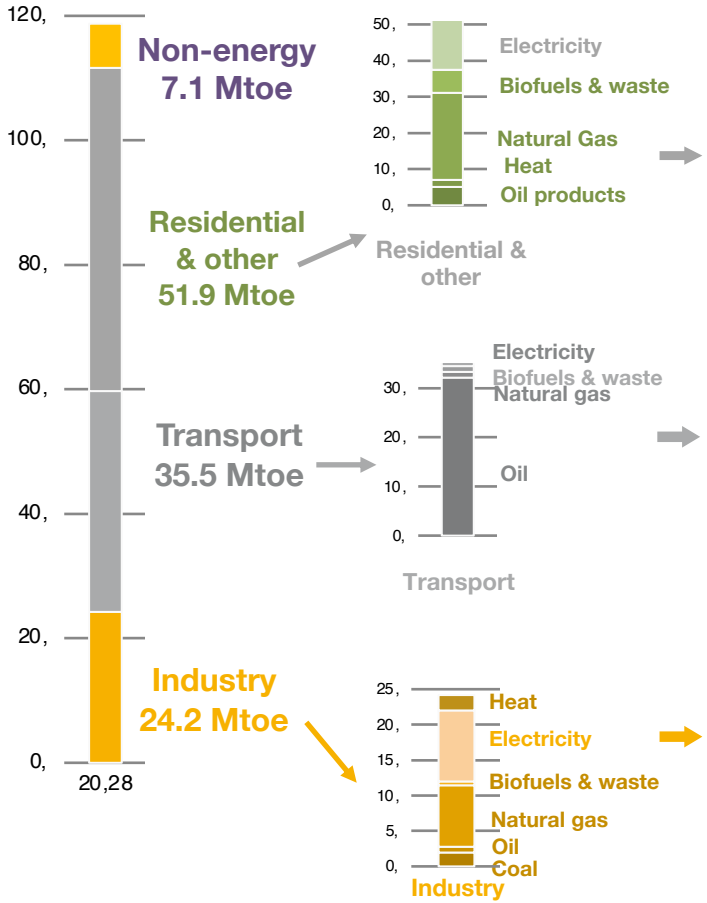
1.1 Energy system picture : key system realities



Italy's mix has a strong dependency on hydrocarbon imports. Electricity generation depends on coal and gas imports as well as RE investments.

1.2 System inertias & policy drivers

Italy final energy consumption 2018 : 118.7 Mtoe



Inertias
(by sectors)

Inertia1: gas dominance

- Residential: 61.7% (32 Mtoe)
  - **Gas (52%),** biofuels & waste (20%), **electricity (18%)**, oil (7%), heat (4%)
- Commerce & public: 32.3% (17Mtoe)
  - Electricity (48%), gas (43%), heat (4%)
- Agriculture: 5.3% (2.7 Mtoe) Oil **(78%), electricity (19%)**

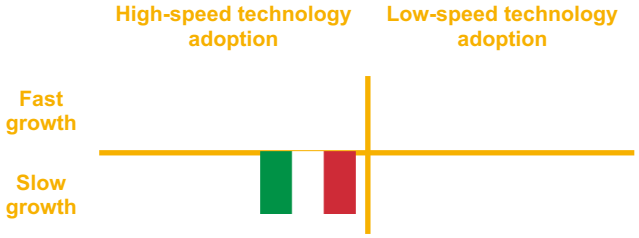
Inertia2: relatively high share of biofuels

- Road : 92,3% (32,8 Mtoe)
  - Oil (94%), **biofuels (4%)**, gas (3%)

Inertia3: gas & electricity duality

- Non-metallic minerals: 17.8% (4.3 Mtoe)
  - **Gas (47%)**, oil (21%), **electricity (19%)**, heat (7%)
- Iron and Steel: 15.2% (3.7 Mtoe)
  - **Electricity (43%), gas (35%)**, coal (16%)
- Chemicals and petrochemicals: 13.2% (3.2 Mtoe)
  - **Electricity (37%), gas (28%)**, biofuels and waste (19%), oil (13%)

Policy drivers
(on energy and/or sector)



Objectives: 33% GHG emissions reduction in comparison to 2005, 30% of RE in total energy consumption
Our view: national objectives above EU objectives thanks to the coal phase-out policy, but high dependency on extended inherited gas system
Timeframe : 2030
Governance type: central government, autonomous regions with big corporations

Driver 1 : Energy security for gas and electricity supply

- Total share mix concerned: 31.7% (59.7 Mtoe)
- Reduce gas imports dependency by multiplying supply sources
- Create interconnected networks in Europe for electricity supply, strong competition for interconnecting electricity networks

Driver 2 : RE investments

- Total share mix concerned: 13% (25.2 Mtoe)
- Objectives : 30% RE in total energy consumption (22% in the transport sector) and 55% in the electricity mix

Driver 3 : Energy efficiency

- Weight on total use: 28.6% (53.8 Mtoe)
- Sectors at stake: residential, transport sector, constructors, industries

Minor Driver 4: Coal phase-out

- Total share mix concerned: 4.7% (8.9 Mtoe)
- Objective: all coal power plants and mines closed in 2025

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)
Residential - Inertia1 : gas dominance	**Energy efficiency** **Coal Phase-Out** **RE Development** **Energy security**
Transport - Inertia3 : relatively high share of biofuels	**Energy efficiency**
Industry- Inertia4 : Gas & electricity duality	**Energy efficiency** **Coal Phase-Out** **RE Development** **Energy security**

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1: inter-energy renewables substitution
- *Inter-energy coupling: coal (7.1Mtoe) / RE (19.2 Mtoe) substitution will create a competition between RE & gas (23.4 Mtoe) for electricity generation*
- *49.7 Mtoe (26%)*

Coupling2: inter-use competition for gas and electricity
- Competition based on industry and residential demand for gas (32.5 Mtoe) & electricity (24.8 Mtoe)
- Industry & residential on total energy consumption: 56.2 Mtoe (47%)

Coupling3: infrastructure coupling
- *Legacy system in the north that distributes energy between urban centres and industrial districts*
- *Gas is key for energy transition; use of gas infrastructures to inject green gas into the system*

Coupling4: mobility coupling
- *Inter-energy coupling: gas, biogas and electricity competition for mobility*
- *34.4 Mtoe (29%)*

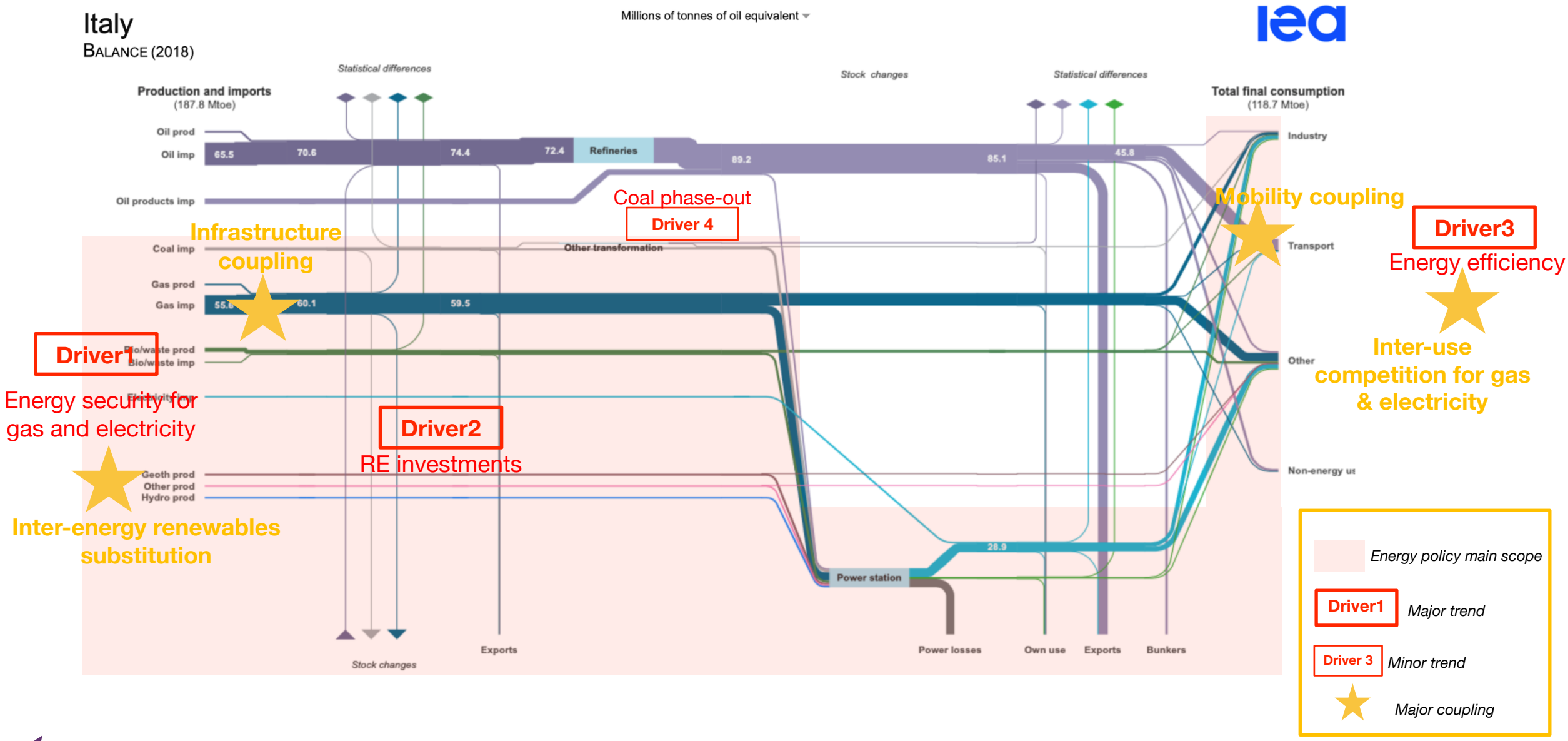
Structuring issues

Issue1: greening gas system
- *Weight on total supply: 28% (53.8 Mtoe)*
- Structuration for gas mobility
- Sectors concerned: industry, residential and transport

Issue2: uncertainties for electricity
- *Weight on total supply:15% (28.9 Mtoe)*
- Greening electric system through RE and European electric system integration
- Industries concerned: automotive, rail, freight

Issue3: Energy efficiency
- Key for GHG emissions reduction
- Sectors concerned: transport, construction

1.4 Gas imports and networks' management will determine Italy's energy transition



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Italy is focusing its energy strategy on strengthening its gas supply.

2. Italy bets on following EU regulation to stay on track for its transition. Ongoing debate on the structuration of this transition involves industrial organizations.

3. Main investments would come from industries for H2 and biogas deployment in gas networks to leverage legacy investments.

Fuel, mobility & LCA policy

Weak signal for E-gas mobility from gas industrial companies (SNAM).

EU Circular Economy Action Plan (section 3.2 Vehicles and batteries)

- Revision of the Battery Directives
  - Ban on non-rechargeable batteries
  - Recycling rates for all batteries (target still undefined)
- End-of-life vehicles package to promote material reuse

Messages

Gas mobility is structuring for equipment manufacturers.

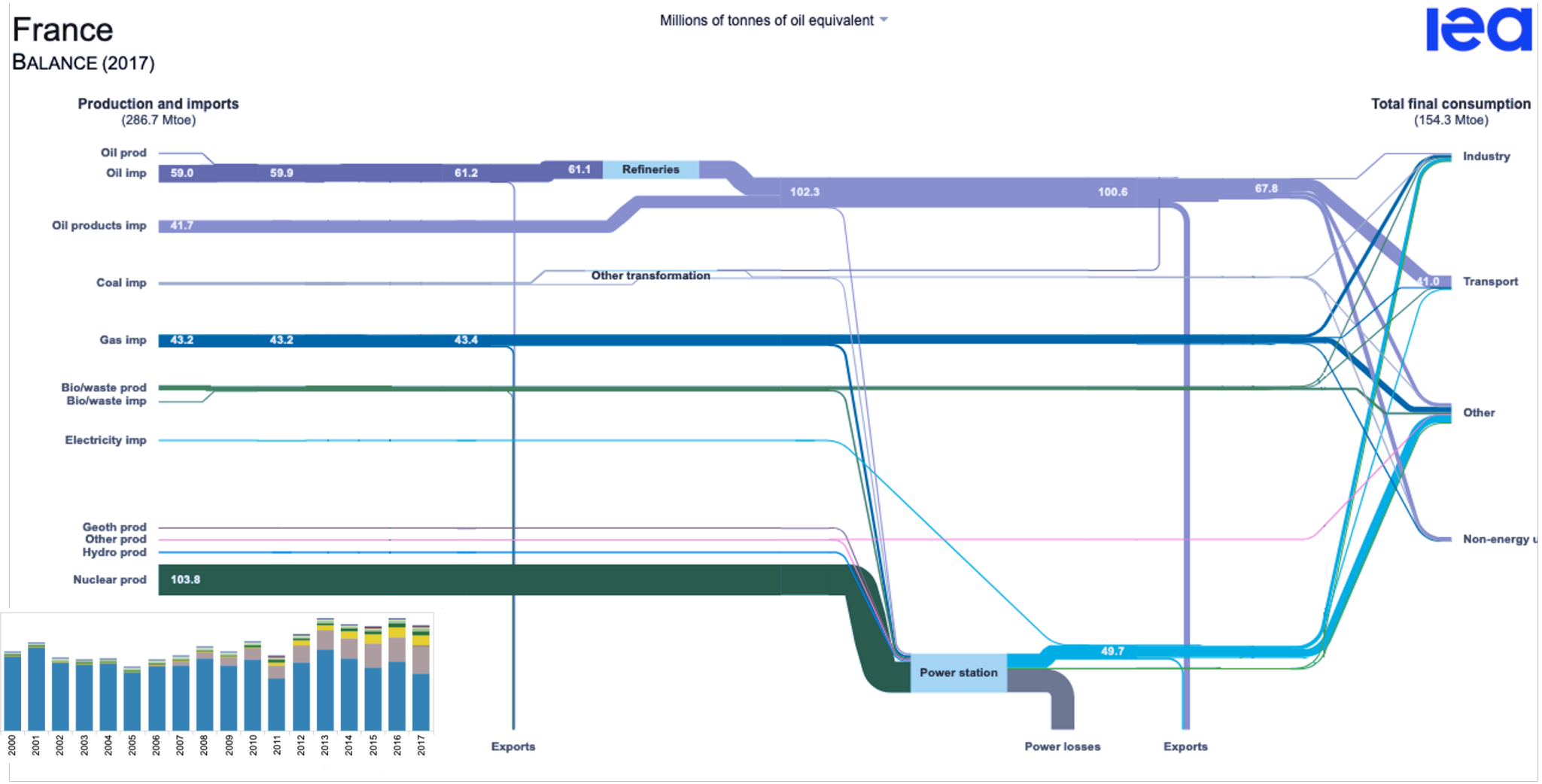
LCA policy relies on EU regulation.

Actualized mobility BAU scenario

1. Italy is betting on gas mobility for HDVs to take advantage of their gas infrastructure.

2. Electrification of the mobility is not the priority and relies on European trends and possibilities for interconnections with France and Switzerland.

1.1 Energy system picture : key system realities

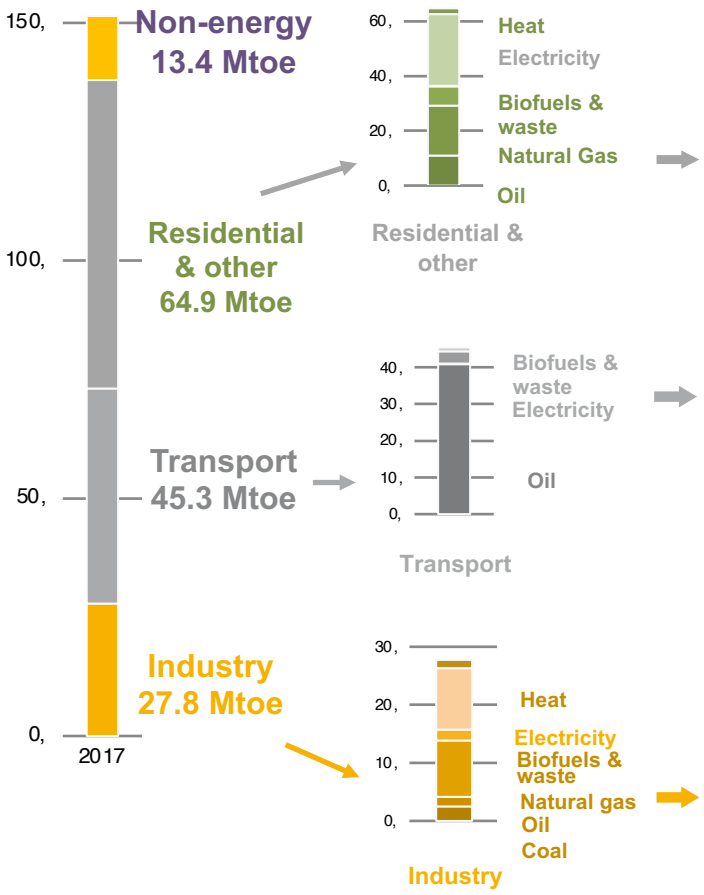


Electric generation from renewables
(Irena 2017 data, GWh)

France is highly dependent on its domestic nuclear production. However, the country's historic investment in hydro and recent commitment in wind & solar production is to be underlined. Marginal coal imports as well as oil & gas imports remain at historic levels.

1.2 System inertias & policy drivers

France final energy consumption 2017: 151.4 Mtoe



Inertias
(by sectors)

Inertia1: electricity dominance

- Residential: 57% (36.9 Mtoe)
  - **Electricity (37%), gas (29%)**, biofuels & waste (17%), oil (13%)
- Commerce & public: 35% (23 Mtoe)
  - **Electricity (52%), gas (31%)**, oil (11%)
- Agriculture & forestry: 6% (4 Mtoe)
  - **Oil (73%)**, electricity (18%)

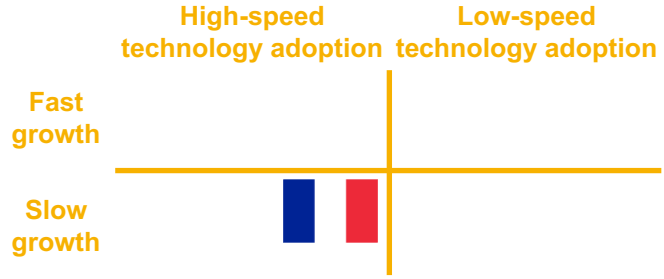
Inertia2: relatively high share of biofuels

- Road: 93% (42 Mtoe)
  - Oil (92%), **biofuels (8%)**

Inertia3: gas/electricity duality

- Food & tobacco: 18% (5.1 Mtoe)
  - **Gas (45%), electricity (39%)**, coal (8%)
- Chemical & petrochemical: 14% (4 Mtoe)
  - **Electricity(43%), gas(43%)**, coal (10%)
- Non-metallic minerals: 14% (4 Mtoe)
  - **Gas(46%), electricity (18%)**, oil (15%), biofuels & waste (13%)

Policy drivers
(on energy and/or sector)



Objectives : 40% GHG emissions reduction between 1990 and 2030, 40% primary energy reduction

Our view: achievable but not so ambitious objectives, some gaps in downstream sectors

Timeframe : 2030-2050

Governance type : centralized, market-led

Driver 1: Fossil energy reduction

- Total share mix concerned : 64% (97.2 Mtoe)
- Objectives: decline of oil by 34%, natural gas by 22%, and coal by 80% in 2028 in relation to 2012

Driver 2: Uncertain trajectories on nuclear and RE

- Total share on energy supply: 46.7% (134.5 Mtoe)
- Objectives: 50% of nuclear in the electricity mix by 2035 (70.6% today), 36% RE in the electricity mix in 2028, Green H2 development

Driver 3: Energy performance

- Total share mix concerned: 49% (74.8 Mtoe)
- Objectives: implementation of an « *energy performance* » by 2023; energy savings certificate (CEE), “Plan de relance” and higher investments

Minor driver 4: zero carbon mobility

- Total share mix concerned: 29% (45.3 Mtoe)
- Objectives: achieve European goals of GHG emissions reduction of new vehicles by 37.5% in 2030 in relation to 2021

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)	Coupling (dynamics on energy-to-energy, energy-to-use and use-to-use)
Residential - Inertia1: electricity dominance	**Energy performance** **Fossil energy reduction** **RE development and nuclear controversy**	**Coupling1: inter-energy renewable competition for electricity** • *Inter-energy coupling: more renewables while reducing nuclear power* • *Weight on energy supply: 46.7% (134.5 Mtoe)*
		Coupling2: inter-use electricity demand competition • *Rise of electricity share in final energy mix* • *Competition for electricity demand* • *Weight on total use: 50.6 Mtoe (33%)*
Transport – Inertia2 : relatively high share of biofuels	**Fossil energy reduction**	**Coupling3: Maturity in residential sector** • *Coupling inter-energy: biogas substitution in residential* • *Electricity & biogas competition (26.3 Mtoe + 7.1 Mtoe)* • *Weight on total uses: 21% (33.5 Mtoe)*
Industry- Inertia3 : gas/electricity duality	**Energy efficiency** **Fossil energy reduction** **RE development and nuclear controversy**	**Coupling4: guideline gaps in transport and industry** • *Biogas (3.4 Mtoe) and electricity (0.9 Mtoe) coupling: uncertainty on energy use for mobility zero carbon policy* • *Weight on total use: 4.3 Mtoe (2.8%)*

Structuring issues

Issue1: Uncertainty on nuclear legacy for electric integration

- *Weight on total supply: 47% (136 Mtoe)*
- Nuclear controversy: trade-off between RE development and nuclear reduction
- RTE study on H2 will change debates: nuclear can be used for low carbon H2 production
- Sectors concerned: industry, residential and other

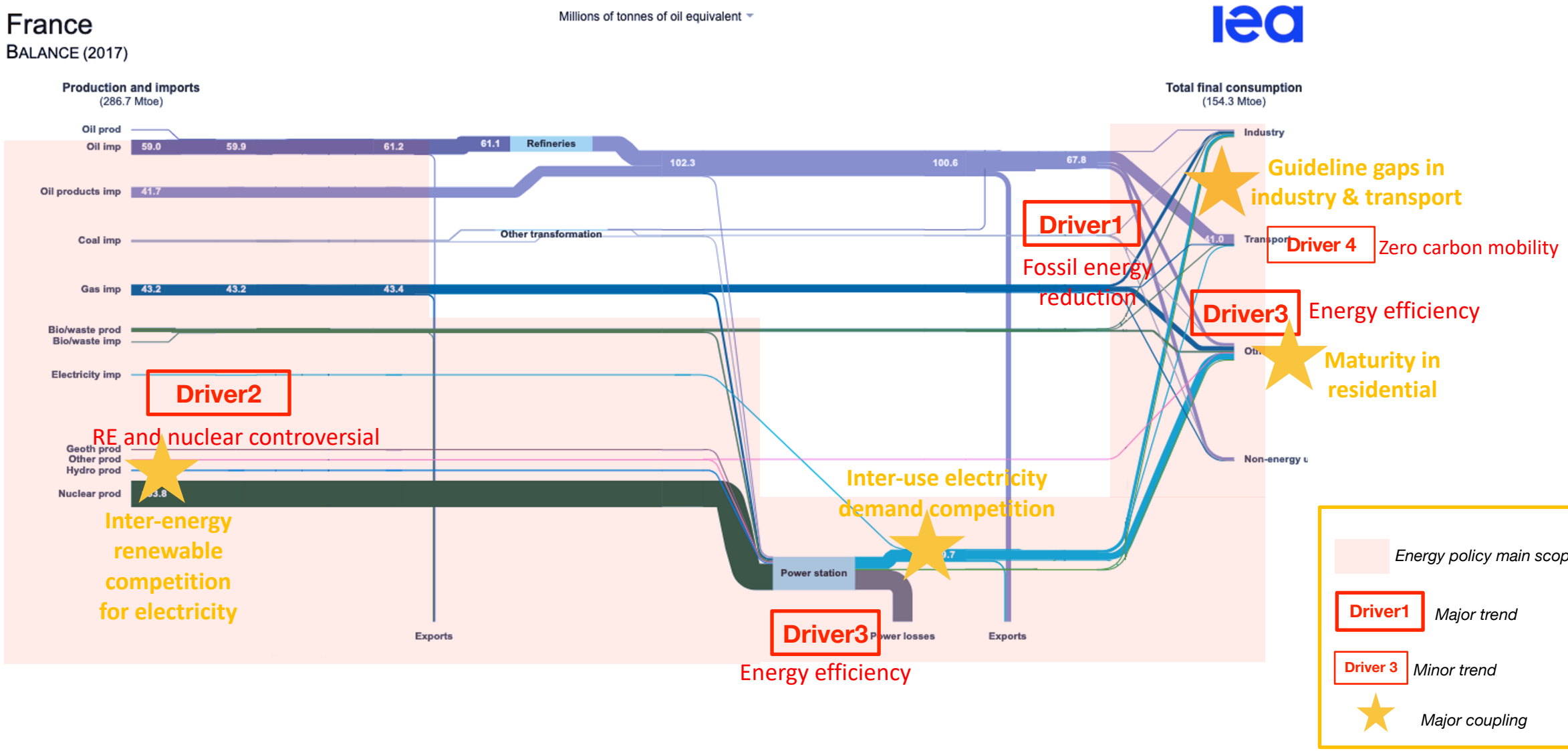
Issue2: Energy performance

- Generic notion that encompasses energy suppliers and downstream reduction in residential
- Sectors concerned: construction, energy suppliers

Issue3: Mobility

- *Weight on total use: 30% (45.3 Mtoe)*
- Uncertainty on technological development in transport
- Coupling: car mobility policies and automotive industry, local investments and infrastructures
- Sectors concerned: transport, industry

1.4 French energy transition relies on a questioning of the system



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. France's electric future is uncertain (nuclear, RE…). However, the country is stepping up in its energy transition through its latest recovery plan setting priorities for 2025.

2. Housing refurbishment polarizes efforts and should contribute to reduce pressure on electric supply. Window for electric mobility expansion by 2025.

3. "Yellow vest" movement put a red light on fuel taxes, leaving open transition policies based on subsidies and industrial promotion. The question of a just transition has entered the policy agenda.

Fuel, mobility & LCA policy

EVs and PHEVs are the priority in the recovery plan.
No ban on ICE vehicle.

Green municipal turn.
Recent trend to foster **soft mobility** as a way to reduce car uses in city centers.

EU Circular Economy Action Plan (section 3.2 Vehicles and batteries)

- Revision of the Battery Directives
  - Ban on non-rechargeable batteries
  - Recycling rates for all batteries (target still undefined)
- End-of-life vehicles package to promote material reuse

Messages

Electric mobility benefits from support policy but no ban on ICE.

Metropolitan governments are taking actions reinforcing mobility territorial segregation.

LCA policy relies on EU regulation.

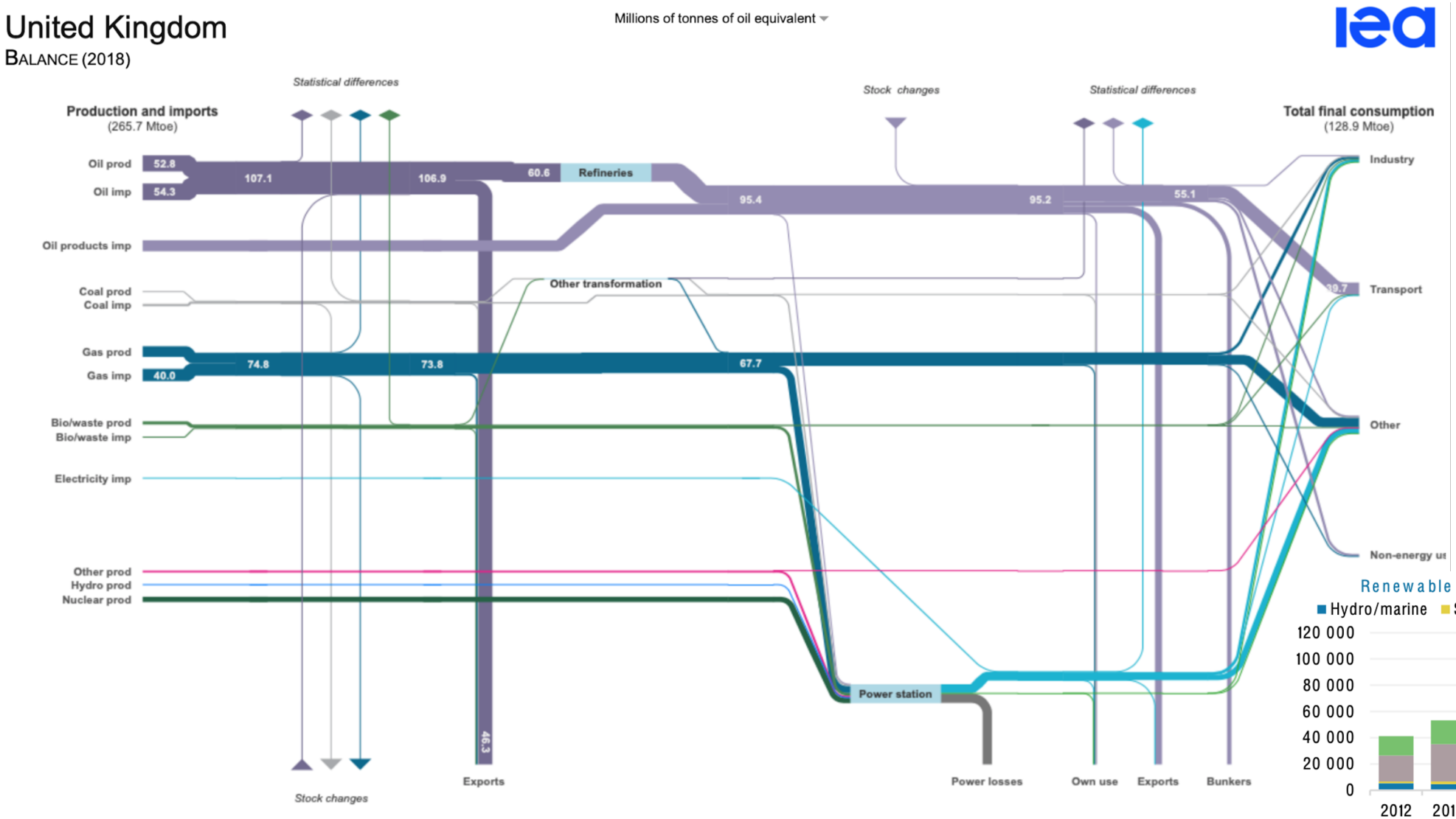
Actualized mobility BAU scenario

1. EVs and PHEVs share will probably rise in captive fleet for LDVs (corporate fleet) in a first phase, and HDVs (logistic) thanks to territorial infrastructure investments in a second phase. No major shift for households LDVs due to the "yellow vest" effect.

2. Thanks to investments in energy savings in residential, public and commercial buildings, there will be an opportunity for electric mobility expansion.

3. Reconfiguration perspective for the use of cars in France: metropolitan policies will probably reduce the number of cars while shared mobility may rise. In the longer-term, car uses may shift to peri-urban areas and multimodal zones.

1.1 Energy system picture : key system realities

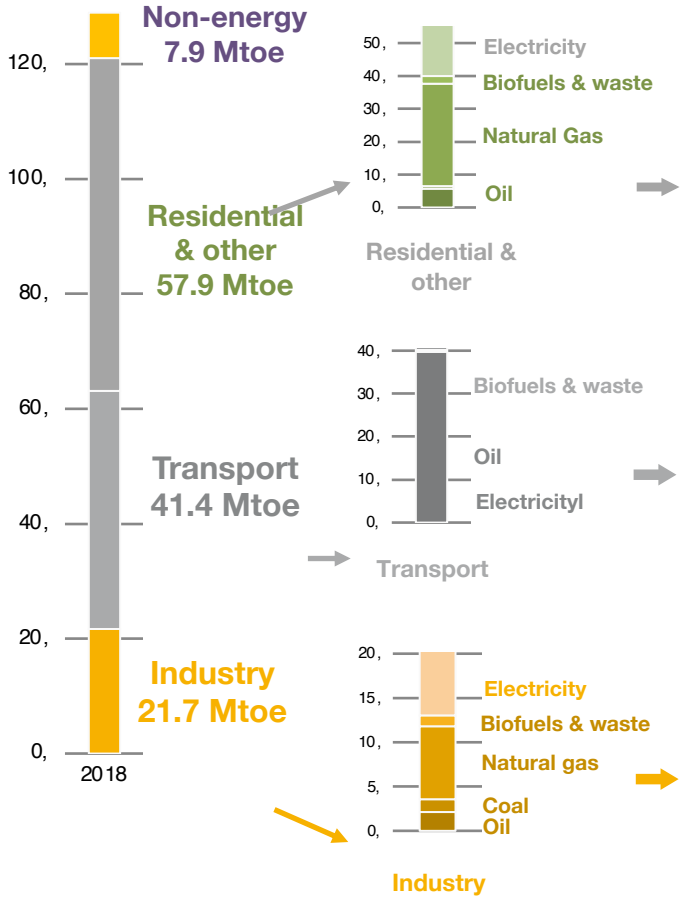


Electric generation from renewables (Irena 2017 data, GWh)

United-Kingdom's mix relies on a hydrocarbon production. Nuclear energy is key to electricity generation while renewable energy has risen during the last decade.

1.2 System inertias & policy drivers

United Kingdom final energy consumption 2018 : 128.9 Mtoe



Inertias
(by sectors)

Inertia1: electricity and gas duality

- Residential: 65% (38 Mtoe)
  - Gas (63%), **Electricity (24%)**, oil (6%), biofuels (5%)
- Commerce & public: 29% (17 Mtoe)
  - Electricity **(46%), gas (38%),** oil (13%)
- Agriculture: (2.4Mtoe) Oil (62%), **electricity (23%)**

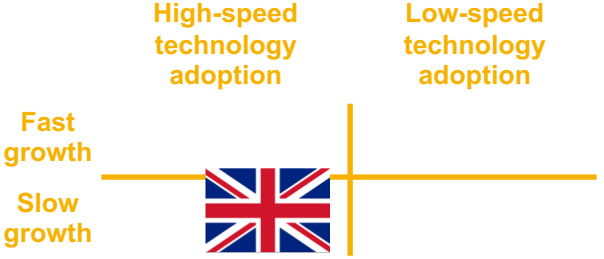
Inertia2: biofuel share is relatively high

- Road : 93% (38.6 Mtoe)
  - Oil (94%), **biofuels** (3.6%),
- Domestic aviation (0,8 Mtoe)

Inertia3: gas & electricity equipment dominance

- Chemicals: 15.5% (3.4 Mtoe)
  - **Gas (50%), electricity (38%)**, biofuels (6%)
- Food and tobacco: 12.9% (2.8 Mtoe)
  - **Gas (57%), electricity (36%)**
- Non-metallic minerals: 11% (2.4 Mtoe)
  - Gas (46%), Electricity (21%), coal (17%), oil (8%), biofuels (8%)

Policy drivers
(on energy and/or sector)



Objectives: The 6th UK's Carbon budget has set a goal of a 78% emissions reduction by 2035 (compared to 1990's level), and climate neutrality by 2050. The UK is a world leader in climate change
Our view: ambitious but well adapted energy transition for climate change mitigation
Timeframe: 2030-2050
Governance type: government, industry-led, Climate Change Council

Driver 1 : Electricity mix security at national level

- Weight on total supply: 12.7% (33.9 Mtoe)
- Objectives: new generation of nuclear plants by 2030, 28% of RE in the total mix in 2030, reinforce electric interconnection between Western Europe
- Power industries and partners countries will be key actors for this driver

Driver 2 : Energy efficiency

- Weight on total use: 29% (38 Mtoe)
- Objectives: renovation of public and private buildings, energy savings, *Energy Performance Certificate* for homes
- Construction sector will be strongly impacted

Driver 3: Hydrocarbon industry decoupling from domestic consumption

- Weight on total supply: 32% (87,6 Mtoe)
- Objectives: maintain exports level

Minor driver 4: Hydrogen investments

- Extended investments that will involve transport, industry, power and buildings. Investments hold by municipalities and key local actors
- World leadership production of a blue and green hydrogen

Minor driver 5: Coal phase-out

- Total share mix concerned: 27% (23,1 Mtoe)
- Objectives: remove coal power altogether by 2024

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)	Coupling (dynamics on energy-to-energy, energy-to-use and use-to-use)
Residential - Inertia1 : electricity & gas duality	**Electric mix security** **Energy efficiency**	**Coupling1: inter-energy substitution in electricity from gas to RE & nuclear/ imports** • *Share of RE will be dominant, nuclear & imports will shape the electric base* • *Weight on total supply: gas (23.4 Mtoe) + imports (1.8 Mtoe) + nuclear (17 Mtoe) = 42.2 Mtoe (15.8%)*
Transport – Inertia2 : biofuel share is relatively high	**Electric mix security** **Sustainable car fleet**	**Coupling2: electrification in mobility** • *Power generation will rise & mobility will electrify in conflict to current uses* • *Weight on total use: 25.8 Mtoe (20%)*
Industry- Inertia4 : electricity & gas equipment dominance	**Coal Phase-Out** **Hydrocarbon industry decoupling from domestic consumption** **Electric mix security**	**Coupling3: from 2030, uncertainty on gas role in the energy transition** • *Gas remains key for energy transition whilst industry and transport equipment might have to shift to H2 and electricity* • *Weight on total mix supply: 39,8 Mtoe (30%)* **Coupling4: blind spot regarding liquid fuel mobility** • *Need for investments returns and uncertainty regarding a potential shift toward Internal Combustion Engine reduction policy* • *Weight on total use: 39.7 Mtoe (30%)*

Structuring issues

Issue1: Electric autonomy

- *Weight on total energy supply: 20% (25.8 Mtoe)*
- Long term policy that aims at achieving electric autonomy
- Electricity autonomy is structuring for energy transition
- Sectors concerned: industry, mobility, residential and other

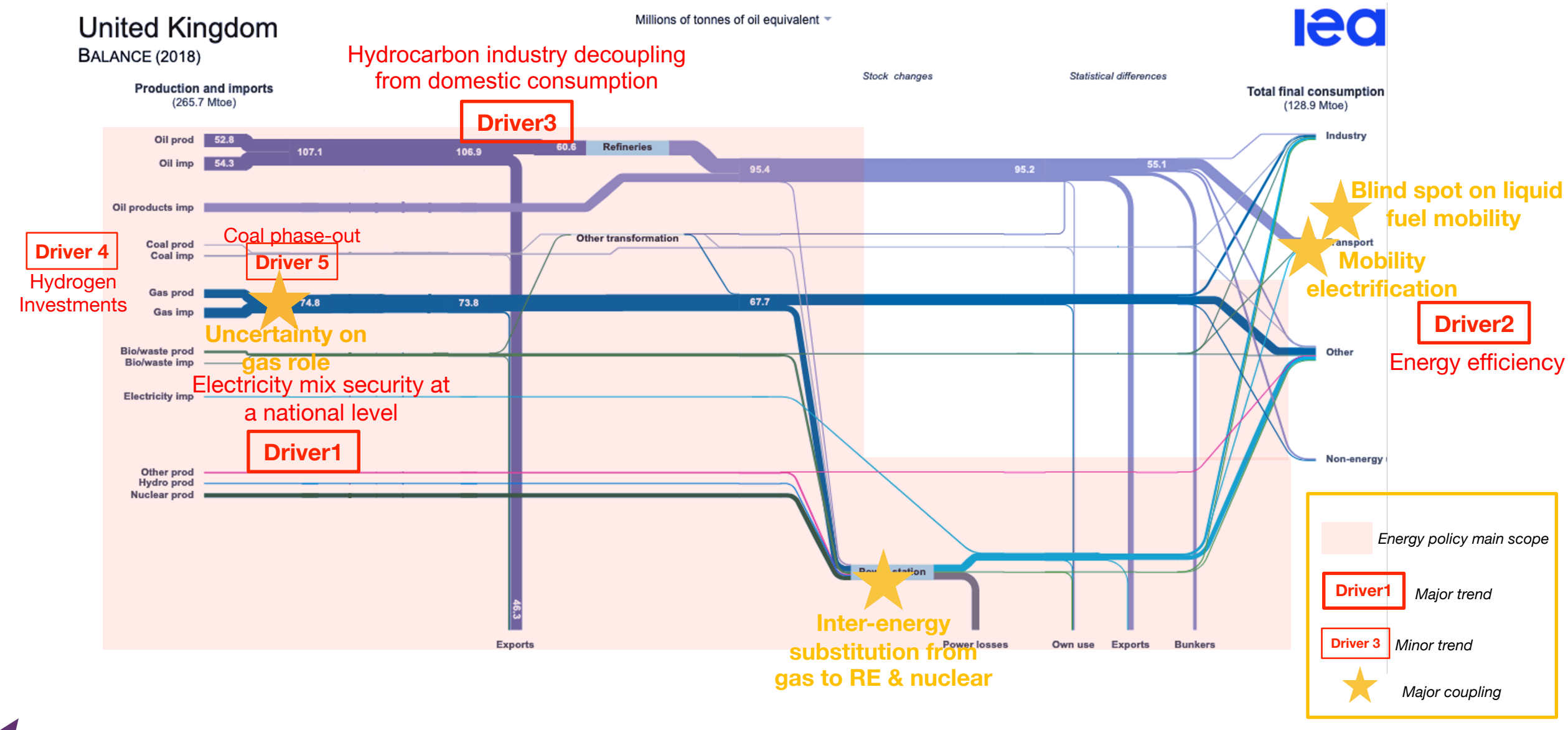
Issue2: Stranded assets in O&G

- *Weight on total energy use: 50%*
- Mobility is not the priority to maintain returns on investment in UK continental shelf
- Hydrogen seen as a landing horizon
- Sectors concerned: industry, construction, transports, power

Issue3: Energy efficiency

- Generic notion that encompasses energy suppliers and downstream reduction in residential
- Coupling with energy performance for buildings
- Sectors concerned: transport, industry, residential

1.4 An advanced transition that is able to focus on new energy production investments more than on energy uses

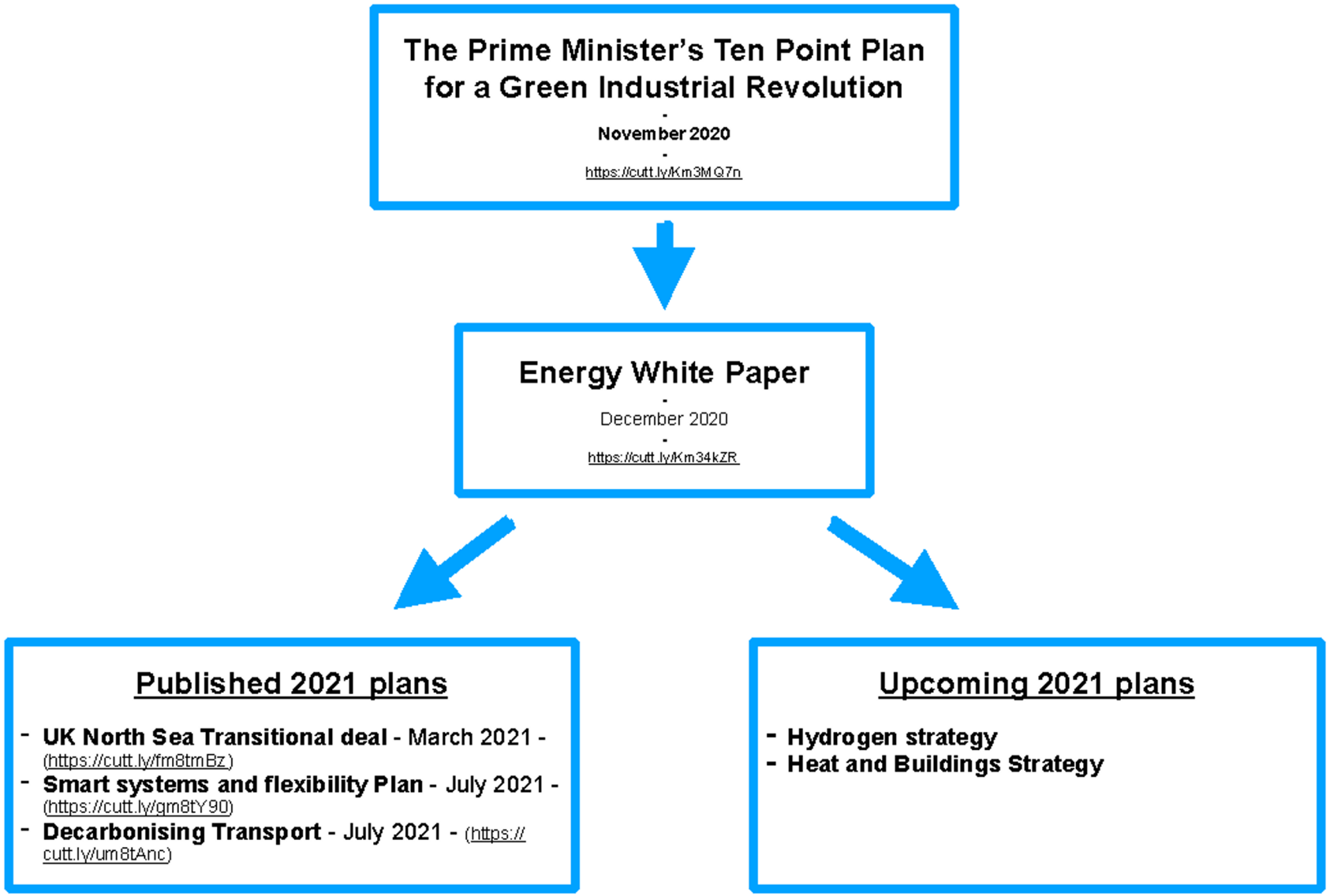


2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario	Fuel, mobility & LCA policy	Messages	Actualized mobility BAU scenario
1. The UK is on a structured and consistent pathway towards a nearly decarbonized society with a strong electric autonomy by 2030. 2. Decarbonized electric investments enable coal-phase out for 2025 and gas reduction in the electric mix. Infrastructures are gradually retrofitted for new uses of biomass, waste and heat network. Gas infrastructure opportunity for H2 in industry and heating. 3. Massive territorial investments and coordination are shaping transition infrastructure.	Concept plan for the future of mobility in the UK - 2019 Principle-based approach among which: - Subordination of future systems to zero-carbon transition - Walking and cycling promotion - MRT as a cornerstone in urban areas - Safer mobility (automation and elderly care) and safer micro-mobility - Strict data use and service policy No specific LCA regulation on mobility.	Singapore-like mobility policy but subordinated to zero-carbon transition (CCC) and physical activity promotion. No LCA policy in mobility	1. The UK has developed a strong cross-institutional reflection on mobility towards a post-car mobility. **Concept planning is the main tool to give a framework to territorial and urban planning.** 2. Subordination to zero-carbon strategy promotes shared mobility and slow-mobility as planning principles starting from now. 3. Mobility will be key to a zero-carbon transition. High-technology innovations such as automated vehicles will be promoted as a tool for sustainable mobility inclusiveness for 2025.

ANNEX

The UK public policy architecture for the energy transition towards net zero



The Prime Minister's Ten Point Plan for a Green Industrial Revolution

10 points plan for a green industrial revolution :

- nuclear power
  - The UK is pursuing large scale nuclear but also anticipating the future of nuclear power (small modular reacts notably and advance modular reactors)
- green public transport, cycling and walking
  - Thousands of zero emissions buses will be funded and city lanes established
- offshore wind
  - Quadruple its offshore wind capacity by 2030 (targets 40GW)
- hydrogen
  - Target of 5GW of low-carbon H2 by 2030
- jet zero and green ships
  - Investments in R&D to develop zero-emissions aircrafts and green ships
- greener buildings
  - Make more efficient buildings
  - Move away from fossil fuel boilers
- protecting our natural environment
  - Restore habitats for wildlife to combat biodiversity loss
- zero emission vehicles
  - By 2030, the sale of new petrol and diesel cars and vans will end
  - A £2.8 billion package of measures to support industry and consumers will be implemented
- carbon capture, usage and storage (CCUS)
  - Ambition to capture 10Mt of carbon dioxide per year by 2030
  - Will invest up to £1 billion to support the establishment of CCUS in four industrial clusters creating éSuperPlaces »
- green finance and innovation
  - Will raise total R&D investments to 2.4% of GDP by 2027
    - Announced a £1 billion Net Zero innovation Portfolio

Energy White Paper

- published in December 2020
- Builds on the Prime Minister's Ten Point Plan
- Establishes the framework for energy policy in the UK for years to come.
- Reaffirms net zero commitment by 2050
- Public policy measures from the white paper could reduce emissions by up to 230Mt C02e.
- Will establish a new UK ETS
- Bring one large-scale nuclear project to the point of FID by the end of the legislature
- Considering stoping gas grid connections to new homes by 2025
    - Gas currently represents 30% of final energy consumption and 40 percent of electricity generation
- Growing the installation of electric heat pumps
- Modeling suggests that :
    - Overall power demand could double out 2050 (mostly driven by heating and mobility)
    - Electricity could provide more than half of final energy demand in 2050
    - Would require a four fold increase in clean energy generation
- intend to have an energy mix mostly composed by nuclear and renewables by 2050
- Intend to base their action on the Nuclear Sector Deal published in 2018 and to promote advanced nuclear innovation (£385 million to an Advanced Nuclear Fund)

EUROPE G5 - Germany, Italy, France, Spain, United Kingdom

Country	Actualized energy scenario	Actualized mobility scenario
G5	• Despite disparities, G5 has a structured pathway toward carbon neutrality by 2050 (and Brexit won't change it; COP26 will accelerate it for UK). • Electricity system reinforcement is the priority since electrification of uses is core of energy transition strategies (except for Italy, gas priority; UK has an hybrid priority: electricity + gas: first NG then H2) • Energy efficiency to rise as a tool to relieve electric system pressure • Gas will be used as a *transitory* energy waiting for RE (and potentially H2) infrastructures to produce at scale	• 2020 is a pivotal year for electric mobility. EV market resisted to Covid-19 crisis and have shown significant progress across Europe. • Electricity will be dominant for sustainable mobility but gas mobility will also develop particularly in Italy. • Biofuels blending will increase due to EC promotion. Bioethanol + biodiesel will be used as transitory energy for mobility to decrease ICEs pollution. • Urban plans question the future of personal car in cities & Strong promotion of shared mobility & slow-mobility
Country	**Alternative energy scenario**	**Alternative mobility scenario**
G5	**Energy efficiency accelerates decarbonation & electrification** Energy efficiency aims to decrease electricity consumption in buildings & relieve pressure on the electric system. **By 2030, H2 shift will be possible both mobility & industry uses**. Nuclear will be used for low carbon H2 production.	Energy efficiency policy is to relieve pressure on the electric system & enable acceleration of electrification of mobility. Shift toward green H2 mobility for HDVs will be possible by 2030.

Energy transition through electrification of uses

Coupling 1 : RE will substitute polluting energy in the electricity mix

Coal power generation will be substituted by massive RE investments.
Nuclear (France, UK) + RE + gas will shape the electric base.
Interconnections between countries will increase due to fear of electricity generation.
Gas to rise over few years waiting for RE infrastructure to be build (Spain, Italy, UK)

Coupling 2: Electrification and competition in demand should prevent electric saturation

Electrification of transport and industry uses, rising competition of Power uses
In Italy, competition based on industry and residential demand for gas & electricity

Coupling 3: Alternative energies will compete for sustainable mobility

ICE ban in Spain (2040) & UK (2030)
Inter-energy coupling for sustainable mobility
Alternative competition (electricity, biofuels, H2) for mobility

Coupling 4 : Major country specific couplings

- **Spain:** Some industries to shift equipment from coal to undecided sources
- **Germany:** Gas/electricity competition in renewing industrial equipment
- **Italy:** Infrastructure coupling Legacy system in the North that distributes energy between urban centres and industrial districts.
- **France:** Maturity in residential sector Inter-energy coupling : biogas substitution in residential by electricity & biogas competition
- **UK**: From 2030, uncertainty on gas' role in energy transition Gas remains key for energy transition whilst industry & transport equipment might shift to H2 and electricity

G5 countries: world leaders in energy transition. Their energy systems are being transformed towards a green electrification of uses.

Framed by the ambitions of the EC with a growing influence by Germany (and COP26 for UK)

Despite an overall ambition to green transportation, the strongest of inertia remains oil. Oil weight in energy transition is hardly mentioned, except for UK.

Mobility's impact on the environment will only be positive by greening electricity (& green/low carbon H2 for heavy duty).

Particular couplings analyses in G5, major particularism highlighted in red

France	Germany	Spain	UK	Italy
Coupling1 : RE addition for electricity	**Coupling1 : inter-energy substitution**			
More RE & nuclear reduction	• FROM coal + nuclear to RE • **Electric mix saturation focus**	• From nuclear + coal to gas + RE	• Gas to RE + nuclear imports • Will shape the electric base	• Coal to RE substitution • Competition RE-gas for electricity
Coupling2 : inter-use electricity demand competition				**Coupling2 : inter-use competition gas & electricity**
• Rise of electricity in energy mix electricity demand competition	• Competition electric mobility rise & industry/residential stable demand			• Competition industry & residential demand for gas & electricity
Coupling3 : Maturity in residential sector	**Coupling3 : inter-energy : gas/electricity competition**	**Coupling3 : fossils exit for specific industries**	**Coupling3 : From 2030, uncertainty on gas role in the energy transition**	**Coupling3 : infrastructure coupling**
• Biogas substitution in residential, electricity-biogas competition	• Equipment competition gas - electricity	• Cement factories to substitute fossils to undecided sources	• Gas keeps a role; industry & transport equipment might shift to H2 + electricity	• Gas is key for energy transition; gas infrastructures for green gas
Coupling4 : Unspecified Role of biogas	**Coupling4 : car industry uncertainty**	**Coupling4 : technology shift in fossil liquid fuel mobility**	**Coupling4 : technology shift in fossil liquid fuel mobility**	**Coupling4 : mobility coupling**
• Biogas & electricity : uncertainty on energy use for low carbon mobility	• Low commitment of local car makers	• ICE ban for 2040 • Competition (electricity, biofuels, H2) for sustainable mobility	• ICE ban for 2030 • Alternative competition (electricity, biofuels, H2) for sustainable mobility	• Inter-energy coupling : gas, biogas and electric competition for mobility

Energy & mobility trajectories in G5 countries – points of focus

Country	Actualized energy scenario Points of Focus	Actualized mobility scenario Points of Focus
Germany	Coal & nuclear substituted with ER and gas. Investments in H2.	Not a priority. Incentive for renewable gases. Hybrid transportation also encouraged
Spain	Coal & nuclear substituted with gas & major RE ambition (100% RE 2035 electricity mix). In the meantime, gas is key to the transition to renewables.	Prohibition of new ICE LVDs from 2040. Promotion of shared mobility + electricity price increase = potential decrease of the private fleet LVDs
Italy	Energy transition using old gas and electricity infrastructure (via European interconnections)	Development of gas-powered mobility (mainly biomethane), Encouragement also of EVs and PHEVs
France	Nuclear to account for 50% in electricity mix by 2050, rise of RE but uncertainty on partial substitution of nuclear future role of H2	Post-Covid recovery plan has as a priority the development of EVs and PHEVs. Decrease in car use in cities
UK	"Nearly decarbonized society": coal phase-out & reinforcement of the power system (nuclear, RE, imports), Investments in H2	High ambition for slow & sustainable mobility. ICEs ban for 2030 will boost electric mobility. Strong promotion of shared & slow mobility

Possible trajectories turnpoints

EU regulation for mobility

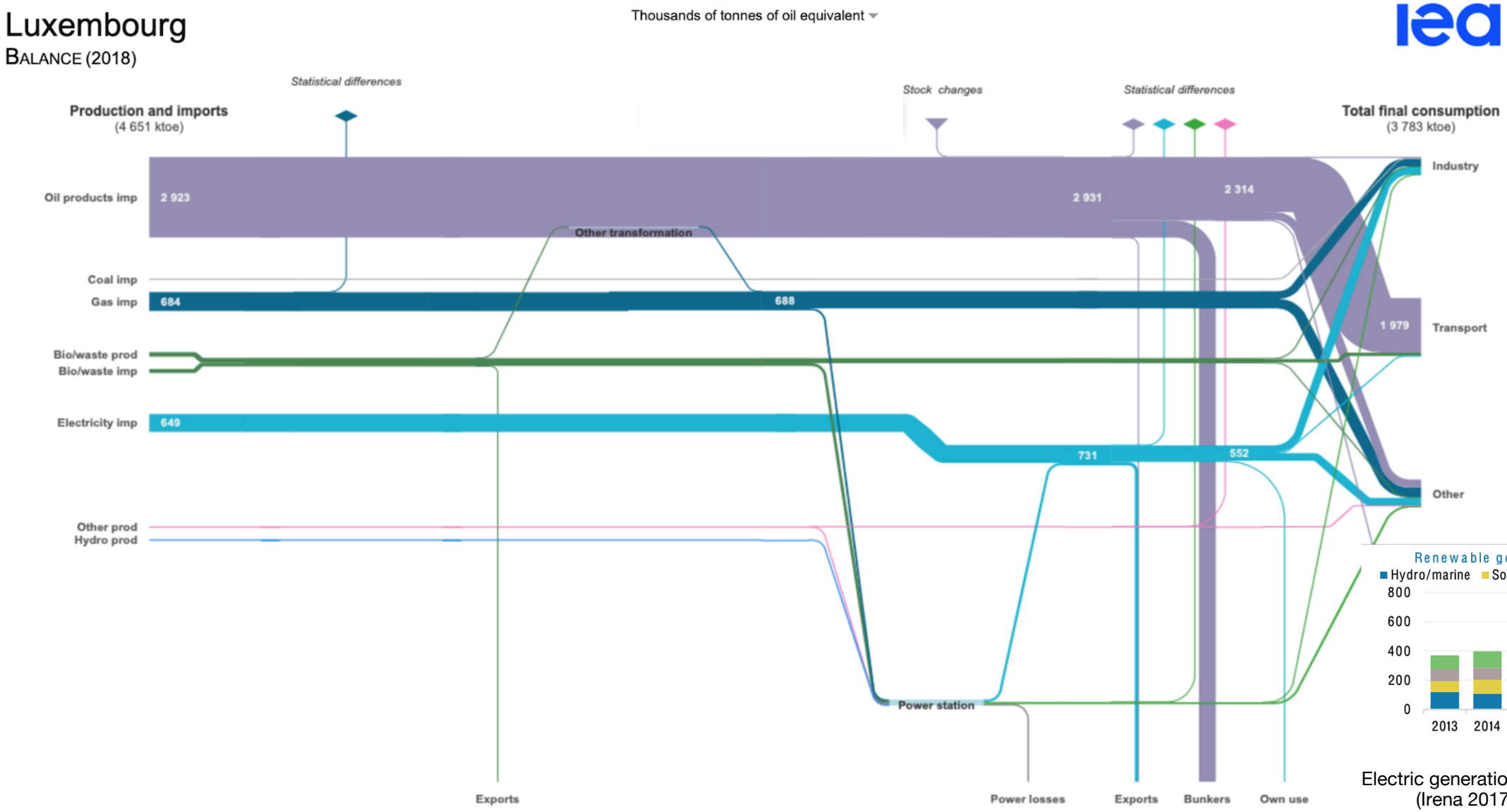
Deployment of electric infrastructures

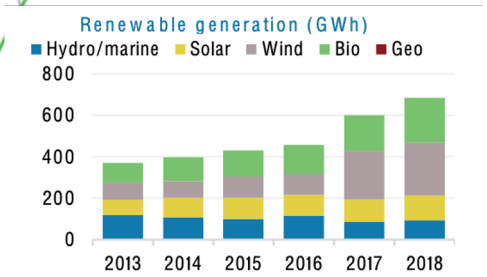
H2 penetration

Risks for a car manufacturer

- Need to anticipate TCFD
- Ongoing electrification rivalries: mobility – residential – industry

1.1 Energy system picture : key system realities



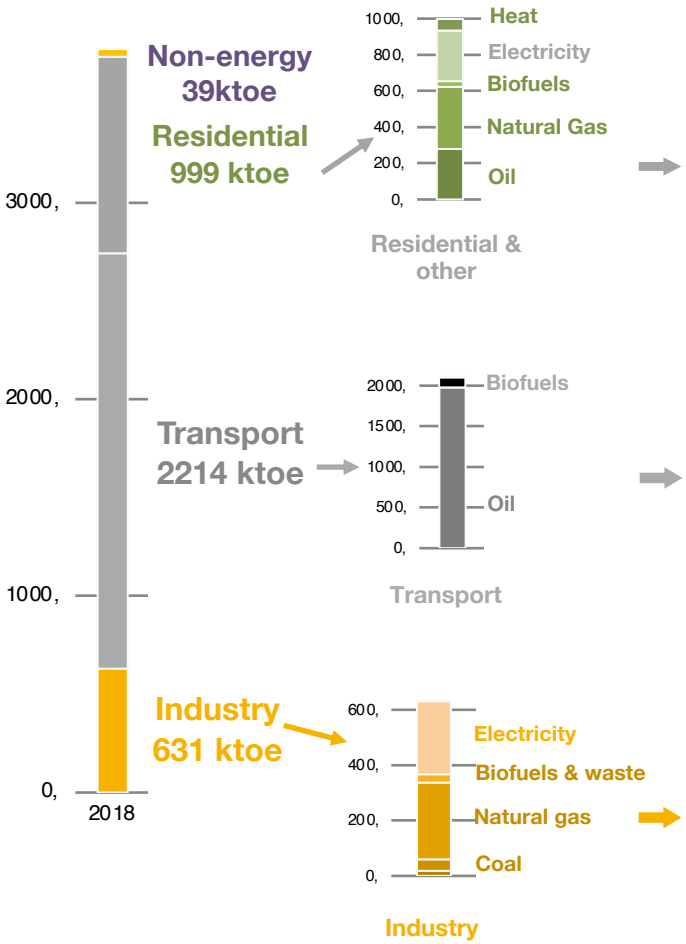


Electric generation from renewables (Irena 2017 data, GWh)

Luxembourg is highly dependent on primary energy imports. RE is increasing steadily since 2013 thanks to biomass & wind investments.

1.2 System inertias & policy drivers

Luxembourg final energy consumption 2018: 3783 ktoe



Inertias
(by sectors)

Inertia1: balance between gas, electricity & oil use

- Residential: 50% (497ktoe)
  - Gas (49%), oil (30%), electricity (26%), biofuels (5%)
- Commerce & public: 48% (478ktoe)
  - Electricity **(41%)**, **oil (24%),** gas (21%), heat (14%)
- Agriculture: (23ktoe) **Oil (70%)**, biofuels (17%), electricity (13%)

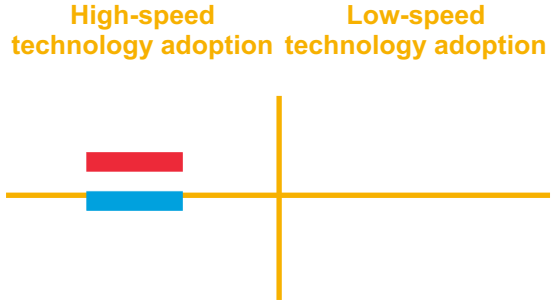
Inertia2: biofuel share is high

- Road : 94% (2085ktoe)
  - Oil (94%), **biofuels (6%)**

Inertia3: gas/electricity equipment duality

- Iron & steel: 45% (284ktoe)
  - **Gas (50%), electricity (49%),** coal (1%)
- Non-metallic minerals: 23% (144ktoe)
  - **Gas (47%), coal (24%),** biofuels (14%), electricity (13%)
- Chemical & petrochimical: 7% (46ktoe)
  - **Electricity (67%),** gas (30%), oil (3%)

Policy drivers
(on energy and/or sector)



Objectives : decrease GHG by 55% by 2030 in relation to 2005 (-21.4% achieved in 2017) & be an international hub for climate solutions
Our view: ambitious objectives, very well inscribed within a European vision
Timeframe : 2030-2040
Governance type : central government, 12 cantons

Driver 1: Fostering interconnections within the EU for energy security

Weight of imports on total supply: 95.5% (4,442 ktoe)

- Objective: further developing the EU energy market for gas and electricity & increasing the interconnection rate from 270% to 400% in 2030
- Diversifying the importers of oil besides Belgium, Germany, France and the Netherlands
- Expanding the domestic electricity capacity on the existing grids

Driver 2 : RE development

Weight of RE on total energy supply (non-including electricity imports): 4.5% (209 ktoe)

- Objective: 25% of RE in gross final energy consumption by 2030 (15.4% in 2017)
- Share of RE: 33.6% in electricity, 30.5% in heating, 25.6% in transport
- Wind: +489 GWh & photovoltaic: +1004 GWh in electricity from 2020 to 2030

Driver 3 : Energy efficiency

Weight of residential on total energy consumption: 13.14% (497 ktoe)

- Objective: reduce final energy consumption to 35.6 TWh by 2030 (vs. 48.4 TWh in 2017)
- Cumulative energy savings between 2021 and 2030: 97.3 TWh
- Cumulative energy savings from renovation : 28.6TWh with renovation rate of 72%, notably 100% of sustainable public buildings with roof PV by 2025

Driver 4 : Investments in sustainable mobility

Weight of the transport sector on total energy consumption: 55.9% (2,114 ktoe)

- Objective: 49% of electric or hybrid vehicles in 2030
- Limit the use of first-generation biofuels to 5% to promote second-generation biofuels
- Investments in green hydrogen: plan to build a hydrogen station
- Massive expansion of public transportation and railway network

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)
Residential - Inertia1 : balance between gas, electricity & oil use	**Energy security** **Energy efficiency** **RE development**
Transport – Inertia2: biofuel share is high	**Energy efficiency** **Electromobility**
Industry- Inertia3 : **gas/electricity equipment duality**	**Energy security** **Energy efficiency** **RE development**

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1: greening electricity via energy efficiency
- *Weight of electricity imports on total energy supply: 14% (649ktoe)*
- *Weight of RE on total energy supply: 4.5% (209ktoe)*
- *RE share in electricity mix: recent & rapid increase*
- *Energy efficiency aims to decrease electricity consumption in buildings and allows electrification of mobility*
- *RE addition in the electricity mix, but imports will remain the electricity base until RE infrastructure produce at scale*

Coupling2: inter-energy competition in transports
- *Weight of oil in final energy consumption in transport: 93.6%; biofuel: 5.8%; electricity:0.6%*
- *Investments on electromobility, second generation biofuels and green hydrogen will progressively decrease oil imports*

Coupling3: domestic use of oil & bordering countries consumption on national territory
- *GHG emissions attributable to sales of fuels: 70% to foreign vehicles, 60% to heavy load trucks*
- *Reinforcing the shift in pricing policy of gas & diesel would be needed to affect cross-border fuel purchase*
- *European neighbours' electrification of transport will also determine the decrease in sales of fuel*

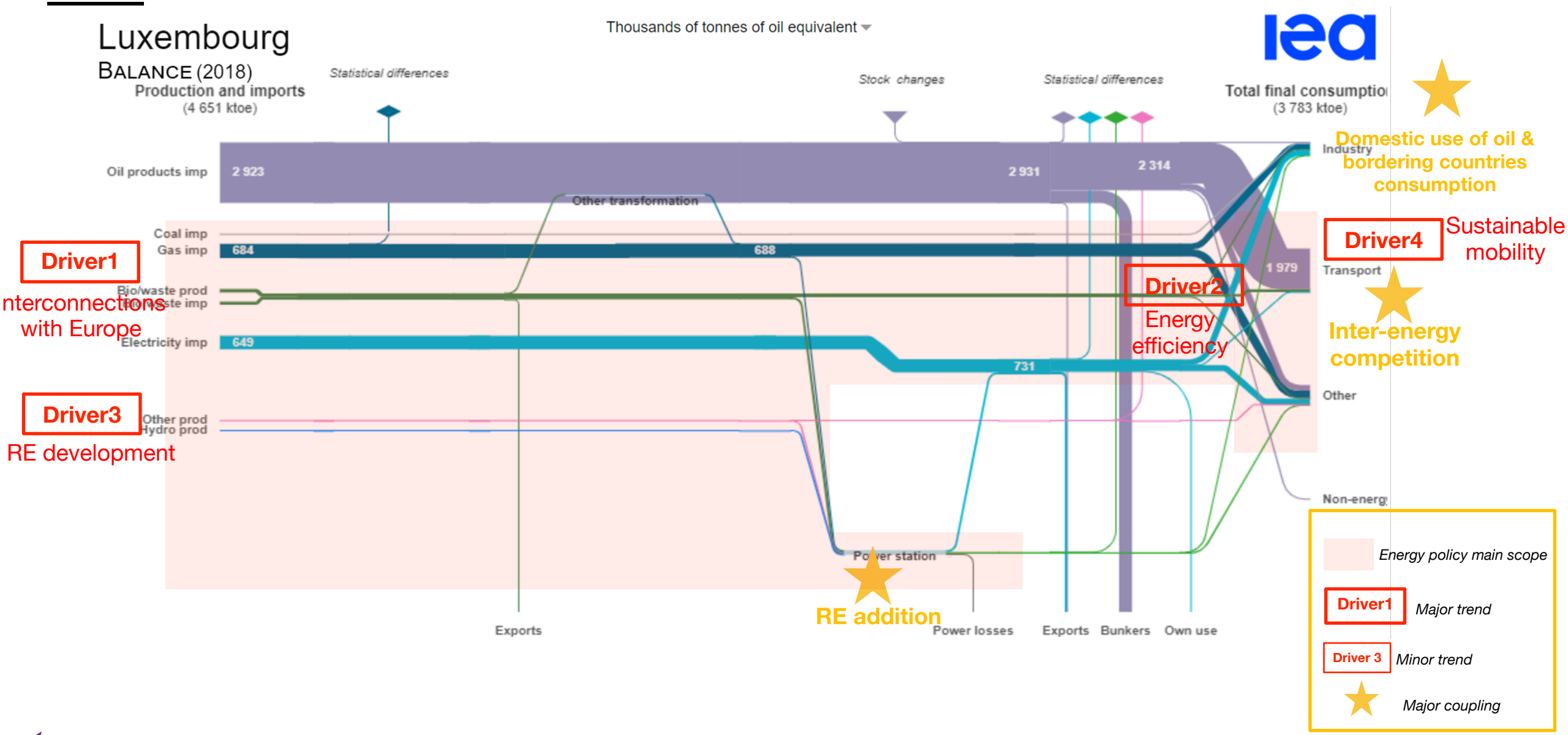
Structuring issues

Issue1: Energy security via EU integration & RE investments
- *Weight of imports on total supply: 95.5% (4,442ktoe)*
- Luxembourg depends on its imports from EU partners. Increasing interconnections with its neighbours is needed
- Luxembourg is participating in the development of RE resources in the EU (e.g. North Seas Energy Cooperation)
- Despite domestic investments in wind, solar, geothermal and biomass energy, RE is not sufficient for energy autonomy

Issue2: Energy efficiency & electricity consumption
- Notion that relies on European Commission energy efficiency model
- Encompasses energy sobriety, building renovation & public sector exemplarity
- Residential & non-residential building renovation: heating needs drop, thereby decreasing households' consumption of electricity
- Saving electricity for the increased demand for electromobility while controlling oil imports
- Hydrogen as a possible alternative to electricity in transportation: need EU cooperation

Issue3: a country of transit at the center of Europe
- Location at the center of Europe, by which lots of commercial heavy load trucks transit
- Attractiveness of neighboring countries for gas & oil prices threaten the reduction in GHG emissions

1.4 Overdependency on imports motivates RE development and integration within the EU energy market



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Luxembourg's energy transition plan is very ambitious, well structured & integrated within the EU framework, in coherence with their strong dependency on energy imports & lack of domestic resources.

2. Major investments in energy efficiency in buildings (e.g. PRIMe House, Luxembourg LED 2025 initiative) will make electricity available for new uses.

3.Luxembourg will reinforce its interconnections with EU countries, notably through cross-border RE infrastructure.

4. The government launches yearly call offers for installing PVs. 2020 call offer will result in new units capable of producing 40 MW, which could cover electricity needs of 27,000 residents. In this way, the relative share of RE in the electricity mix will increase, thereby increasing domestic production starting in the short-term.

5. The relative share of electricity & gas used in industry will essentially remain the same.

6. Objective of 49% of electromobility and supporting the EU to forbid passenger cars & LDVs relying on fossil fuels by 2030 should lead to a decrease in oil imports.

Fuel, mobility & LCA policy

Concept plan for the future of mobility in Luxembourg:
« *MoDu 2.0* » establishes several objectives for 2025 regarding mainly home-work and home-school trips: raising the number of people walking and using a bicycle, increasing the number of people using public transportation by 50%, raising the occupancy rate to 1.5 per car, improving train services.

Promotion of electric mobility & public transportation:

- **2020 "Clever Fueren + Clever Lueden" programme: direct subsidies** for the purchase of a new, fully electric vehicle (EUR 8,000) or motorcycle (EUR 1,000), a plug-in hybrid vehicle (EUR 2,500), a bicycle (EUR 600), and 50% of home charging stations
- **2020 free public transportation** in the whole country for all

Mobility is the priority to decarbonizing the economy.

No specific LCA regulation on mobility besides EU regulation.

Messages

Luxembourg follows EU directives & has some ambitious goals with concrete policies, but it needs to go further in the reflection and plan about hydrogen development.

To achieve objectives in terms of GHG, the government targets energy efficiency in building & transportation.

Transportation represents a major part of Luxembourg's economy. As a country of transit at the centre of the EU, foreign commercial and personal vehicles are attracted by its low prices of gasoline & diesel.

Transforming transportation towards sustainable mobility is a government priority. In 2020, 7% of the newly registered passenger cars & LDVs were HEVs & EVs. This should keep increasing fast in the years to come, along with slow mobility, carsharing and public transportation.

No LCA policy in mobility

Actualized mobility BAU scenario

1. **Important shifts in mobility are likely to happen in the short-term (before 2030) thanks to strongly incentivizing public policies.**

2. Subsidies are the government's main tool to encourage a shift in the population's habits of consumption. This is an open gate for EVs development. Passenger cars and LDVs will be the first to benefit from such policies, notably company-owned cars which benefit from incentivizing fiscal policy.

3. Slow mobility, public transportation and carsharing is likely to become more important in cities.

4. Green hydrogen is an important alternative which Luxembourg is aware of the potential. The country is currently elaborating a strategy for the use of hydrogen, from which HDVs could be the first to benefit from.

KPIs that can influence the actualized BAU energy and mobility scenario

KPIs on energy

1) Interconnection levels with EU member states
- Influence on the development rapidity of the relative share of RE in the electricity mix

2) Neighbouring countries' shift towards the electrification of their mobility
- An important shift of EU neighbours towards greener mobility is likely to lead to faster decrease in oil imports

3) Gasoline & diesel prices
- The more the increase in prices for harmonisation with neighbouring countries, the less demand for oil, the more decrease in oil imports

4) Drop in sales of fuel (due to Covid-19, teleworking & lockdown)
- Impact on fuel prices
- Influence on oil imports

5) Hydrogen development in Europe & the world
- Influence on the rapidity of strategies for hydrogen development in Luxembourg

KPIs on mobility

1) EU ban on ICEs by 2030
- Impact on the population's adoption of EVs and HEVs
- Influence on gas & diesel prices

2) Gasoline & diesel prices
- Influence on the population's questioning of its habits in terms of transportation & change of culture
- Possible influence on the shift of the population towards greener mobility

3) Hydrogen development
- Influence on the deployment of EVs and HEVs
- Influence on the share of ICEs in the car fleet

Weight of transport in total oil consumption: 68%

Weight of transport in total energy consumption: 56%

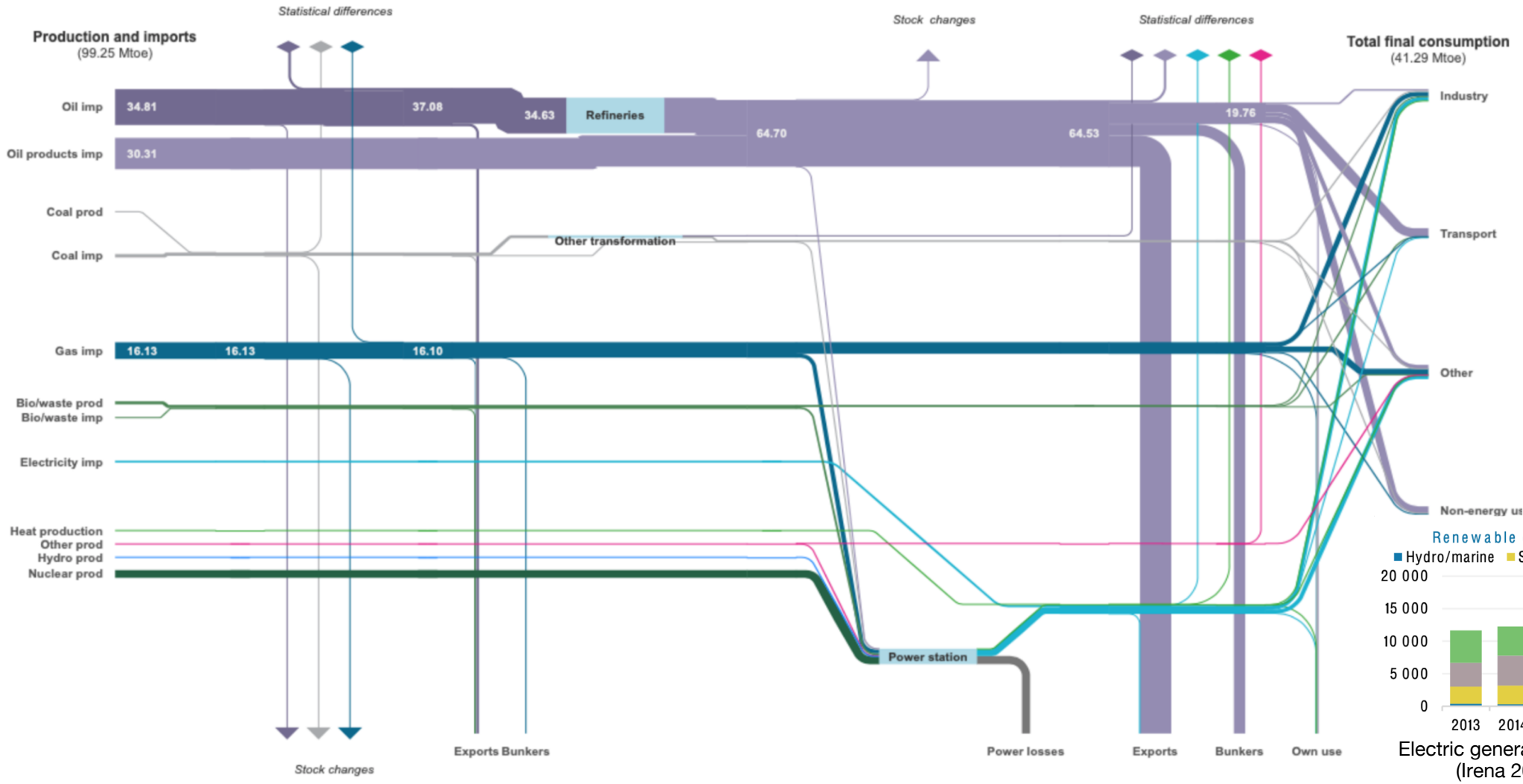
The success of Luxembourg energy transition will depend on its capacity to reach its objectives in terms of electrification of the mobility.

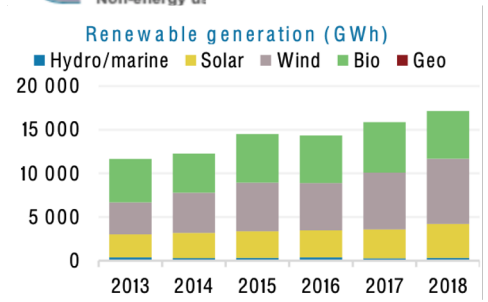
1.1 Energy system picture : key system realities

Belgium

BALANCE (2018)

Millions of tonnes of oil equivalent



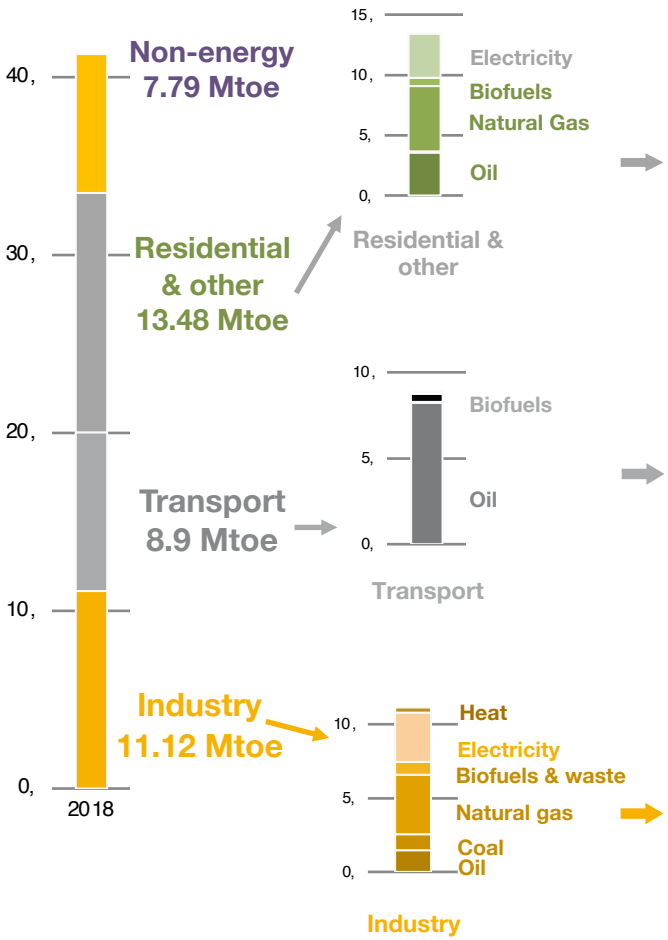


Electric generation from renewables
(Irena 2017 data, GWh)

Belgium energy mix is dependent on hydrocarbon imports and nuclear production for electricity. Steady growth in RE production.

1.2 System inertias & policy drivers

Belgium final energy consumption 2018: 41.29 Mtoe



Inertias
(by sectors)

Inertia1: electricity and gas duality, oil share is high

- Residential: 59.7% (8.06 Mtoe)
  - Gas (41%), Oil (30%), Electricity (20%), biofuels (7%)
- Commerce & public: 34% (4,59 Mtoe)
  - **Electricity (41%), gas (39%),** oil (16%)
- Agriculture: (0.79 Mtoe) Oil (39%), gas (35%), electricity (19%), biofuels (5%)

Inertia2: biofuel share is high

- Road : 96% (8.56Mtoe)
  - Oil (94%), **biofuels (6%)**

Inertia3: gas/electricity equipment duality
Interia4: steel-making still running on old coal equipment

- Chemical & petrochemical: 37% (4.18Mtoe)
  - **Gas (33%), oil (30%),** electricity (30%), biofuel (6%)
- Food & tobacco: 16% (1.59Mtoe)
  - **gas (57%), electricity (33%),** biofuels (5%), heat (3%)
- Iron & Steel: 13% (1.51Mtoe)
  - **coal (40%),** gas (34%), electricity (25%)

Policy drivers
(on energy and/or sector)

Objectives : decrease GHG by 35% by 2030 in relation to 2005
Our view: Achievable objectives, but will depend on nuclear and gas policies from 2025 onwards
Timeframe : 2030-2050
Governance type : central government, 3 regions, industry-led

Driver 1: Progressive nuclear phase-out from 2025 onwards

Weight on electricity supply: 51% (7.45 Mtoe)

- 3 January 2003: law for nuclear phasing-out. It has been modified in 2013 & 2015 to postpone nuclear phase-out date
- Phase-out of 7 nuclear reactors by 2025 (5*1000 MW + 2*500 MW)

Driver 2: Energy security via RE investment and European interconnection

Weight on total energy supply: 19.4% (19.27 Mtoe)

- Need to substitute nuclear production with RE and by strengthening electricity & gas interconnections in Europe. Electric interconnection is to increase from 21% (2020) to 30% by 2030.
- 18.3% of RE in the total mix by 2030, 4GW offshore wind capacity by 2030 with a "*New development plan for marine areas*", & North Seas Energy Cooperation (NSEC) with investment in the Belgium-Netherlands, UK clusters.
- Main actors: Belgian Offshore Platform (BOP), CREG, Elia

Driver 3: Energy efficiency

Weight on total supply: 13% (20,4Mtoe)

- Notion used to define energy savings, specially primary energy savings
- Decrease primary energy by 22% and final energy by 17% by 2030 in relation to 2007

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)
Residential - Inertia1 : electricity and gas duality	**Energy security** **Energy efficiency** **Nuclear phase-out**
Transport – Inertia2: biofuel share is high	**Energy efficiency**
Industry- Inertia3 : electricity/ gas equipment competition	**Energy security** **Nuclear phase-out**
Industry- Inertia4 : steel making still running on coal	**Energy efficiency**

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1: unrealistic nuclear phase-out

- *Uncertainty concerning the feasibility of nuclear phase-out policy (e.g.: 2 reactors' phase-out will be postpone to ensure energy security)*
- *Gas & imports will play a key role in the electric generation transition, until RE infrastructures get ready to produce at scale*
- *Weight on electricity mix: 100%*

Coupling2: inter-energy substitution for industrial equipment

- *Gas (10.55Mtoe) & electricity (7.12Mtoe) will substitute old coal (1.4Mtoe) equipment in some industries such as iron and steel industry*
- *Weight on total use: 42.7% (19.04Mtoe)*

Coupling 3: electricity mix under pressure

- *Increasing demand for electricity will put power system under pressure*
- *Promotion of auto production & flexibility in the electric system (need to increase storage capacities)*
- *Interconnection optimisation will be needed: new project with Germany (Alegro) for 2021, 2 potential projects after 2025 (Nautilus (UK) & Alegro II)*
- *Weight on total use: 42.7% (17.64Mtoe)*

Structuring issues

Issue1: nuclear phase-out threatens energy security

- Nuclear phase-out is a long term policy, but unrealistic soft landing
- Necessary adjustments for gas and electricity networks
- Expected decrease of low calorific value gas imports from the Netherlands from 2022 forces the country to establish new partnerships with Russia
- *Weight on total supply: 23.7% (23.5Mtoe)*

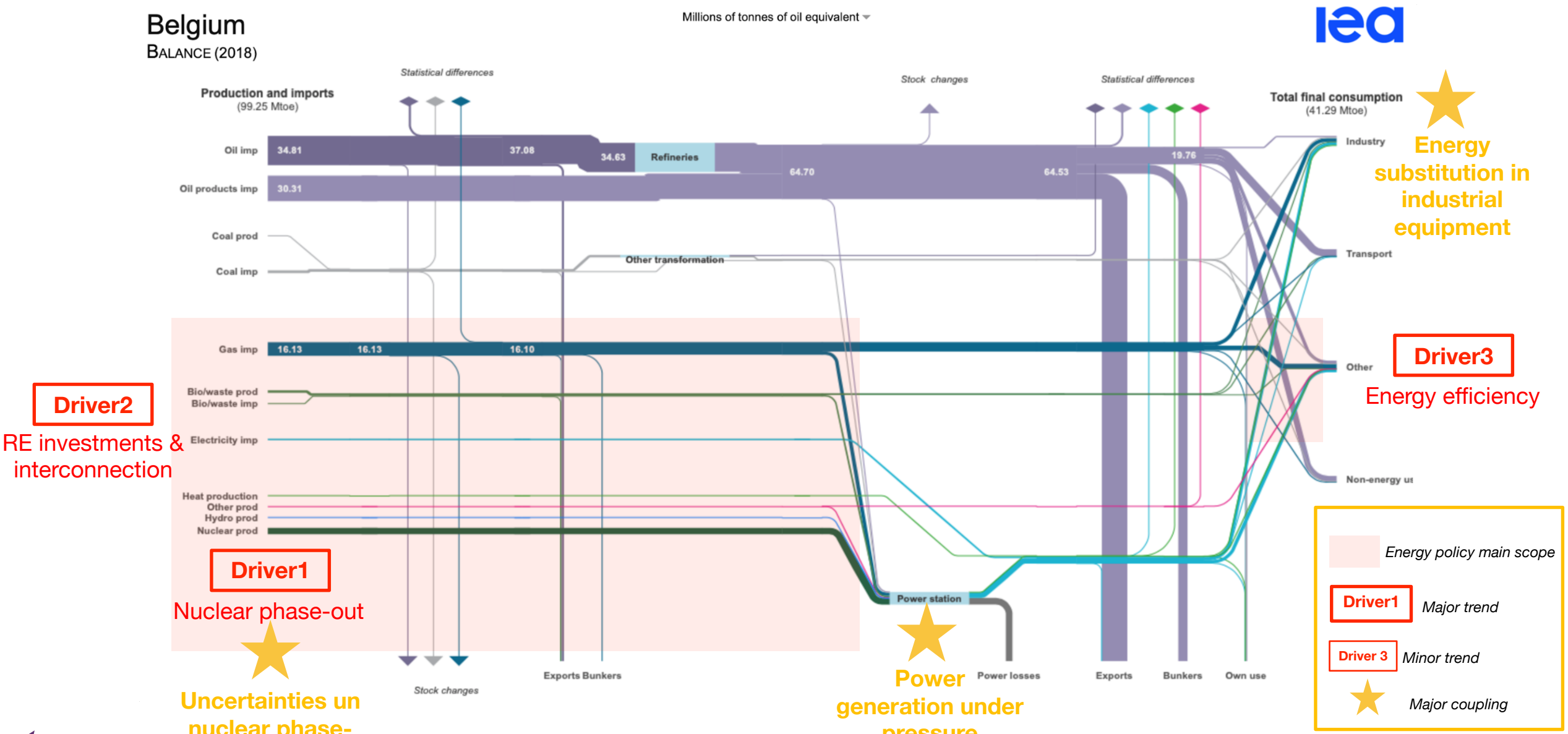
Issue2: lack of RE resources

- Flat country with no hydro resources and poor solar capacities
- Offshore wind is the main component of RE capacity
- RE saturation
- *Weight on total supply: 2.7% (2.77Mtoe)*

Issue3: Energy efficiency

- Notion that relies on European Commission energy efficiency model.
- Notion that encompasses energy savings, building renovation & public sector exemplarity.

1.4 Overdependency on imports + nuclear phase-out policy oblige Belgium to secure its mix electric



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Belgium energy transition plan is limited because of the strong dependency on energy imports & lack of domestic resources. Lack of investments in RE and gas infrastructure makes nuclear phase-out complicated. A total nuclear phase-out would put the electric system under pressure.

2. Engie investments in gas-steam turbines for electricity generation show that gas will be the core of the transition in the mid-term. However, in the long-term, RE capacity should increase and lead toward a low carbon economy. Major investments in energy storage will be needed. H2 development will be an opportunity for electricity storage.

3. Cogeneration & heat networks (using gas or biomass) are likely to increase, but important investments have to be made.

Fuel, mobility & LCA policy

Concept plan for the future of mobility in Belgium**:**

« *Plan National Énergie Climat* » (PNEC) establishes a minimum percentage of biofuels by 2030: **14%** (7% of 1st generation biofuels, 7% of advanced biofuels), mainly biodiesel.

 It follows EU policy for mobility

Promotion of electric mobility & slow mobility, but yet no objectives nor policies at the federal level.

- **Flanders** wishes to deploy 30,000 charging points by 2030; between 2000-4000€ bonus for purchasing EVs (but very few purchases even with the bonus).
- **Grid operators,** such as Sibelga in Brussels, are in charge of developing charging stations

Mobility is not the priority for decarbonizing the economy.

No specific LCA regulation on mobility besides EU regulation.

Messages

Belgium follows EU directives & has some ambitious goals, but for now lacks concrete & realistic policies.

Transportation represents a major part of Belgium's economy. Being a country of transit at the core of the EU, Belgium benefits from efficient transportation infrastructures. Also, the number of personal car is rising steadily.

Transforming transportation towards a sustainable mobility is not a government priority. Comparing to bordering countries, Belgium is a latecomer in terms of electrification of mobility.

To achieve objectives in terms of GHG, governments relies on sectors such as residential & wastes. Reduction of GHG emissions from transport is likely to come around 2030.

No LCA policy in mobility

Actualized mobility BAU scenario

1. **No major shift in mobility is likely to happen in the short-term (before 2030) because of a lack of federal policy. Besides, there is no market for electric cars in Belgium.**

2. By banning polluting vehicles such as diesel vehicles, municipalities can be key for a mobility transition (Brussels, Anvers & Gand already have such policies). This will be an open gate for EVs development.

3. Biofuel share is likely to increase. Diesel is decreasing at the profit of gasoline.

Other possible energy/mobility scenarios

More probable actualized energy BAU scenario

1. Belgium energy transition plan is limited because of the strong dependency on energy imports & lack of domestic resources. Lack of investments in RE of gas infrastructure make nuclear phase-out complicated. 2 nuclear reactors will still be running waiting for alternatives

2. Engie investments in gas-steam turbines for electricity generation show that gas will be core for the transition in the mid-term. However, in the long term, RE capacity should increase and lead toward a low carbon economy. Major investments in energy storage will be needed. H2 development will be an opportunity for electricity storage.

3. Cogeneration & heat networks (using gas or biomass) are likely to increase, but important investments have to be made.

Secondary actualized energy BAU scenario

1. **Nuclear phase-out is effective by 2030.**
2. **5.9MW from nuclear have to be substituted by RE or gas for electric generation.**

- **Lack of RE capacity in the short-term. In the long-term, wind will shape the electric base, coupled with massive use of gas to avoid pressuring the electric system.**
- **Two possibilities for gas plants:**

1) Implementation of small gas plants for local consumption, no need for major investments, & ***easily closable***	2) Major investments in big gas-steam turbine for a central production & distribution. ***Long term investments***
- *Could enable a transition towards RE for power generation in the longer term* - *Heating networks & cogeneration is an opportunity*	- *Long term investment will compromise feasibility of GHG objectives* - *Ensure energy security & power generation* - *On a longer term, possibility to use infrastructure for H2 storage & transportation*

Other scenario for mobility

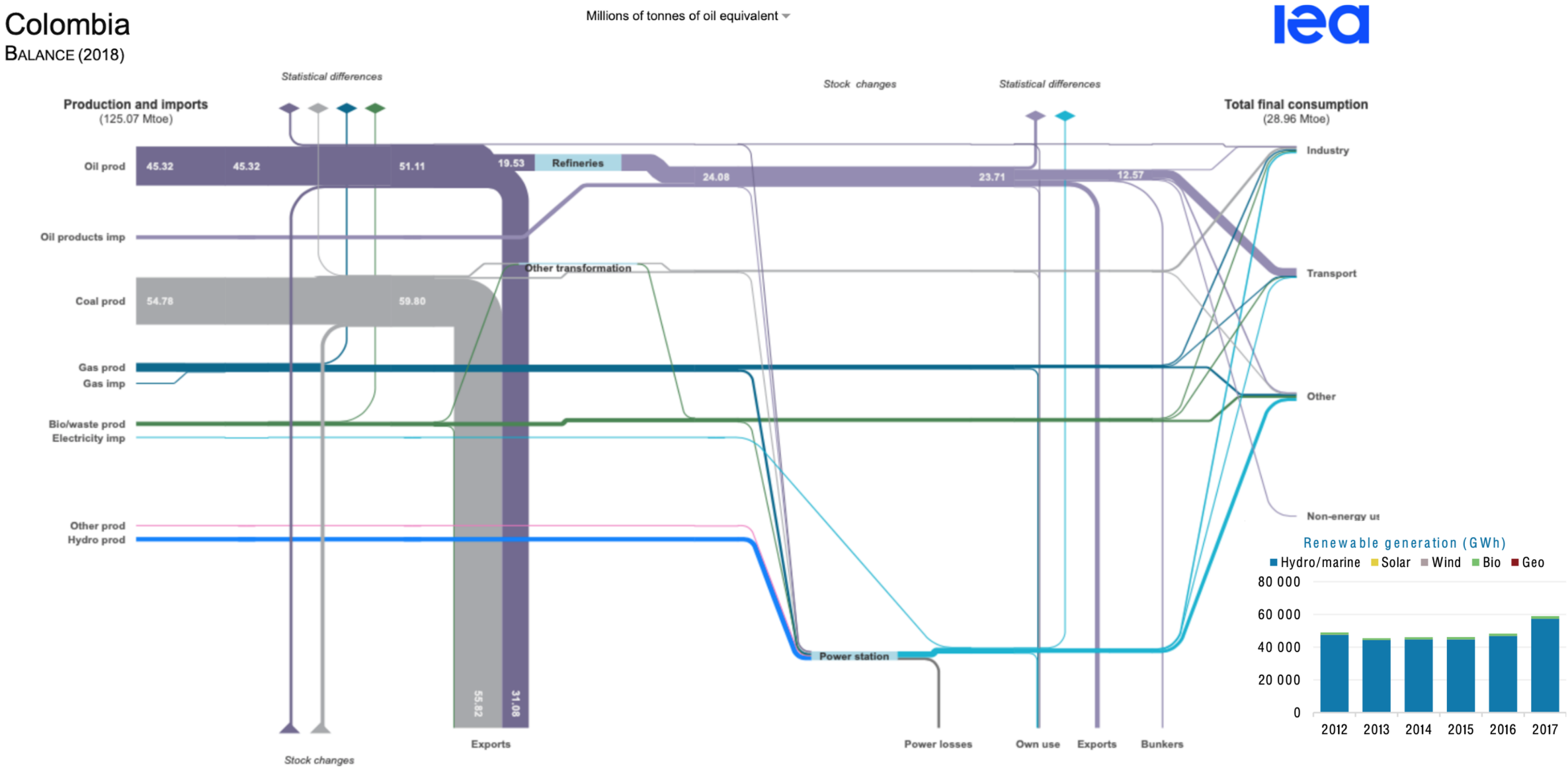
1) EU pushes forward the electrification of mobility:

- ***Integration of electrification in the PNEC***
- ***Implementation of more efficient subsidies*** for EVs from the federal government and from the regions.
- ***Grid operators*** invest massively on charging points
- Creation of a possible ***EVs market***
- Municipalities will be the first to shift toward electric vehicles

2) Industry leading the electrification of mobility:

- Industry will rely on public transport in cities that banned ICE
- Charging points will increase in & between cities with an active role of grid operators
- Efficient subsidies for EVs personal car market development

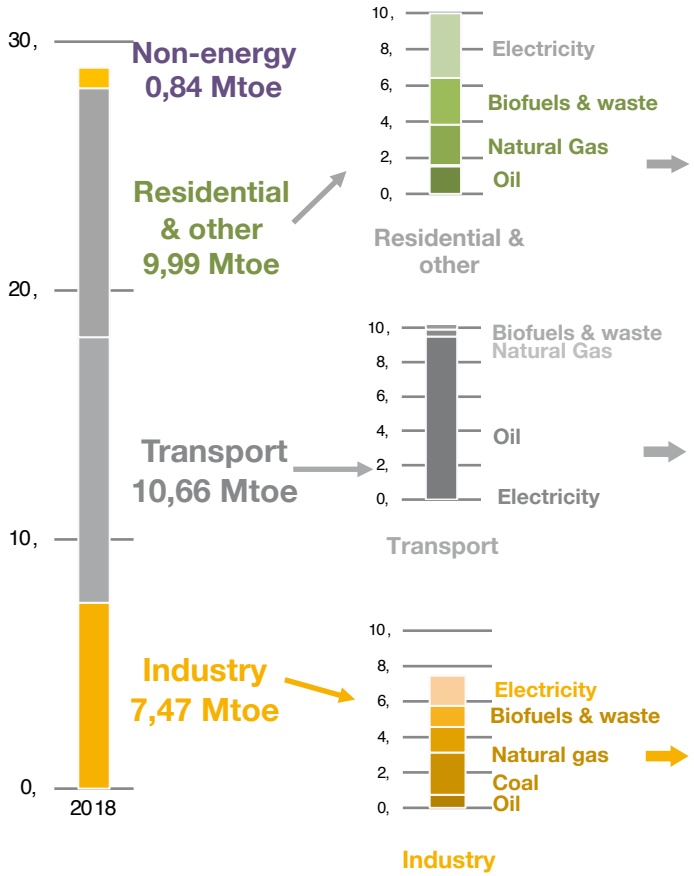
1.1 Energy system picture : key system realities



Colombia is highly dependent on oil and coal exports. Consumption relies on domestic gas and biomass production. Electricity generation is dominated by hydro.

1.2 System inertias & policy drivers

Colombia final energy consumption 2018 : 28,96 Mtoe



Inertias
(by sectors)

Inertia1: electricity and biofuels duality

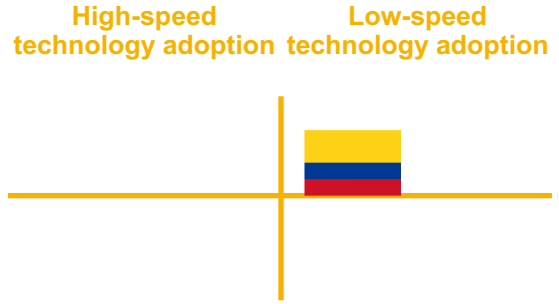
- Residential: 61,6% (6,16Mtoe)
  - Biofuels (40%), Electricity (34%), gas (18%), oil (7%)
- Commerce & public: 16,5% (1,65Mtoe)
  - **Electricity (69%),** gas (23%), oil (8%)
- Agriculture: (2.4Mtoe) Oil **(**36%), **biofuels (36%), electricity (28%)**

Inertia2: biofuel saturation

- Road : 88% (9,44Mtoe)
  - Oil (89%), **biofuels (7%), gas (4%)**
- Domestic aviation (0,02 Mtoe)

Inertia3: coal equipment dominance

- Food and tobacco: 27% (2,02 Mtoe)
  - **Biofuels (48%), coal (19%)**, electricity (15%), gas (14%)
- Non-metallic minerals: 17,2% (2.8 Mtoe)
  - **Coal (63%),** gas (20%), electricity (14%)
- Iron and Steel: 12% (0,91 Mtoe)
  - **Coal (49%),** gas (26%), electricity (23%)



Policy drivers
(on energy and/or sector)

Objectives : reduce GHG emissions by between 20% and 30% in 2030 in relation to 2020, electrification of transport
Our view: economic development and prosperity priorities, hence unstructured objectives for energy transition
Timeframe : 2030-2050
Governance type : government, industry-led

Driver 1: Reactivation of hydrocarbon sector

- Weight on total supply: 88% (110.33 Mtoe)
- Objectives: new partnerships to secure exploitation and increase oil exports
- Specific private and public partners will be key for hydrocarbon development

Driver 2: Mobility transformation

- Weight on total use: 36.8% (10.66 Mtoe)
- Objectives: electrification of mobility from 2025, between 15% and 27% of electric personal cars by 2050
- Automotive industry and action from the government through sales quotas will be key for mobility transformation

Driver 3: RE investments

- Weight on total supply: 8% (10.12 Mtoe),
- Objectives: from 1% to 12% of RE (without hydro) in the electric mix in 4 years & maintaining a high electricity production from hydro (52% of the electric mix in 2018).

Minor driver 4: Energy intensity

- Total share mix concerned: 29% (38 Mtoe)
- Objectives: increase GDP with less energy used

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)	Coupling (dynamics on energy-to-energy, energy-to-use and use-to-use)
Residential - Inertia1 : hydroelectricity and biofuels duality	**Energy intensity** **RE investments**	**Coupling1: electricity generation greening in relative share** • *Electricity generation will rise and rely on hydro and RE investments* • *Solar and wind will relieve pressure on hydro production* • *Weight on total use: 3.58Mtoe (19.7%)*
Transport – Inertia2 : biofuel share is high	**Electrification of transport** **Sustainable car fleet**	**Coupling2: growth in usage will rely on electrification** • *Share of electricity (5.32 Mtoe) will rise while use of oil (12.56 Mtoe) and natural gas (4.08) will remain high* • *Weight on total use: 9.48 Mtoe (88%)*
Industry- Inertia4 : coal equipment dominance	**Reactivation of hydrocarbon sector** **RE investments** **Energy intensity**	**Coupling3: final consumption and demand for energy will rise but uncertainty remains** • *Political necessity to face poverty and give access to energy and consumption to everybody* • *Urban population will rise*

Structuring issues

Issue1: RE electricity growth

- *Weight on total energy supply: 55% (5.53 Mtoe)*
- Diversification of electricity supply through RE investments
- Sectors concerned: industry, mobility, residential and other

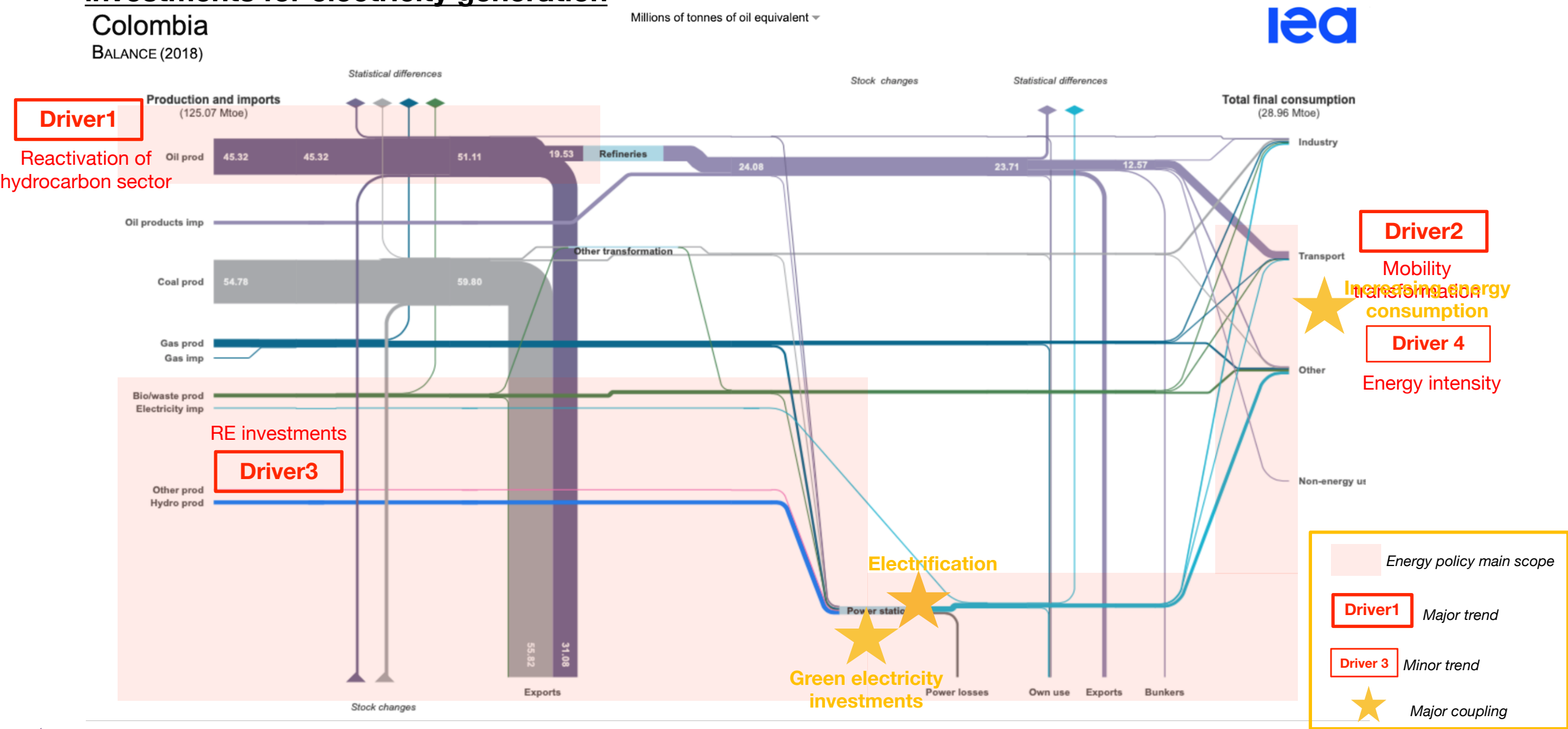
Issue2: Mobility is key to face social issues

- *Weight on total use: 35.5% (10.66 Mtoe)*
- Mobility is key to social inclusion and demographic issues
- Necessity to invest in public transports

Issue3: Demographic dynamics toward livability

- Urban population will keep increasing
- Necessity to rethink urbanity through livability
- Sustainable urban mobility

1.4 Colombia energy transition relies on an ambitious mobility transformation and RE investments for electricity generation



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Colombia is the most South-American advanced country in its energy transition. Infrastructures for greening electrification are being implemented efficiently.

2. Transformation of mobility is a core strategy for energy transition. Electrification of transport will rely on RE and coal generation.

3. A stable economic growth will increase RE share in the energy mix and decrease coal share in the electric generation. **Uncertainties remains regarding economic growth** for the next decade.

Fuel, mobility & LCA policy

Concept plan for the future of mobility in Colombia - 2020

Principles based approach among which:

- Public transport vehicles: 10% of new public vehicles will be electric by 2025 & 100% in 2035 (***law n°1964, July 11, 2019***)
- Construction of a subway in Bogota

Definition of zero & low emission fuels:

Zero emission fuels: electricity/H2

Low emission fuels: Natural Gas, Liquid petroleum gas, Gasoline, Mixture of petrol with fuel alcohol, Diesel, Diesel-biodiesel mixture, ***all with a maximum sulphur content of 50ppm***

- **Biofuels blending** for freight vehicles, freight transport & mass transit system will be key for a transition toward electricity.
- **Hydrogen** potential will be explored.

Messages

Transforming urban mobility towards sustainability should have a consequent impact on air quality in cities.

Following developed countries in the electrification of mobility & leading South-America mobility transformation.

Mobility is key for social integration & economic development of rural areas.

Actualized mobility BAU scenario

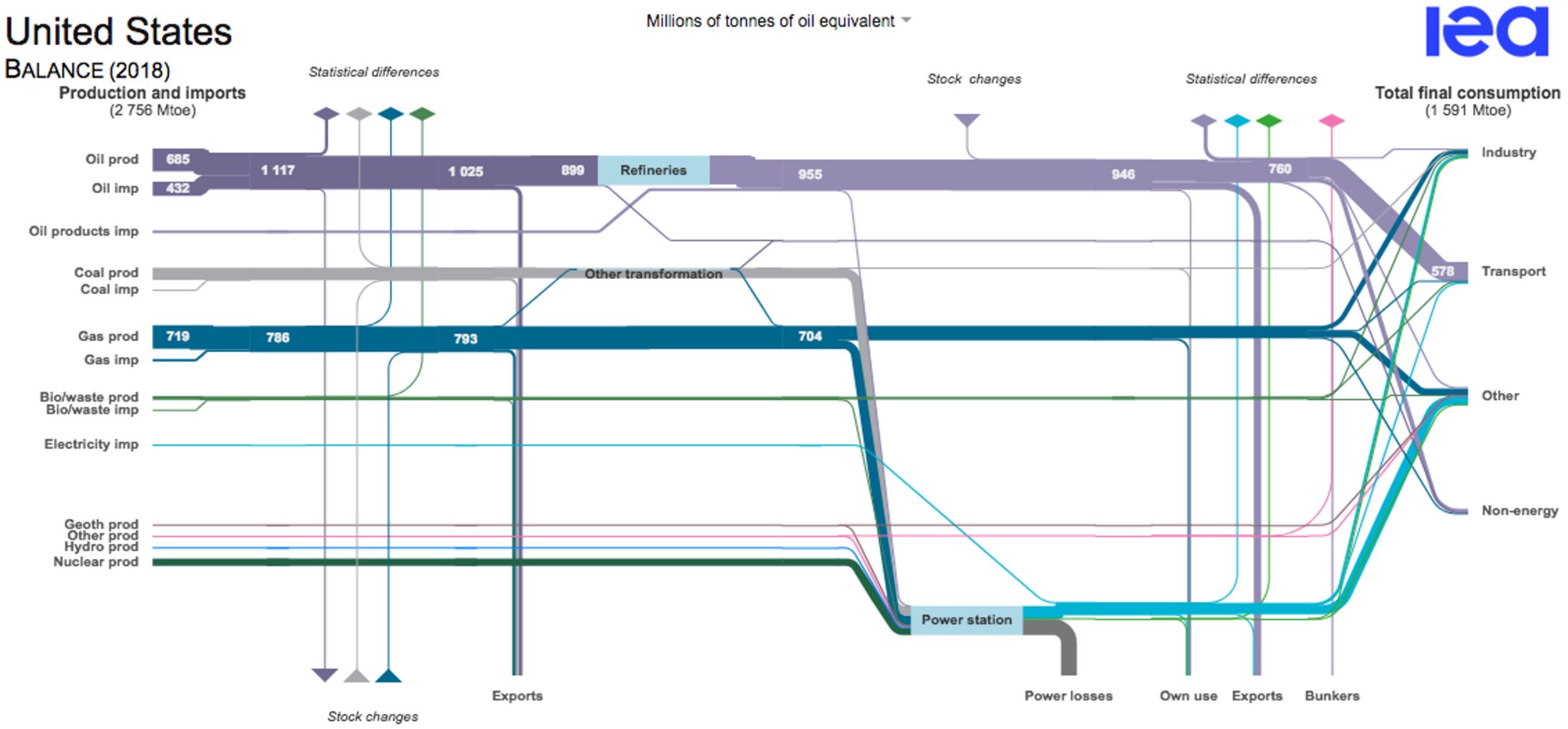
1. Colombia has developed a strong mobility transformation strategy as the core of its energy transition pathway.

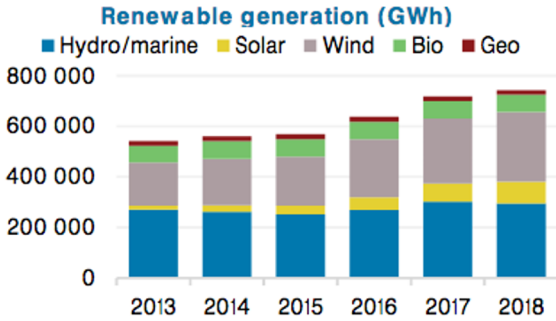
2. Electrification of mobility will rely in a first instance on **urban mobility via public transportation & taxis**. Diesel & gasoline will remain major fuels for personal vehicles at least until 2050. Restrictions in cities for diesel & gasoline passenger vehicles will be implemented.

3. For cargo transport, natural gas is likely to substitute or at least compete with diesel.

1.1 Energy system picture : key system realities

https://www.iea.org/sankey/#?c=United%20States&s=Balance

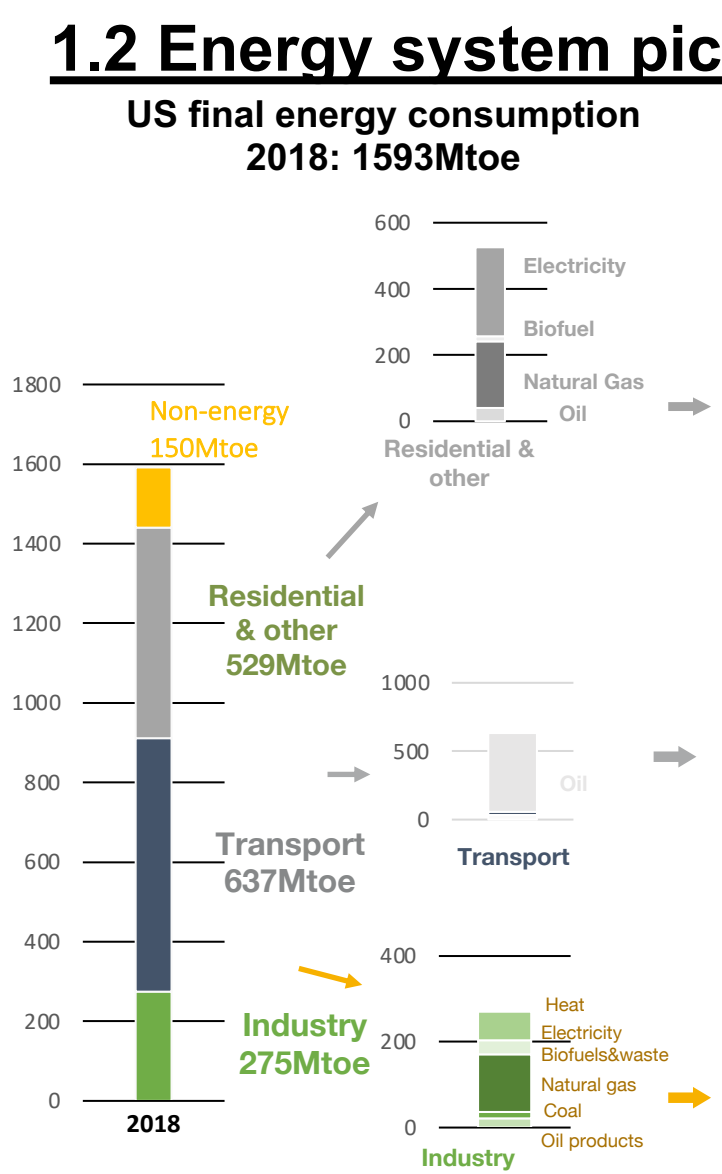




Electric generation from renewables (Irena 2018 data, GWh)
https://www.irena.org/Statistics/Statistical-Profiles

The US' energy mix relies on oil, gas & coal production & oil Imports. Coal, gas and oil each represents roughly 1/3 of the electric mix. RE production is increasing but still marginal (+60% in 6 years).

1.2 Energy system picture : final uses analysis



Inertias
(by sectors)

Inertia1 : electricity dominates
Inertia2: gas share is high overall (38%)

- Residential: 51% (271Mtoe)
  - Electricity (46%), gas (43%), oil products (6%), biofuels (4%)
- Commerce & public: 41% (217Mtoe)
  - **Electricity (54%), gas** (38%), oil products (5%)
- Agriculture: 3,8% (20Mtoe)
- **Oil(70%),** electricity (20%), gas (5%),

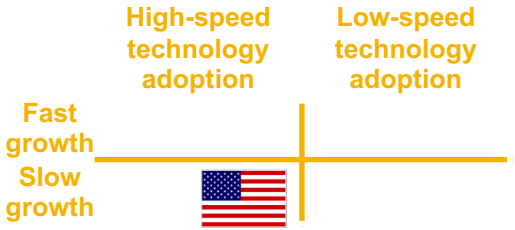
Inertia3 : oil dependent

- Road : 84% (535 Mtoe)
  - Oil (93%), **biofuels (7%)**

Inertia4 :gas dependence (48%)

- Chemical & petrochemical: 27% (73Mtoe)
  - **Gas (77%),** electricity (14%), heat (4%)
- Iron & Steel: 6,6% (18Mtoe)
  - **gas (50%),** electricity (28%), coal (22%)
- Non-metallic minerals: 6,6% (18Mtoe)
- **gas (50%),** coal (28%), electricity (17%)

Policy drivers
(on energy and/or sector)



Objectives : Paris Agreement : reducing GHG emissions by 26% to 28% from 2005 to 2025 (in 2019, were 13% below 2005 levels, 7points below 2020's goal) => NDC has to be re-determined following US' reintegration of the Paris Agreement
Biden's energy plan : zero-carbon electricity by 2035, net-zero emissions by 2050.
Our view: 2015 US NCD is insufficient to limit global warming to 2°C. Moreover, Biden's plan is ambitious but appears hardly feasible. Modalities are also imprecise.
Timeframes : 2025, 2035, 2050
Governance type : federal democratic republic. 50 states. Bicameral Parliament. Powerful republican senate opposition might pose problems for climate legislations (Congress has the sole authority to pass climate change legislation)

Driver 1 : RE investments to substitues gas and coal in the power mix

Weight of gas and coal energy in the power mix : 64% (559 Mtoe)

- Biden's objective: zero carbon electricity by 2035
- Substitute gas and coal by wind, solar, hydro
- extension of federal tax credits for wind and solar power

Driver 2 : Promote regulations to incentives changes

- new greenhouse gas standards for vehicles (transportation is the first CO2 emitting sector in the US in 2018 : 28% of emissions) and major industrial sectors
- Re-instore environmental norms that were abrogated under the Trump administration

Driver 3 : Promote energy efficiency and sobriety

- upgrade four million buildings to gain efficency and reduce consumption
- Improve vehicle efficiency (allowed an 8% reduction of emissions between 2005 and 2014)

Minor driver 4 : Carbon sequestration

- Promote investments in carbon sequestration
- Develop carbon sinks : extend forests with incentives ; achieve net additions to forests' biomass

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)
Residential - Inertia1 : electricity dominates	Energy efficiency
Residential – Inertia2 : gas share is high	RE investment to substitute gas
Transport – Inertia3: oil dependency	Energy efficiency
Industry- Inertia4 : gas dependence	No driver promoted

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1 : Continue replacing coal plants by gas ones

- Coal's share in the power mix is still 34%
- More than 100 coal-fired plants have been replaced by natural gas since 2011

Coupling2 : Increase RE addition in the electricity mix

- Renewable energy only represents 6,4% in the power mix (56Mtoe)
- It seems likely that gas will keep a high share in the electricity mix al least in the middle-term

Coupling 3: industry's electrification must be promoted

- Weight of gaz in industrial energy use: 48% (133 out of 275 Mtoe) ; electricy : 24% (66 Mtoe)

Coupling 4: Inter-use competition for electricity

- Electricity already represents 21% of total energy use
- Reaching Paris agreement goals and Biden's promises imply further electrification of consumption (in transportation and industry especially)
- Might render a saturation of the power grid and competition between agents to have access to electricity
- Energy efficiency could limit these pressures on the grid

Structuring issues

Issue1 : Gas dependence in the long- term

- gas represents 38% of uses in residential and 48% in industry
- if it is useful for phasing out of coal short term, mid to long term it might pose problem and act as an inertia against electrification
- hydrogen blending in gas infrastructures could possibly be used

Issue2: Transport's oil dependence

- Weigh on total uses : 40% (578Mtoe)
- is 91% oil dependent
- electrification of transport seems a long way for cultural and economical reasons (car culture and importance of shale oil)
- electricity scarcity might come to be a problem if electrification was pursued

Issue3 : Energy efficiency to avoid electricity shortage

- electrification one of the main tool for the ecological transition, inter-use competition might emerge
- efficiency will therefore be required to match supply needs
- sectors concerned : transport and residential notably and possibly industry

ANNEX

US energy transition public policies

President Biden's ecological agenda

The political agenda around the ecological and energy transition has been very intensive since Joe Biden was elected president of the US and took office :

- he immediately re-entered the Paris Agreement
- Launched the National Climate Task force composed of Cabinet members with the purpose to facilitate a government-wide approach to fighting climate change
- Nominated John Kerry as the 1st United States Special Presidential Envoy for Climate
- He held a Leaders summit on Climat in April 2021 convening 40 world leaders.
    - The President took the occasion to announce a goal of a 50-52% reduction of GHG emissions by 2030 compared to 2005 levels.

President's Biden leaders summit on climate

- During President Biden's leaders summit on climate, Secretary of Energy Jennifer Mulhern Granholm declared that they anticipate a $23 trillion global market in the clean energy transition by 2030.
- She also announced a goal of cutting both the price of solar and of the price of battery cells in half by 2030.
- Also mentioned the objectif of reducing the cost carbon capture.

Hydrogen Energy earthshot

- launched by the US department of Energy (DoE)
- Aims to slash the cost of « clean » hydrogen by 80% to reach $1 / kg by 2030 (against $5/kg currently)
    - Anticipate it will allow for a 5 fold increase in demand
- hydrogen production could render form « renewables, nuclear and thermal conversion ».
- It establishes a framework for hydrogen development thing the American Jobs Plan (proposal by Pr Joe Biden to spend $2 trillion on U.S. infrastructure over eight years, the second part of Biden's « Build Back Better » agenda)

II) Countries where industrialization is dominant

A growing and/or structuring energy demand leads to prioritizing easily accessible primary energies, at the expense of an effort to structure investments in renewables, necessary to scale up. The issue of energy security sometimes dominates that of transition, which is often absent from public policy tools, compromising the achievement of the COP-21 objectives by the 2030 transition point.

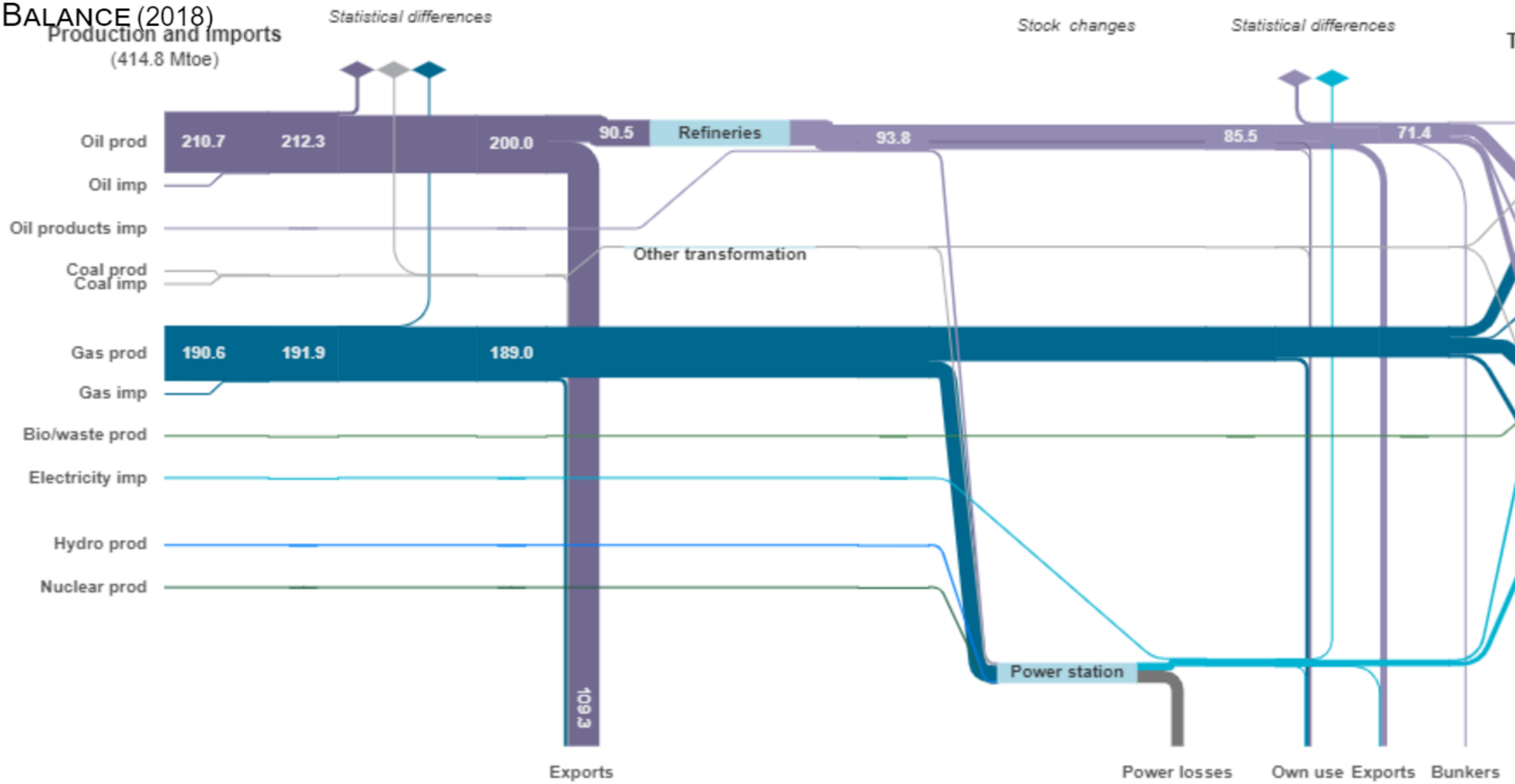
Iran, Turkey, South Africa, Russia

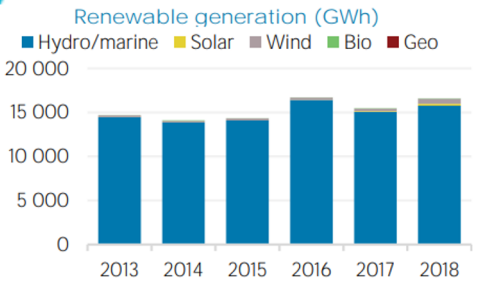
1.1 Energy system picture : key system realities

Islamic Republic of Iran

BALANCE (2018)

Millions of tonnes of oil equivalent



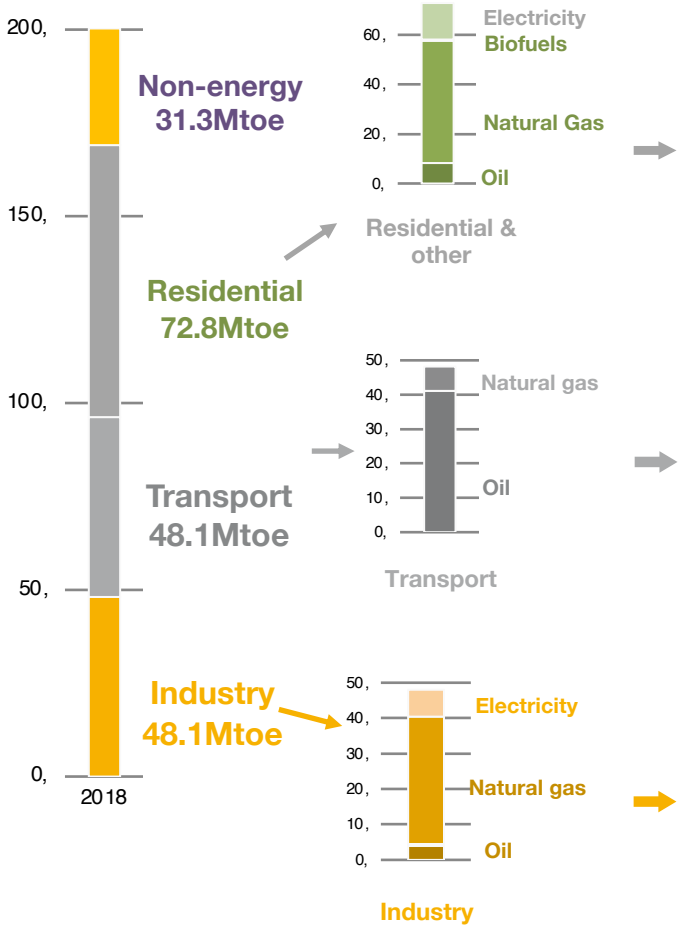


Electric generation from renewables (Irena 2017 data, GWh)

Iran's energy mix depends on its domestic production of oil and gas. RE generation is relatively stable and centred on hydro potential.

1.2 System inertias & policy drivers

Iran final energy consumption 2018: 200.2Mtoe



Inertias
(by sectors)

Inertia1: gas dominance

- Residential: 73% (53.4Mtoe)
  - Gas (77%), electricity (14%), oil (9%), biofuels (5%)
- Commerce & public: 15% (11Mtoe)
  - **Gas (57%)**, electricity (34%), oil (7%), biofuels (1.8%)
- Agriculture: (7.8Mtoe) Electricity (42%), oil (33%), **gas (24%)**

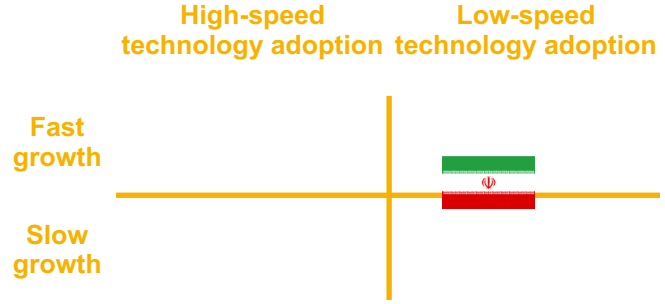
Inertia2: high share of gas

- Road : 97% (46.8Mtoe)
  - Oil (86%), **gas (14%)**

Inertia3: gas overdominance

- Chemical & petrochemical: 21% (10.1Mtoe)
  - **Gas (98%),** oil (2%)
- Non-specified: 79% (37.8Mtoe)
  - **Gas (69%), electricity (20%),** oil (10%)

Policy drivers
(on energy and/or sector)



Objectives : decrease GHG by 12% below BAU scenario by 2030
Our view: no official plan for energy transition, dispersed information
Timeframe : 2021-2050
Governance type : central government, 5 administrative regions

Driver 1: Expanding gas and oil extraction to foster exports

Weight of exports on total supply: 35% (147Mtoe)

- Objective: using less hydrocarbons for electricity production so as to free up oil & gas for exports
- Recent contracts with local contractors for raising oil production by over 180,000 b/d by 2023, drilling 165 new wells & repair of 71 existing ones
- Attracting foreign investments: China ($280bn allocated to oil, gas and petrochemicals), Europe

Driver 2 : RE & electricity development

Weight of RE on total energy supply (non-including electricity imports): 0.5% (1.9Mtoe)

- Objective: 16% of RE in final energy consumption by 2030, 80% of RE by 2050 (vs. less than 1% in 2017), among which 65% non-hydro power renewables by 2030 (solar & wind)
- Wind: 6,000 MW & hydro: 18,700 MW power plants by 2025 (vs. 98 & 10,266 MW in 2013)
- Increase total installed power-generating capacity from 74 GW to 120 GW by 2025
- Increase the share of renewables and clean power plants to at least 5% of the capacity by 2021
- Attracting foreign RE investments: China, Europe

Driver 3 : Optimisation of production & energy efficiency

Weight of residential, commercial & industrial sector on energy consumption: 56% (112.5Mtoe)

- Objective: reducing gas consumption by 9.85 million m^3 per day through central heating systems & decreasing industrial energy consumption by 1% annually through equipment renewal
- Improving power plants' efficiency (2018: 62% of energy losses during the generation process)
- Raising share of efficient combined cycle power plants with thermal efficiency of around 45% in power generation mix from 27.3% in 2015 to 54.2% in 2025

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)
Residential - Inertia1: gas dominance	**Expanding hydrocarbons** **RE development** **Energy efficiency**
Transport – Inertia2: high share of gas	**Expanding hydrocarbons** **RE development** **Energy efficiency**
Industry- Inertia3: **gas overdominance**	**Expanding hydrocarbons** **Energy efficiency** **RE development**

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1: RE addition in the electricity mix to decrease share of oil & gas for generation

- *Weight of gas & oil for electricity generation: 65.3% (68.9Mtoe)*
- *RE addition in the electricity mix, but gas & oil will remain the electricity base until RE infrastructure produce at scale*
- *More oil & gas available for exports*

Coupling2: inter-energy use substitution: hydrocarbon exports will substitute part of domestic consumption

- *Weight of oil & gas on total energy consumption: 88% (176.7Mtoe)*
- *Energy efficiency policy & increased use of RE will decrease domestic consumption of hydrocarbon*
- *In parallel, hydrocarbon production will expand*
- *The domestic reduction in hydrocarbon use will be compensated by greater oil & gas exports*

Minor coupling3: increasing electricity consumption

- *Growing demand for electricity together with economic development*
- *Growing electricity generation in coherence with the increased share of RE for power generation*
- *Potential electrification of mobility*

Structuring issues

Issue1: attractiveness of Iran's resources across the world

- *Weight of exports on total supply: 35% (147Mtoe)*
- US sanctions on Iran left space for China to step in through massive investments
- Iran is expanding its capacity for gas & oil production to prepare for the lift of the sanctions
- The oil & gas sectors still receive the most attention from European and Chinese companies
- Important foreign investments also develop in RE

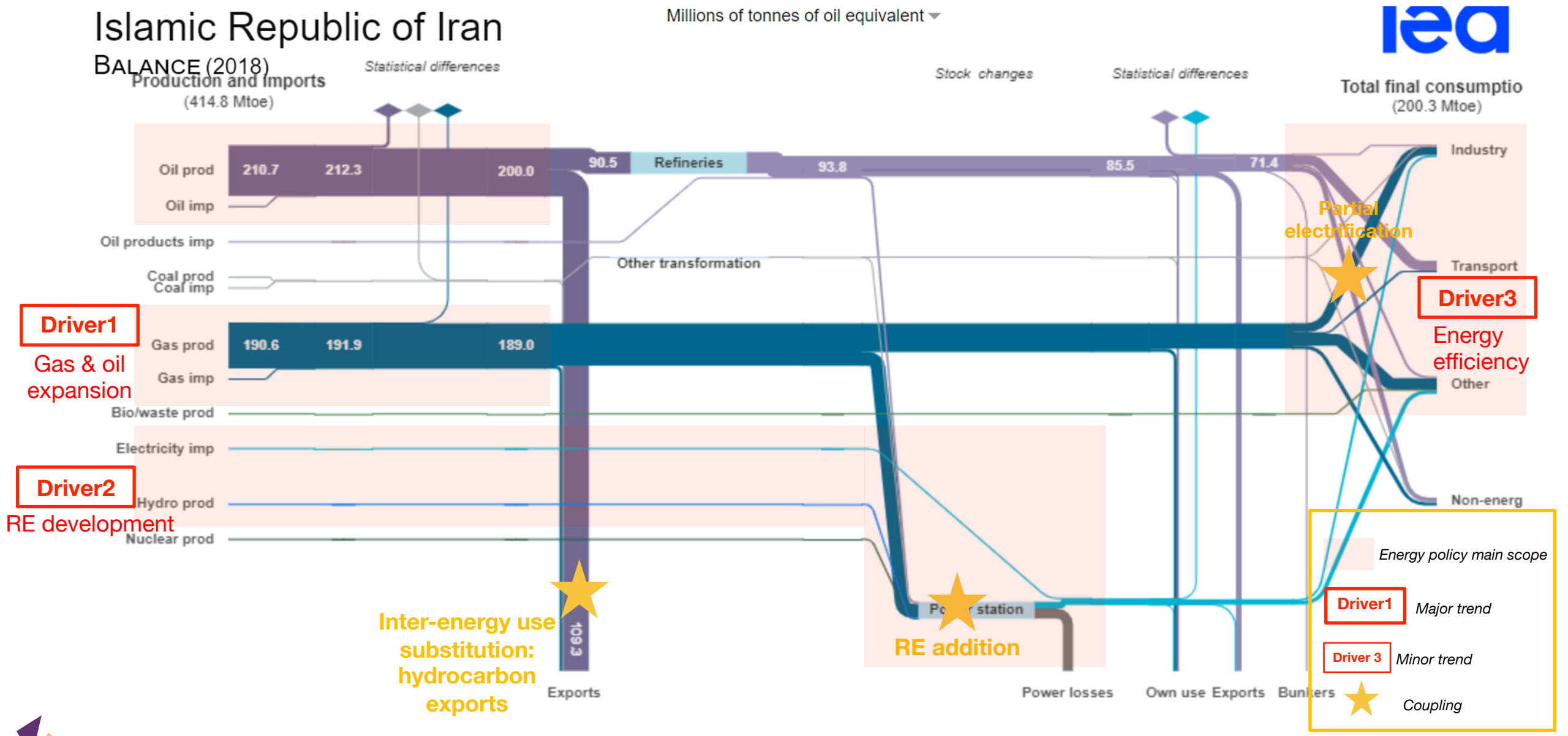
Issue2: large RE potential

- Interest in RE to reduce internal dependence on hydrocarbons & meet the projected growth in electricity demand
- Large potential in hydro, wind & solar energy
- RE development attracts major foreign investments from European & Chinese firms

Issue3: Energy efficiency

- Notion that relies on European Commission energy efficiency model
- Notion that encompasses energy savings, building renovation & public sector exemplarity
- Saving electricity for new uses
- Reduction in hydrocarbon consumption to free up oil & gas for exportations

1.4 Energy efficiency & development of RE to decrease domestic dependency on oil & gas while increasing hydrocarbon exports



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Iran's energy transition plan lacks a clear framework of action. The country relies on foreign investments to diversify its energy mix while extending exportations of gas & oil.

2. **Increasing absolute levels of gas in total energy supply**. 2019: Iran's Petropars and Pars Oil & Gas Company signed a $440 million deal to expand exploitation at South Pars, the world largest natural gas field (after Total's withdrawal).

3. In 2020, contracts have been signed with 13 local contractors for an **increase in oil production** by over 180,000 b/d by 2023, drilling 165 new wells & repairing 71 others.

4. Differentiated feed-in tariff & government tax incentives for the development of the RE sector will account for an **increasing relative share of RE in the electricity mix**. This will go through such investments as Chinese Sinosteel's $2.5 bn deal to build a 1 GW solar park together with Italian Denikon.

5. Among China's recent pledge of $400bn invested over 25 years, $120bn will be invested in upgrading Iran's transport and manufacturing infrastructure. This will contribute to the country's **electrification to support its economic development**.

Fuel, mobility & LCA policy

Promoting CNG instead of gasoline

- 2019: memorandum of understanding to add 1.46 million dual-fuel vehicles in public transportation: city bus, freight & taxi fleets
- Rationing of subsidized gasoline

Potential electrification of mobility, but lack of effective policy for now.

Development of railways:

- €2.2bn deal with China National Machinery Import and Export Corporation (CMC) to electrify a 926-km railway & raise the speed of the line to 200 km/h (2017)
- Further development of subway network in 8 metropolitans

Incentives for the development of electric vehicles:

- Objective: replacing 400,000 old gasoline-powered motorcycles by electric bikes
- "Clean AirAct (2017)": mandates ministries to work on renewing the urban public and private transport fleet
- All locally-manufactured EVs are exempted from VAT & lower import tariffs for EVs compared to traditional vehicles
- **In Tehran**: Offering of loans for electric motorcycles & EVs are exempt from traffic restrictions in the central parts of the city.

Mobility is not the priority for decarbonizing the economy.

Messages

Iran sees major investments likely to modify its energy mix in the near future, but the country lacks a clear energy transition plan.

To reduce GHG emissions, the government focuses on energy efficiency policies and shift to RE to respond to a growing demand for electricity.

As Iran is still developing, the number of personal cars is rising steadily. While the share of gas in transportation will keep increasing, the country has more difficulty shifting to an electric mobility.

Transforming transportation towards a sustainable mobility is not a government priority. Some plans have been announced but remain largely ineffective for now.

No LCA policy in mobility

Actualized mobility BAU scenario

1. **No major shift in mobility is likely to happen in the short-term (before 2030) because of a lack of effective policy.**

2. Share of gas is high and is likely to increase, notably in public transportation and for HDVs (bus, freight).

3. Some policies seem to have been more effective when it came from the municipality level. By offering some privileges to owners of electric vehicles, municipalities can foster the demand for personal EVs, as well as slow mobility & public transportation (Tehran & Esfahan already have such policies).

4. Railways will continue to develop and substitute for a minor part of LDVs & HDVs in the mid to long-term.

Other possible energy/mobility scenario

Actualized energy BAU scenario

1. Iran's energy transition plan lacks a clear framework of action. The country relies on foreign investments to diversify its energy mix while extending exportations of gas & oil.

2. **Increasing absolute levels of gas in total energy supply**. In 2017, Iran signed a $4.8 bn deal with a consortium led by Total to develop South Pars, the largest natural gas field in the world.

3. In 2020, contracts have been signed with 13 local contractors for an **increase in oil production** by over 180,000 b/d by 2023, drilling 165 new wells & repairing 71 others.

4. Differentiated feed-in tariff & government tax incentives for the development of the RE sector will account for an **increasing relative share of RE in the electricity mix**. This will go through such investments as Norway's Saga Energy $2.9bn deal to build a 2GW solar power plant by 2022, or Chinese Sinosteel's $2.5 bn in a 1 GW solar park.

5. Among China's recent pledge of $400bn invested over 25 years, $120bn will be invested in upgrading Iran's transport and manufacturing infrastructure. This will contribute to the country's **electrification to support development**.

Alternative energy BAU scenario

1. US sanctions remain and/or new UN sanctions are imposed:
In September 2019, a U.S. official stated that the United States will sanction whoever deals with Iran or purchases its oil.
- Given current local & Chinese investments, growing amounts of oil will still be produced
- This oil will be sold to Iran's allies (Arab neighbors, China, Russia)
- However, the price of oil will drop, thus selling abroad will not be at their advantage anymore
- More oil will be sold and used domestically, postponing both RE development & GHG emissions reduction

2. Central government's decision to radically electrify transportation:
- Electrification of transport through green sources will pioneer and encourage the electrification of other uses (residential, industry)
- Rapidly decreasing domestic use of gas & oil, increasing amounts of exports

Actualized mobility scenario

1. **No major shift in mobility is likely to happen on the short term (before 2030) because of a lack of effective policy.**

2. Some policies seem to have been more effective when it came from the municipality level. By offering some privileges to owners of electric vehicles, municipalities can foster the demand for personal EVs, as well as slow mobility & public transportation (Tehran & Esfahan already have such policies).

3. Railways will continue to develop and substitute for a minor part of LDVs & HDVs in the mid to long-term.

4. Share of gas is high and is likely to increase, notably in public transportation and HDVs (bus, freight).

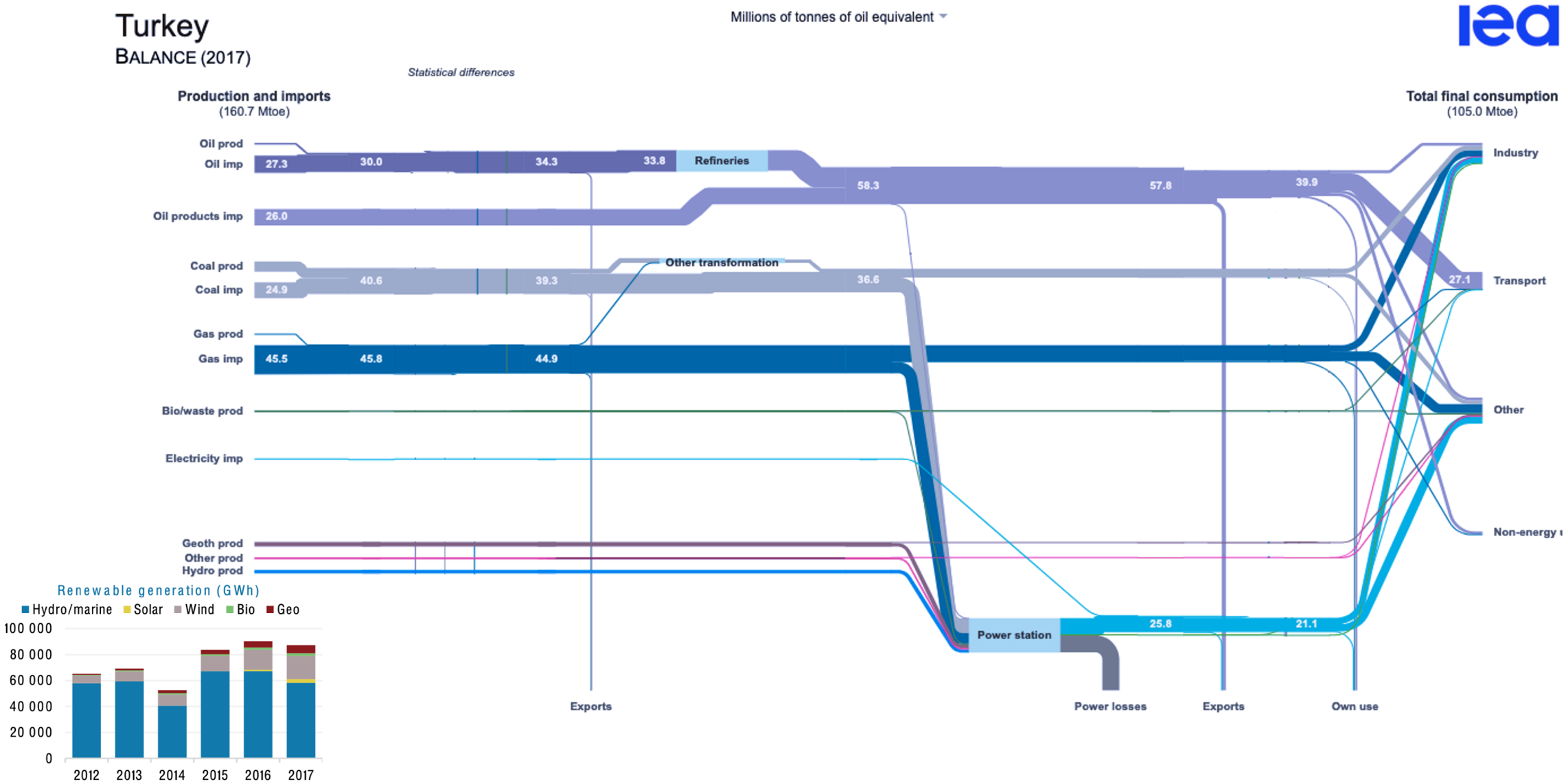
Alternative mobility scenario

1. US sanctions remain and/or new UN sanctions are imposed:
- No push from the government level to move away from oil in transportation
- Oil & gas will remain the basis in transportation, postponing the development of electric mobility

March-December 2017: HEVs only represented 0.05% of total car imports

2. Central government's decision to radically electrify transportation:
- To avoid increasing the share of oil & gas to respond to this growing demand for electricity, an ambitious RE development program will have to be implemented
- Public vehicles (buses, taxis) will be electrified first, resulting from government's directives, followed by private LDVs & HDVs

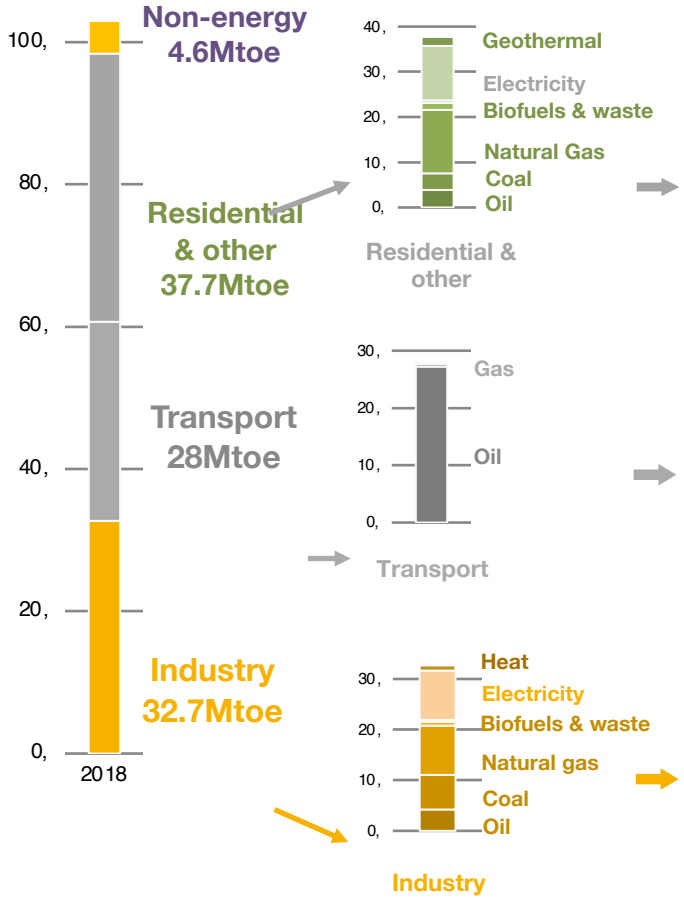
1.1 Energy system picture : key system realities



Balanced fossil mix relies on imports. Geothermal energy seems high in relative share as compared to other countries. Oil is dedicated to transport.

1.2 System inertias & policy drivers

Turkey final energy consumption 2018: 103Mtoe



Inertias
(by sectors)

Inertia1: electricity and gas duality

- Residential: 54% (20.6Mtoe)
  - Gas (51%), **Electricity (23%)**, coal (8%), biofuels (8%), **geothermal (6%)**
- Commerce & public: 33% (12.6Mtoe)
  - **Electricity (52%), gas (26%),** coal (16%), oil (6%)
- Agriculture: (4.3Mtoe) Oil (65%), **electricity (19%), geothermal (14%)**

Inertia2: oil dependency

- Road : 92% (25.8Mtoe)
  - **Oil (99%),** biofuels (0.6%), gas (0.5%)

Inertia3: coal/gas/electricity equipment competition

- Non-metallic minerals: 29% (9.5Mtoe)
  - **Oil (40%), coal (25%)**, biofuels (6%), gas (18%), electricity (13%)
- Non-specified: 16% (5.2Mtoe)
  - **Gas (35%), electricity (33%),** heat (19%), RE (6%), coal (4%)
- Iron & Steel: 15% (5Mtoe)
  - **Coal (32%),** gas (24%), electricity (21%)

Policy drivers
(on energy and/or sector)

Objectives: decrease primary energy consumption by 14% by 2030
Our view: unstructured energy transition through energy security policies, no long-term strategies
Timeframe: 2023, centenary of the Republic
Governance type: government, industry-led

Driver 1: Energy security issues

- Weight on total supply: 74.1% (115.3Mtoe)
- Short-term objectives: reduce dependence on hydrocarbon imports from Russia, Iran and Iraq (for crude oil) as geopolitical risks increase in the region; decrease trade deficit caused by fossil imports by limiting the depreciation of the Turkish lira
- Long-term objectives: Subsidies & investments in conventional coal power; first nuclear plant under construction since 2018 + 2 nuclear plant projects

Driver 2: Detailed plan for energy efficiency

- Objectives: cross sectors policy to reduce energy consumption, **National Energy Efficiency Action Plan** to restructure all industry around energy efficiency
- New compatible regulation with the EU Energy Efficiency Directive

Driver 3: RE investments

Weight on total supply: 13% (20.4Mtoe)

- Objectives: increase RE share in the electricity mix to ensure national energy security 2/3 of RE in the electricity mix by 2023
- 1 GW off-shore wind project; 10 GW of RE over the next 10 years
- Yet no real plan that promotes RE in a long-term perspective

Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)	Coupling (dynamics on energy-to-energy, energy-to-use and use-to-use)
Residential - Inertia1: electricity and gas duality	**Energy security** **Energy efficiency** **RE investments**	**Coupling1: nuclear and RE substitution in electricity; coal & nuclear new electricity base** • *Coal (26.1Mtoe) and nuclear will substitute imported gas (14.2Mtoe) for electricity generation* • *Weight on electricity mix: 40.3Mtoe (72.6%)*
Transport – Inertia2: oil dependency	**Energy security** **Energy efficiency**	**Coupling2: inter-energy substitution for industry equipment** • *Industry equipment shift to cleaner coal equipment at the expense of gas and oil equipment* • *Weight on industry use: 20.8Mtoe (63%)*
Industry- Inertia3: electricity and gas equipment competition	**Energy security** **RE investment**	**Coupling3: decreasing prices of RE will challenge coal subsidies** • *Inter-energy competition between RE and coal for electricity generation* • *Quick payback investments in RE* • *Weight on total mix supply: 20.4Mtoe (13%)*
Industry- Inertia4: **steel-making massively electrified**	**Energy efficiency**	**Coupling4: Turkey's ambition on the international scene** • *Turkey targets Libya and Cyprus exploit fossil resources - tension in Greece territorial waters.* • *At local level, new measures and plans need to be implemented to be in phase with energy transition and international expectations*

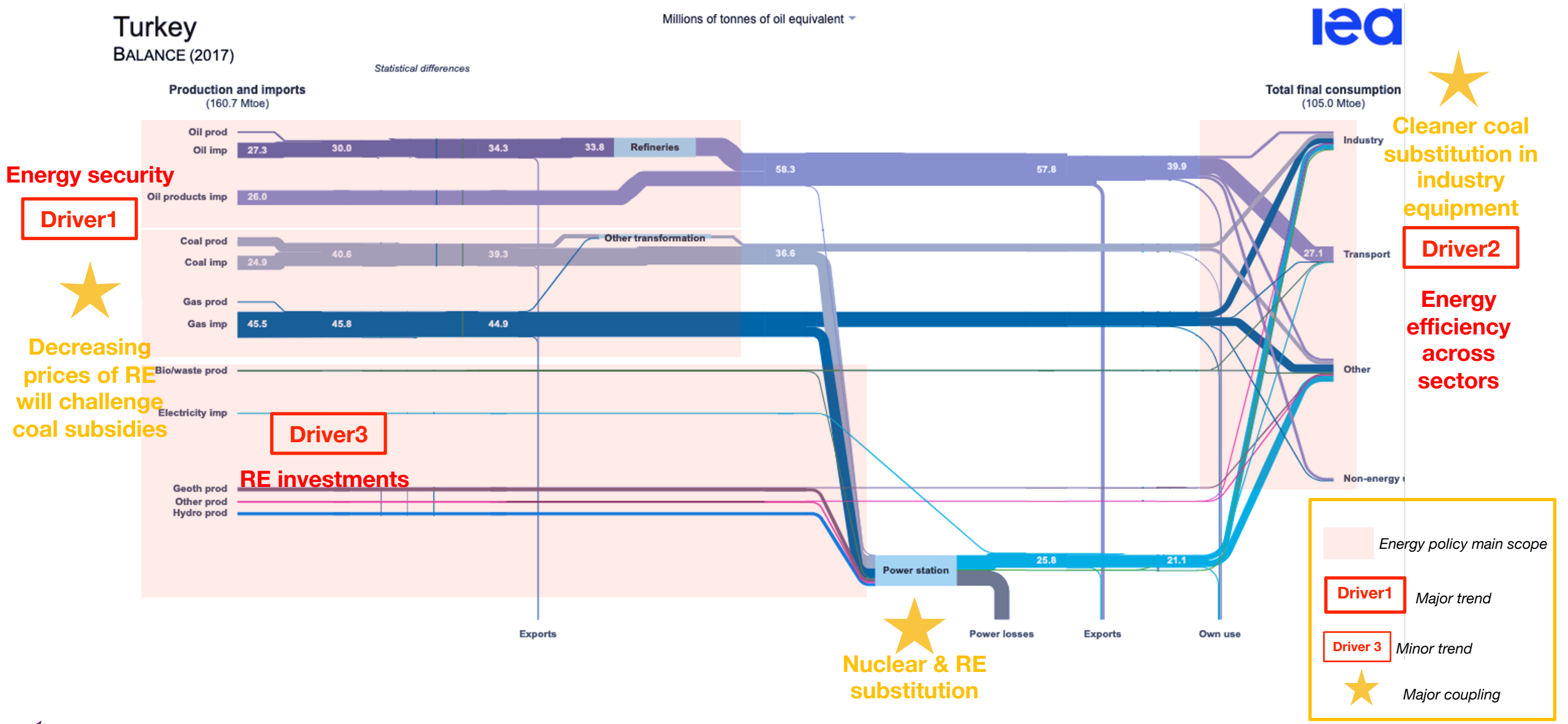
Structuring issues

Issue1: over dependency on O&G for national development
- Macroeconomic fragility & depreciation of Turkish lira increase deficit and dependency
- Relationship with bordering countries
- Oil and gas import for domestic consumption
- Fast economic growth and energy demand

Issue2: clean energy development is seen as one element of energy growth
- Lack of long-term policies
- Need a plan for energy transition and promotion of RE
- Investments on energy transportation and transmission structures are key to attract investors

Issue3: Energy efficiency
- Generic notion that encompass both energy supply and energy use
- Across sector measures
- Major policy tool

1.4 Energy security is core to Turkey international ambition & domestic development to meet growth demand. Energy transition need to be structured in longer term vision



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Turkey's energy transition is not well structured. Lack of long term policies compromises private investments in renewables or alternatives to coal and hydrocarbon importations.

2. Domestic coal investments will remain dominant to strengthen energy security and decrease gas importations used for electricity generation. Electric generation will be key as the government wants the electrification of mobility, though there is no specified national target.

3. RE share is likely to increase slowly in the energy mix. Unlicenced RE (solar) is likely to increase for self consumption in buildings and wind share will rise. Down-top development of RE through solar PV is likely to happen.

4. Cleaner coal use is likely to increase in industry.

Fuel, mobility & LCA policy

Concept plan for the future of mobility in Turkey – government and industry led for electric/hybrid mobility

Renault-Nissan dominates the automotive market (14% of the total market share in 2918). Toyota dominates the electric market with its HEV models.

Turkey's Automobile Initiative Group:

 A consortium of five Turkish industrialists who have worked with Pininfarina, to create a Turkish electric car industry.

Policy for promoting EVs (22 February 2018, ley n°30340):

- Tax subsidies in 2011 & 2016 for HEVs, BEVs, & PHEVs purchase (reduction of ÖTV a tax for EVs).
- Implementation of charging stations and electricity supply across country
- Promotion of electric public transportation

Need to integrate EVs into the power system

Messages

Energy is a major constraint of Turkey's geopolitical ambition. Turkey's covetousness in the Mediterranean, coupled with recent geopolitical tensions with the EU, represent a real economic risk for foreign investors.

Turkey needs a real plan for beyond the anniversary of the Republic in 2023. Urgent need of a long-term vision at the national level. Lack of long-term vision compromises the country's attractiveness.

Electrification of mobility will rely on increasing ownership of cars and growing middle class population.

Electric mobility is a tool to improve air quality in cities and fight against urban congestion.

Actualized mobility BAU scenario

1. **Personal cars and light vehicles are the priority target for the electrification of mobility**. Relying on public & home charging support, EVs market could be well structured by 2030. HEVs market share is likely to increase rapidly.

1. According to Shura Energy Transition Centre study, between 1 and 2.5 million EVs could be sold by 2030, representing 55% of new vehicles sales the same year & 10% of total vehicle stock.

1. No extra tax for diesel & gasoline vehicle, and lower fuel costs will maintain ICE share at a high level.

1. No policy for low emission HDVs will account for LPG and diesel dominance.

2. From a energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Turkey's energy transition is not well structured. Lack of long term policies compromises private investments in renewables or alternatives to coal and hydrocarbon importations.

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4. Cleaner coal use is likely to increase in industry.

Alternative energy BAU scenario

A national plan is set to structure Turkey's energy transition:

1) It would likely include RE long term objectives in order to exploit Turkey's high potential in renewables & position Turkey among developed countries in terms of climate change policy:

- Would accelerate the increase in the share of RE in the electric mix
- Would structure the RE market

2) Would increase visibility for foreign investors & attract new actors:

- Would allow massive investment in RE (solar & wind)

3) Coal share would decrease in the electricity mix

4) May restructure & improve the electric system & therefore allow a better integration of electric mobility in the power system.

Actualized mobility BAU scenario

1. **Personal car and light vehicles are priority target for electrification of mobility**. Relying on public & home charging support, EVs market could be well structured by 2030. HEVs market share is likely to increase rapidly.

1. According to Shura Energy Transition Center study, between 1 & 2.5m EVs could be sold by 2030, representing 55% of new vehicles sales the same year & 10% of total vehicle stock.

1. No extra tax for diesel & gasoline vehicle, and lower fuel costs will maintain ICE share at high level.

1. No policy for low emission HDV will maintain LPG and diesel dominant.

Alternative mobility BAU scenario

A national plan is set to structure Turkey's energy transition:

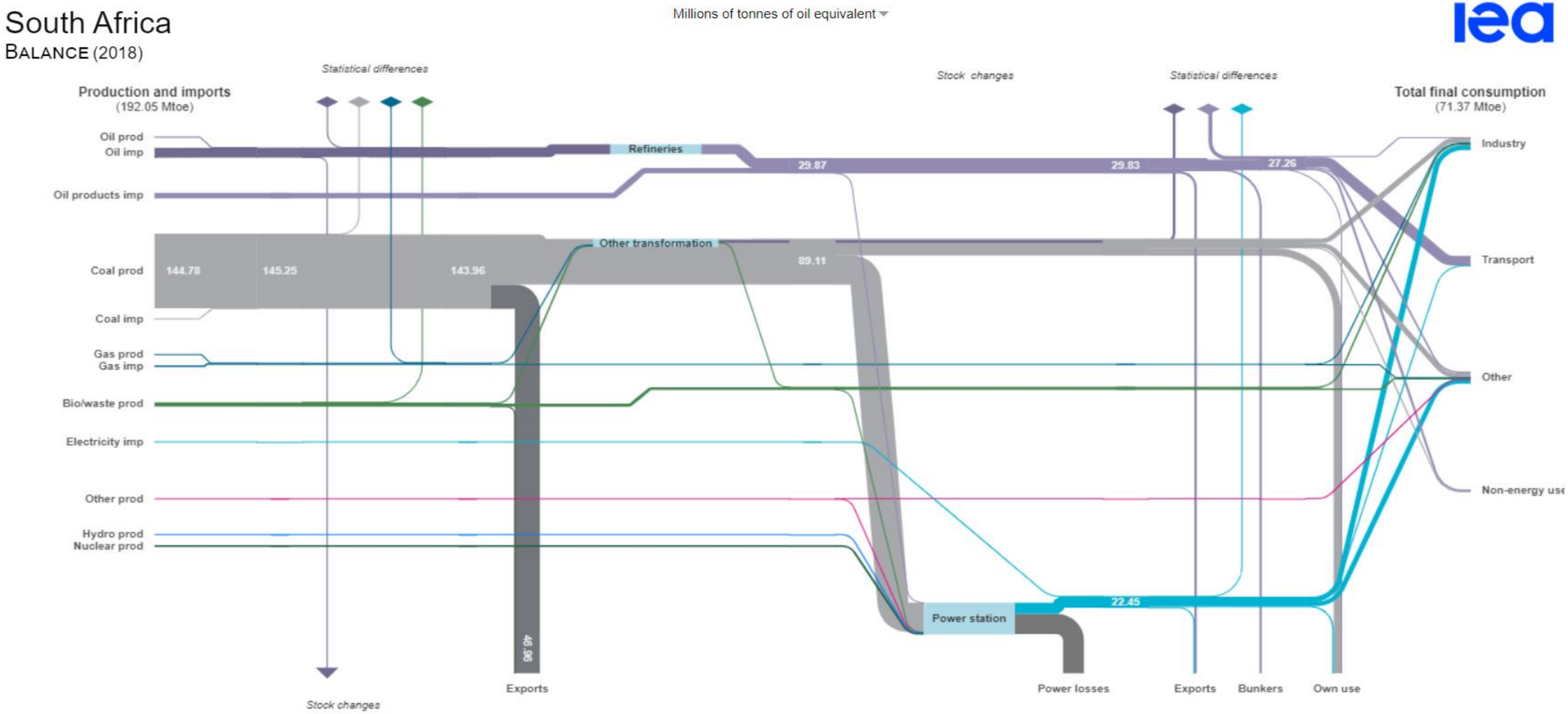
1) **Would structure Turkey's ambition for electric mobility with mid-term & long-term objectives for EVs.**

1) **Greening electricity generation would have a real impact on electric mobility and climate change mitigation.**

Mobility regulation at the local level:

1) **KPIs on cities' regulation on ICE in order to respond to air pollution & congestion issues.**
   - Would accelerate electrification of mobility in cities

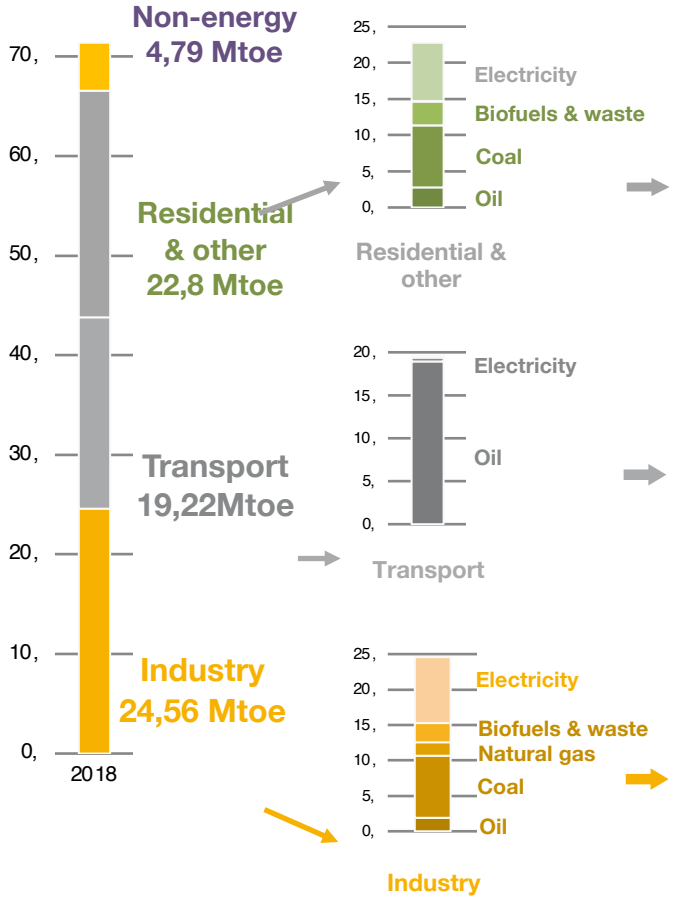
1.1 Energy system picture : key system realities



South-African energy mix is dependent on coal extraction. Coal is used across all sectors and in electricity generation. Oil is exclusively dedicated to transport.

1.2 System inertias & policy drivers

South-Africa final energy consumption 2018: 71.37 Mtoe



Inertias
(by sectors)

Inertia1: electricity & coal duality

- Residential: 58,5% (13.36 Mtoe)
  - Coal (40%), **Electricity (32%),** biofuels (24%), oil (4%)
- Commerce & public: 27% (6.1 Mtoe)
  - Electricity **(53%), coal (43%),** oil (4%)
- Agriculture: (2.19Mtoe) Oil (53%), **electricity (24%), coal (24%)**

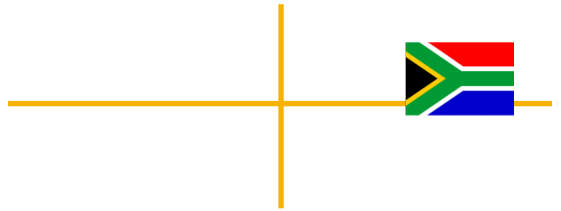
Inertia2: oil dependency

- Road : 89% (17.22 Mtoe)
  - **Oil (100%)**

Inertia3: coal & electricity equipment dominance

- Non-specified: 34% (8.43 Mtoe)
  - **Coal (37%), biofuels (31%)**, electricity (29%)
- Iron & Steel: 20% (5.02 Mtoe)
  - **Coal (62%),** electricity (33%)
- Mining & Quarrying: 16% (3.96 Mtoe)
  - Electricity (67%), oil (31%),

Policy drivers
(on energy and/or sector)



Objectives: respecting international agreements
Our view: ambitious, will need a deep industrial and political restructuration to achieve objectives
Timeframe: 2030-2050
Governance type: government, public conglomerate (Eskom), financial institutions

Driver 1: Maintaining coal consumption at a high level despite financial and social pressure

- Weight on total supply: 75% (144 Mtoe)
- Objectives: investments into a cleaner coal production for electricity generation, 2 new coal plants Medupi and Kusile
- Investors are becoming more reluctant to provide funds for new coal projects, even at national level

Driver 2: Uncertainties concerning energy transition via RE and nuclear development

- Weight on total supply: 6.4% (12.4 Mtoe)
- Decommissioning of former generation coal plants and lack of gas resources lead to an open gate for RE and nuclear investments for national energy security
- Investments in wind and solar: wind will represent 18% of electricity mix and solar 6%.
- Need to create an energy transition plan

Driver 3: Mega energy conglomerate (Eskom) segmentation will be a key factor for the transition

- A top-down pressure to restructure the energy sector and improve the relationships with new private actors and municipalities
- But Eskom remains the major investor in energy production and benefits from a long lasting political structure

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias
(by sectors)

Residential - Inertia1: coal & electricity duality

Transport – Inertia2: oil dependent

Industry- Inertia4: coal & electricity equipment dominance

Policy driver
(on energy and/or sector)

Coal consumption

Role of Eskom

Energy transition uncertainties

Coal consumption

Energy transition uncertainties

Role of Eskom

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1: grass-root RE addition to electricity mix because of economic issues
- *Off-grid electricity costs from RE is decreasing and compete fairly with coal generation*
- *Municipalities invest into off-grid electricity via PV and Independent Power Producers (IPP)*
- *Weight on total use: 1.1 Mtoe (3%)*

Coupling2: inter-energy coupling and attempt to diversify the energy mix
- *The decommissioning of a majority of coal plants creates an uncertainty on coal use from 2030 to 2050*
- *Uncertainty on coal substitution by nuclear and RE while there is no gas resources*

Coupling3: mobility & historical legacy of segregation
- *Accessibility to mobility is seen as a key factor for social inclusion*
- *Urbanisation keeps increasing in a steady way*

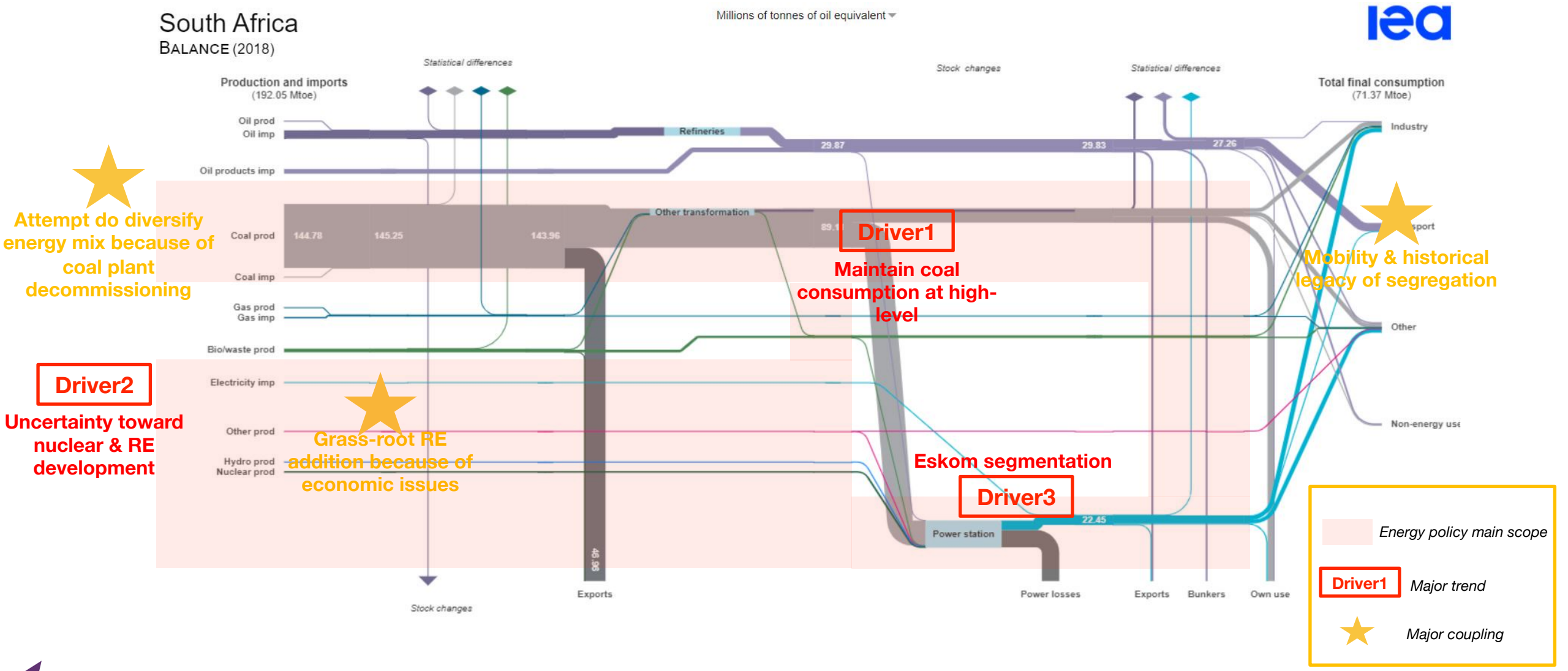
Structuring issues

Issue1: Coal system collapse
- *Weight on total energy supply: 75% (144 Mtoe)*
- At every level, today's coal system is compromised: financial, infrastructure and political issues
- International, financial and social pressure

Issue2: Energy alternative by outsourcing to border countries
- Lack of domestic resources in case of a coal phase-out
- Partnership with bordering countries will be key for gas and hydro generation

Issue3: local tensions regarding vital resources and pollution
- Drought and lack of water resources
- Quality of air is becoming a real issue while urban population is rising
- Social movements are expected to increase

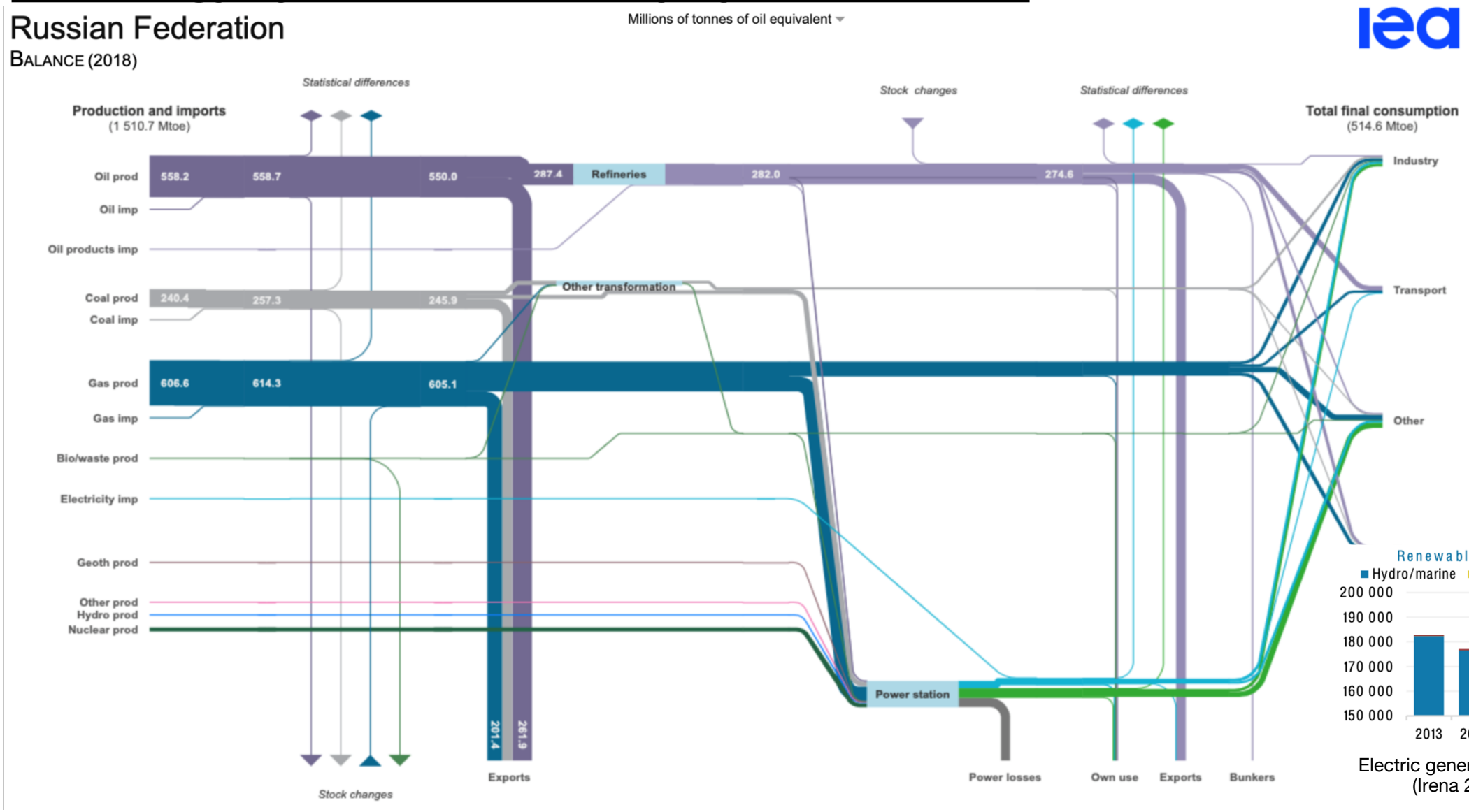
1.4 Lack of domestic resources & management issues will oblige South-Africa to re-think its energy mix composition

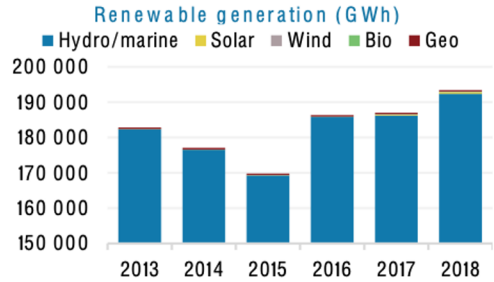


2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario	Fuel, mobility & LCA policy	Messages	Actualized mobility BAU scenario
1. Energy transition in South Africa is unstructured and assumed by prosumers and stakeholders while the government has to deal with its over-criticized coal legacy. 2. Eskom management & financial issues, combined with the need for increasing power generation capacity and decreasing prices of renewable generation will enable alternative developments such as RE or LNG. However, issues of energy security force coal to remain dominant. 3. RE's share is likely to increase in the electricity mix but will depend on the government's capacity to structure RE generation market. 4. No major shift expected in industry. 5. Mobility is not a priority for the government. No technological shift is likely to come from automotive industries.	Old policies still in place for liquid fuel use. Lack of policies for biofuels and electricity generation issues make difficult any technological shift in mobility. **Subsidies for public transport use** in cities (low cost accessibility). **Tsamaya Program (2017):** Program for Sustainable Urban Mobility : - Promotes integrated transport planning including transport demand management and green procurement of vehicles (buses, and light electric vehicles) - Provides technical assistance and capacity development to 10 cities. - Implementation of integrated public transport systems in at least 10 cities **2019: Green Transport Strategy (GST):** - Promotes the use of biofuels & EVs development. - "The vision of the GTS is to substantially reduce GHG emissions and other environmental impacts from the transport sector **by 5% by 2050**"	No real energy transition is planned at the national level but the inefficiency of the current energy system may oblige the country to invest massively in renewables. Wind & solar investment are crucial for energy security while the national coal system collapses. Mobility is not part of the government plan for energy transition. Sustainable mobility is not a priority. Mobility is important for social integration. Modern public transport could be a tool to overpass apartheid segregation legacy. Public transport development to fight congestion in cities and improve air quality.	1. No major technological shift is likely to happen in the next few years. However, urban transport is being restructured toward a more sustainable & integrated system. 1. Public transport system has shown success relying on Bus Rapid Transit (BRT) and more recently on MiniBus Taxi operators (MBT). Flexible MBT system is likely to be developed across the country. Cities and private actors are key actors to develop their own public transport network. **1. <u>Major KPI</u>**: GST implementation. It is not clear yet if the program will be efficient, impact automotive market and achieve modal shift. ***Current GST will need to be more ambitious & more targeted.***

1.1 Energy system picture : key system realities





Electric generation from renewables
(Irena 2017 data, GWh)

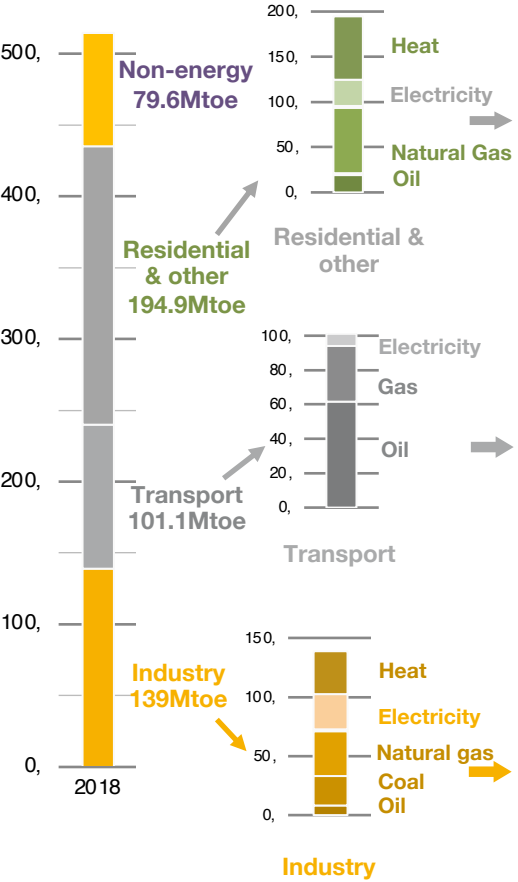
Russia is highly dependent on hydrocarbon exports. Gas, coal & nuclear are the bases of the electricity mix. RE capacity is growing since 2016 & relies mainly on hydro development but remains very low overall.

1.2 System inertias & policy drivers

High-speed technology adoption | Low-speed technology adoption

Fast growth | Slow growth

Russia final energy consumption 2018: 514.6Mtoe



Inertias
(by sectors)

Inertia1: heat & gas duality

- Residential: 76% (148.3Mtoe)
  - Gas (46%), **heat (34%),** electricity (10%), oil (9%)
- Commerce & public: 19% (37Mtoe)
  - Heat (48%), electricity **(35%),** oil (6%), gas (6%)
- Agriculture: 10%(26,1Mtoe)
- **Oil (33%), heat (32%),** electricity (18%), gas (16%)

Inertia2: oil dependency
Inertia3: gas share in pipeline transport

- Road : 51.7% (52.3 Mtoe)
  - **Oil (100%)**
- Pipeline transport: 32.3% (32.7 Mtoe)
- **Gas (94%),** electricity (6%)

Inertia4: industry energy disparities

- Iron & steel: 35% (48.6Mtoe)
  - Coal (49%), **gas (25%)**, heat (13%), electricity (11%)
- Chemical & petrochemical: 17% (24.5Mtoe)
  - **Heat (51%)**, gas (29%), electricity (17%)
- Non-metallic minerals: 9% (13.1 Mtoe)
  - Gas (65%), heat (16%), electricity (11%), coal (6%)

Policy drivers
(on energy and/or sector)

Objectives : Mitigating Russia's emissions to 70-75% by 2030 in relation to 1990 (i.e. a reduction of 30-35%); reducing the country's energy intensity by 56% in 2030.
Our view: low ambition that is easily reachable
Timeframe: Russia's Energy Strategy to 2035 (ES-2035)
Governance type: federal government, states, industry-led

Driver 1: Energy "securization" at two levels

1) Sustaining Russia's position in global energy markets

Weight on total energy supply: 93% (1405.2Mtoe)

- Sustaining export revenues: energy represents 65% of total export revenues & 25% of the country's GDP **Objectives:** increase production of primary energy by 4.8 to 7.4% by 2024 & by 8.6 to 21.2% by 2035 in comparison to 2018.
- Increasing gas share in the energy mix & exports, reducing oil share & maintaining coal share.
- Diversifying exports toward Asia (in 2015, Asia received 27% of Russian oil exports; by 2025, it is to increase up to 40%) & improve coordination with OPEC countries

2) Ensuring energy security for domestic consumers

- Interventionist pricing policy to ensure energy affordability
- Priority to give access to energy across the territory. Gas pipeline projects to connect rural areas

 Gazifikatsyia, Gazprom, in 15 years, Gazprom has invested about 395$bn of rubles (about 5$bn) in terms of infrastructures and services to give access to energy

 Power of Siberia 1 & 2, Agreement between Gazprom & CNPC, signed in 2014 for 30 years cooperation, 38 bn m3 of gas per year (1), 50bn m3 of gas (2)

Minor Driver 2: Energy efficiency

- Objective: decrease energy intensity across sectors, energy savings
- Potential of energy savings reaches 1/3 of the current energy consumption
- Equipment shift toward more efficient equipment especially in the industry sector

Minor Driver 3: Nuclear reinforcement

- Weight on the electricity mix: 15% (53.6Mtoe)
- Fostering both uranium production & current nuclear system efficiency via 3+ generation nuclear power plants
- Increase nuclear capacity with new nuclear plant projects at **Leningrad II** with 4 VVER reactors(1085MW each) & Kursk

Minor Driver 4: RE investment

- Weight on the electricity mix: 8% (21Mtoe)
- Plan of investing in hydro potential, biofuels, solar & wind at local level
- A cross-institutional reflexion on RE development that involves political spheres, universities, engineering).

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)

Policy driver (on energy and/or sector)

Coupling (dynamics on energy-to-energy, energy-to-use and use-to-use)

Structuring issues

Residential - Inertia1: heat & gas duality

Transport – Inertia2: oil dependency

Transport – Inertia3: gas share in pipeline transport

Industry- Inertia3: **industry energy disparities**

Energy security

Energy efficiency

RE investments

Energy security

Energy efficiency

Coupling1: inter-energy competition in export sector: decline of oil & increase of gas production

- *Decreasing share of oil production (558.2Mtoe) due to declining production in existing fields.*
- *Lack of means and technology to exploit new offshore oil fields.*
- *Gas pipeline + LNG exports increase.*
- *Russian gas production (606Mtoe) is demand-driven. Rebound of European gas consumption, decrease of Europe gas production & new opportunities in Asia will increase Russian gas exports.*

Coupling2: inter-energy substitution in industry because of industrial equipment modernization

- *Weight on total use: 27% (130Mtoe)*
- *Old industrial equipment shift toward more efficient equipment* (Ural region, heavy industry connected to the grid).
- *LNG + gas + electricity share in industry is to increase at the expense of old coal equipment.*

Coupling3: inter-energy addition/substitution across sectors in some regions

- *In some regions, energy shifts are impossible because of energy transmissions & prices. Old infrastructure remains dominant (Rural regions + East Siberia,* gas/electricity in the West; coal/heat in the East).
- *Create new infrastructures from nothing (very localized industry).*
- *Heat and gas competition in residential across territory.*
- *Technology transfer is compromised by distance & difficult access.*

Coupling4: RE decoupling from domestic technologies

- *Weight on total electricity generation: 8%*
- *Need of foreign technologies to develop RE infrastructures due to a lack of domestic will, formation and competitiveness*
- *Very located projects development (Rostov region)*

Issue1: Hydrocarbon-based system makes energy transition prospects difficult

- Weight on total energy output: 1510 Mtoe (93%)
- Very structured / traditional economic system based on hydrocarbon domestic resource production.
- Alternatives such as RE are not competitive enough to push forward a structured energy transition.

Issue2: The energy system is challenged by the geographic scope

- "Distance is the scourge of Russia" – Tsar Nicolas the 1st + climate
- Infrastructure inequalities & disparities across territory disparate access to innovation
- Exploration on distribution infrastructures require major investments & political framework
- O&G exports need efficient and costly pipelines pipeline saturation & lack of extent are risks for exports

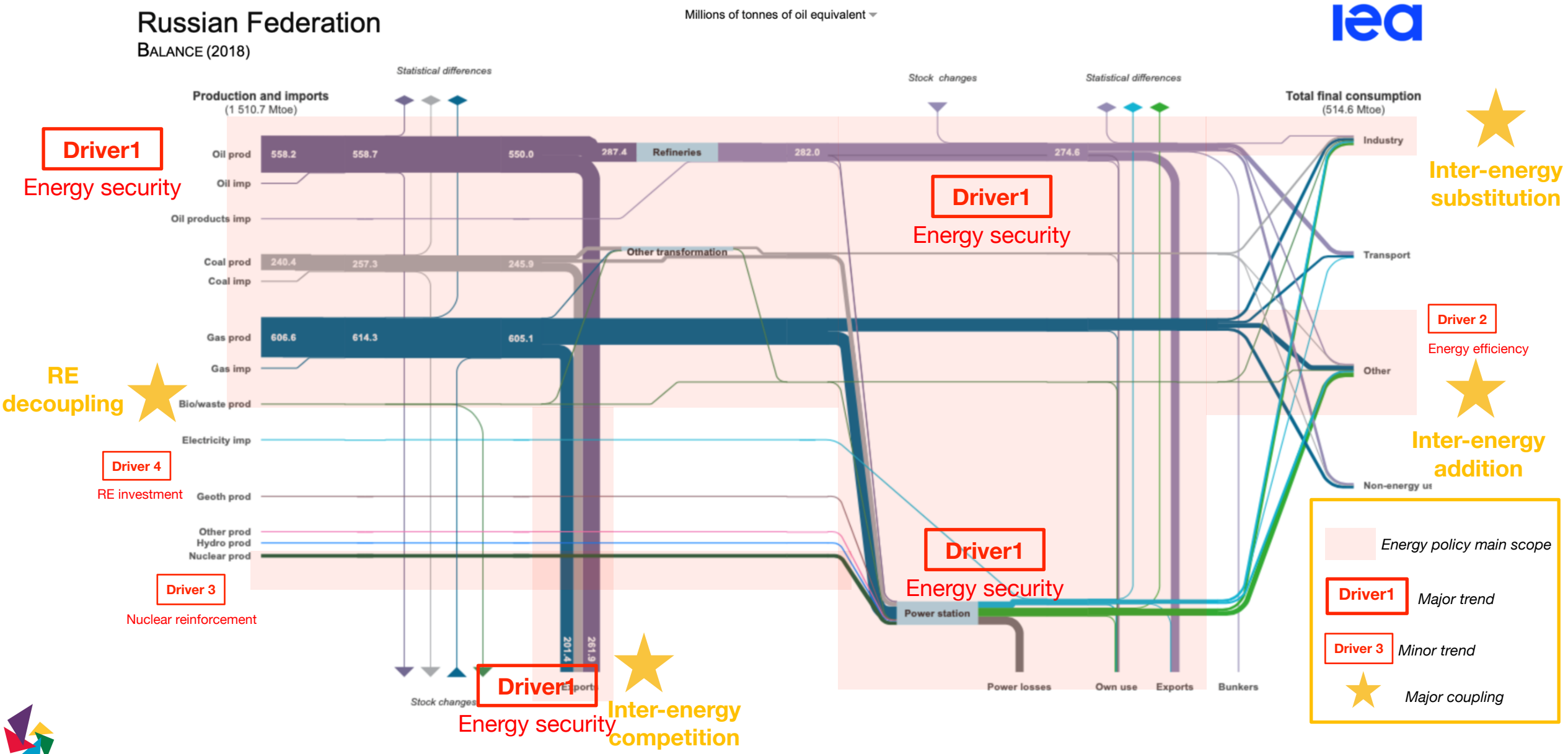
Issue3: Trade-off between modernism & nationalism

- Low penetration of foreign technologies in the energy sector
- Exploration of new O&G fields is compromised by a lack of domestic technologies.
- Russia still has 99% import dependency on the critically important equipment (hydraulic fracturing)
- Russia "rides alone" isolationism

Issue4: Federal government interventionism

- Very centralized energy system
- High level of monopolization of domestic energy market
- Reluctance toward market-mechanism-led
- State control of the system
- Oligarchy

1.4 Energy complex is a demand driven system under a strong policy control



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. **Energy transition in Russia is not a priority.** Energy security dominates Russia's energy strategy in the long-term.

2. **No major energy shift is likely to happen.** Energy efficiency could allow for better energy allocation & uses in residential & industry.

3. **Gas share in the energy mix will increase.** Gas production will increase for both domestic consumption (electricity generation + residential) & exports. LNG is particularly going to increase thanks to major investments in Artic shell from international majors (Chinese for finances & European for technologies).

4. **Oil production will decrease due to a lack of efficient subsidies & plans to foster the sector**. Domestic oil consumption will remain high but oil exports may decrease.

5. **Coal use will remain high in industry & is not likely to decrease**. Coal production will increase in certain areas (Far East) for both electricity generation & industry.

6. **The development of RE is not the priority & is at a standstill**. A well-defined state ambition as well as national & foreign investments could accelerate the exploitation of the strong RE energy potential. .

Fuel, mobility & LCA policy

1) Transport modernization development
- Improving access to mobility through major investment in infrastructures (mainly road and railway)

2) Promotion of CNG vehicles and refuelling stations
- **Gazprom Gazomotornoye Toplivo**, a special-purpose company, was set up by Gazprom to develop the natural gas vehicle (NGV) market
- **NGV Fuel Market Development Subprogram** (RUB19.29 bn = $276 mln allocated from 2020 to 2024): to multiply by 4 the use of natural gas in the transport sector & expand to 1,273 stationary methane refill stations
- Establishment of so-called NGV corridors on key existing and planned highways across Russia (M11 highway part of the Europe-China international transit route)

3) Promotion of electric mobility (hybrid & electric) via $1.1bn annually until 2025.
- 2019: only 6,300 purchases of electric cars (most of them being used) & 400 charging stations over the whole country
- **Moscow**: free charging stations, free parking slots, sharing rent system of e-bicycles, 400 electric buses

For now, still no federal plan for sustainable mobility.

Messages

The Russian system is historically reluctant to major shifts. The government considers decarbonization as a threat to energy security and stability.

Energy transition is not a Russian concept and therefore is hardly ever anchored in strategic programs.

Economic growth is stagnating while revenues are declining. There is an urgent need to rethink dependence on energy exports while the country is confronted to global major shifts (LNG + RE increasing share worldwide).

High potential of RE resources is still not considered as a major opportunity.

Mobility is subject to strong inertia, which makes technological and usage changes difficult.

Actualized mobility BAU scenario

1. No major technological shift is likely to happen in the short- to mid-term. Cheap access to oil makes electric alternative uncompetitive.

1. **NGVs' development** is encouraged by the country's immense natural gas reserves, hence low prices of gas (2 to 3 times cheaper than diesel & gasoline). Both CNG and LNG infrastructure will develop, targeting respectively LDVs & municipal vehicles, or line-haul cars, railway & agricultural equipment. **HDVs for freight and public transportation** will be the first to shift to gas. Besides, construction of new CNG filling stations is the top priority (only 484 in 2020). A lack of subsidies also hampers the development of this market, which is **very unlikely to become dominant before 2030**.

1. Weak signals for electric mobility by Russian automakers. E.g.: AvtoVAZ already has EV prototypes that could be launched in mass production, but it plans to focus on CNG first. Lack of charging points and high prices will also be a real issue for commercialisation.

1. Electric mobility for the LDVs market could eventually develop in large cities thanks to incentivizing municipal policies.

2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. ***Energy transition in Russia is not a priority.*** Energy security dominates Russia's energy strategy on the long term.

2. ***No major energy shift are likely to happen.*** Energy efficiency could allow a better energy allocation & uses in residential & industry.

3. ***Gas share in the energy mix will increase.*** Gas production will increase for both domestic consumption (electricity generation + residential) & exports. LNG is particularly to increase thanks to major investments in Artic shell from international majors (Chinese for finances & European for technologies).

4. ***Oil production will decrease due to a lack of efficient subsidies & plans to foster the sector***. Domestic oil consumption will remain high but oil export may decrease.

5. ***Coal use will remain high in industry & is not likely to decrease***. Coal production will increase in certain areas (Far East) for both electricity generation & industry.

6. ***The development of RE is not the priority & is at a standstill***. A well-defined state will as well as national & foreign investments could accelerate the exploitation of the strong RE energy potential. .

Major energy KPIs

1) **O&G regulation**
- It has a direct impact on hydrocarbon production via subsidies and foreign technology restrictions
- Directly impacts energy prices

2) **Willingness to integrate foreign technologies on the national territory**
- Could accelerate & secure both hydrocarbon and RE development
- Will confront strong Russian interventionism to market-rule approach

3) **Long term strategy that aims at diversifying the Russian energy mix and attract both local and international investors via subsidies and investment security**:
- RE development will benefit from such a plan. RE electricity generation could substitute electricity from old plants in very localized region
- RE share in the energy mix (heat + electricity) will be able to increase significantly.
- Will increase cooperation between bordering countries in the framework of BRI

Mobility major KPIs

1) Plan for sustainable mobility
- Could be integrated into the policy framework in the mid-term

2) Development of the CNG and LNG charging network over the Russian territory
- Could boost demand for NGVs, as it is a cheap alternative to traditional vehicles

3) Electric charging network adaptation to the Russian territory
- Could boost electric vehicles demand

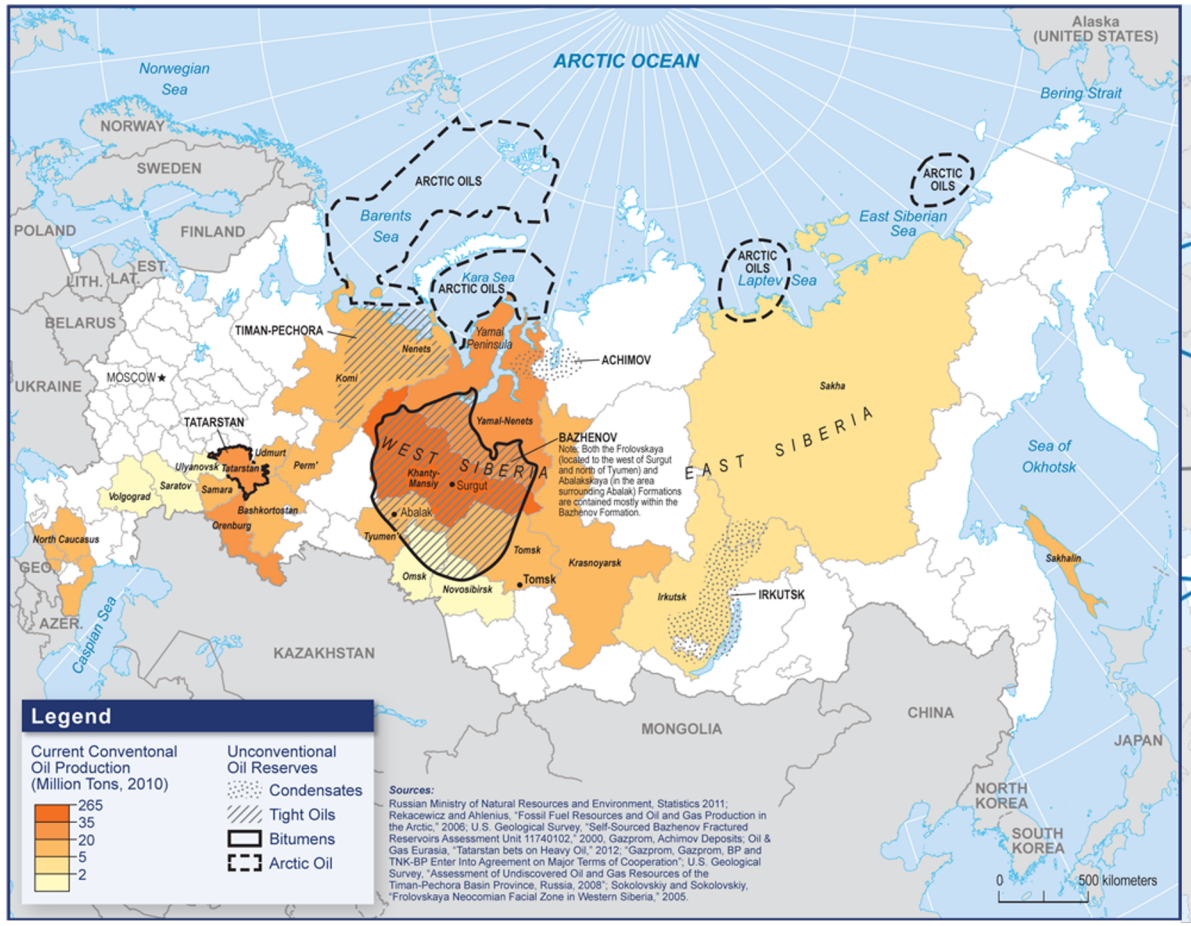
4) Increase in electric vehicles market through new national and international investments
- Increase in the offer
- Contribute to decrease GHG

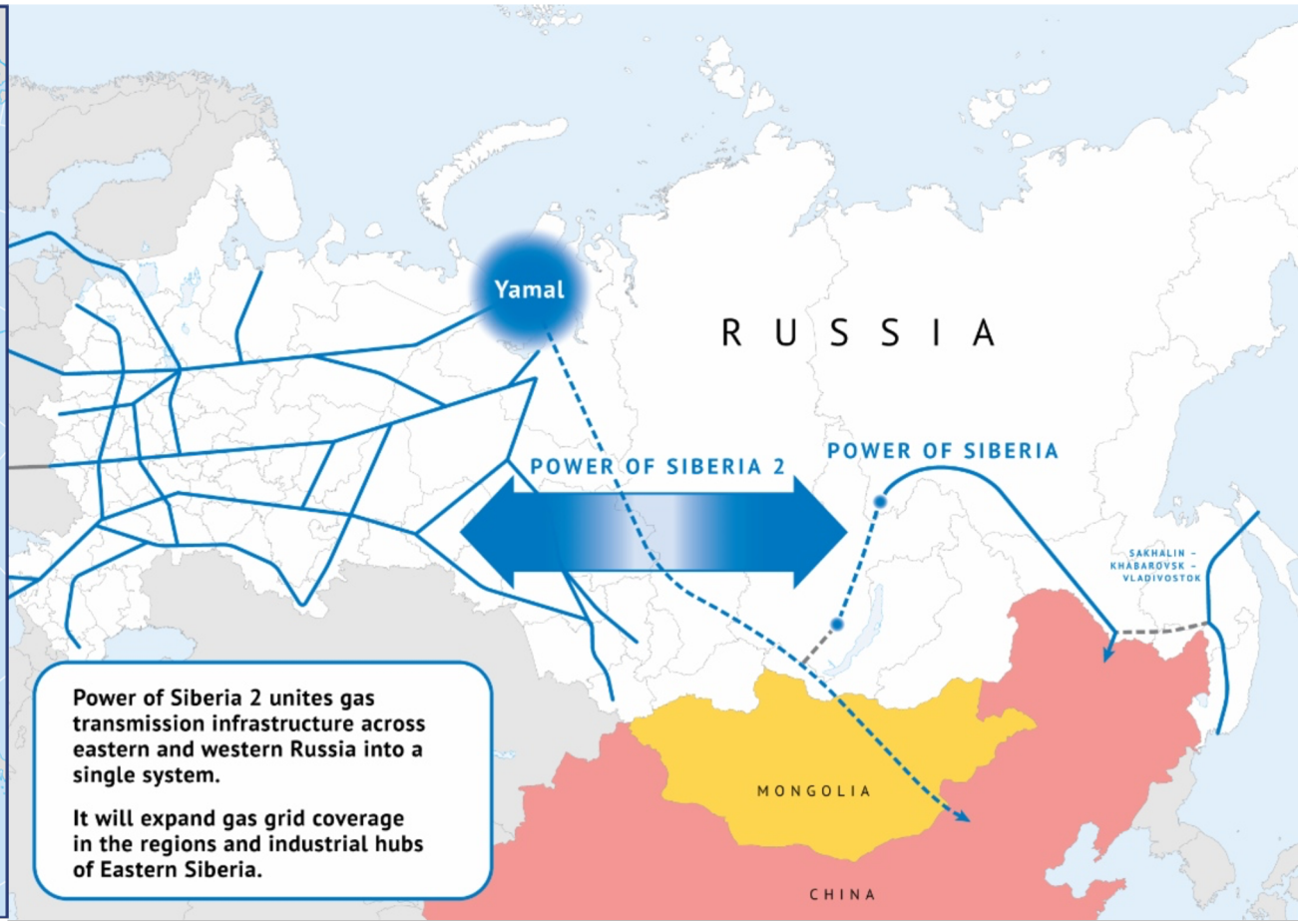
Key messages

Russian pivot towards Asia may contribute to economic diversification, with a deeper access to the Chinese market (i.e. energy technology (RE)).

Sustainable mobility may increase the inequality in development across the territory (Gini Index 2018: 0.4).

Energy resources is more used for inward strategic objectives





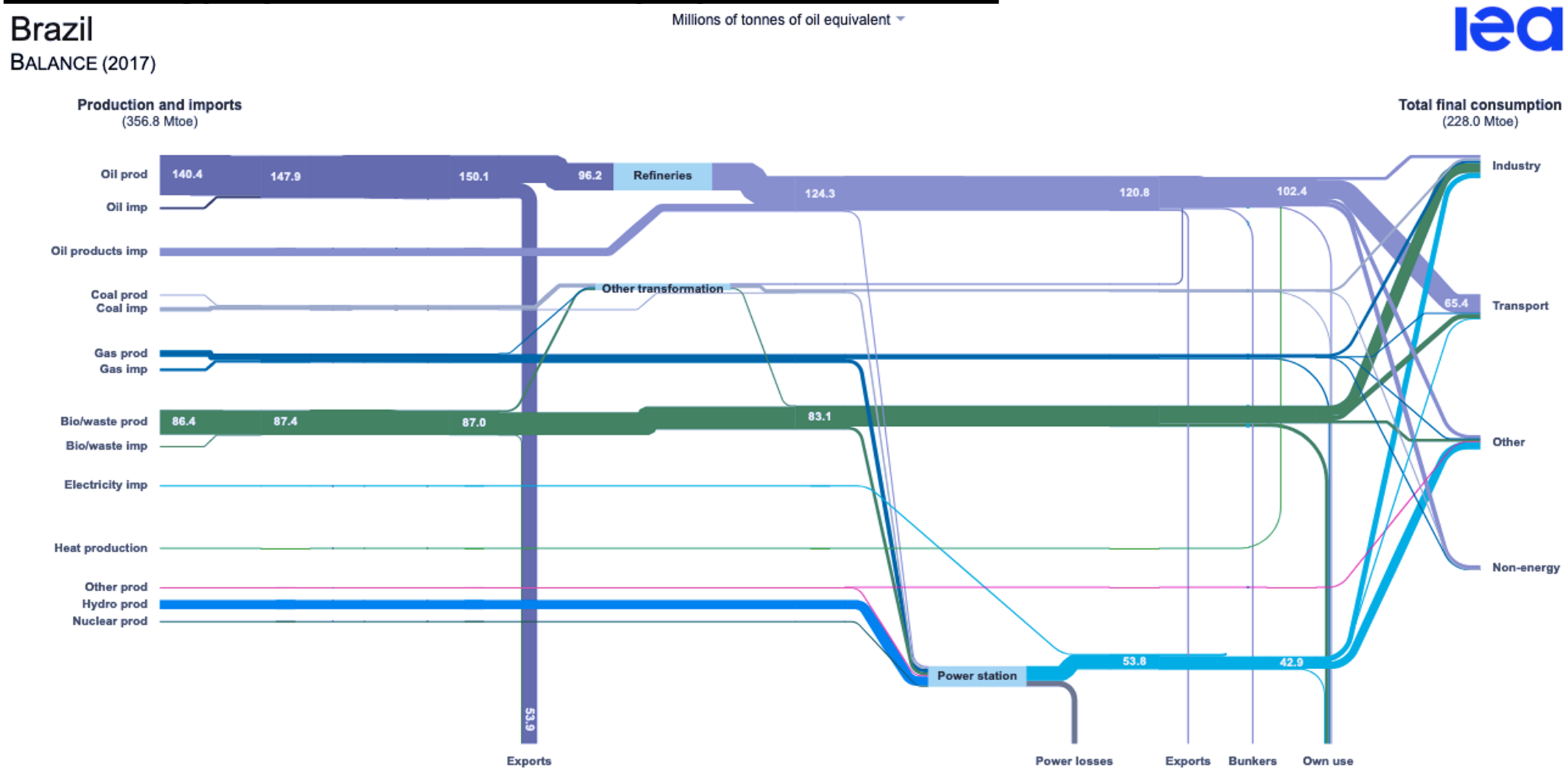
- New oil fields require expensive investments and technologies that Russia does not possess.
- Bipolarisation of the energy system towards Asia.

III) Heterogeneous countries-continents in rapid transformation

These countries still rely significantly on inherited energy inertia (hydro, biomass for Brazil, coal for India). Official public policies are either fragmented or unstable over time. There is a high risk of having already lost the window of opportunity for economic modernization and demographic dividends.

Brazil, India

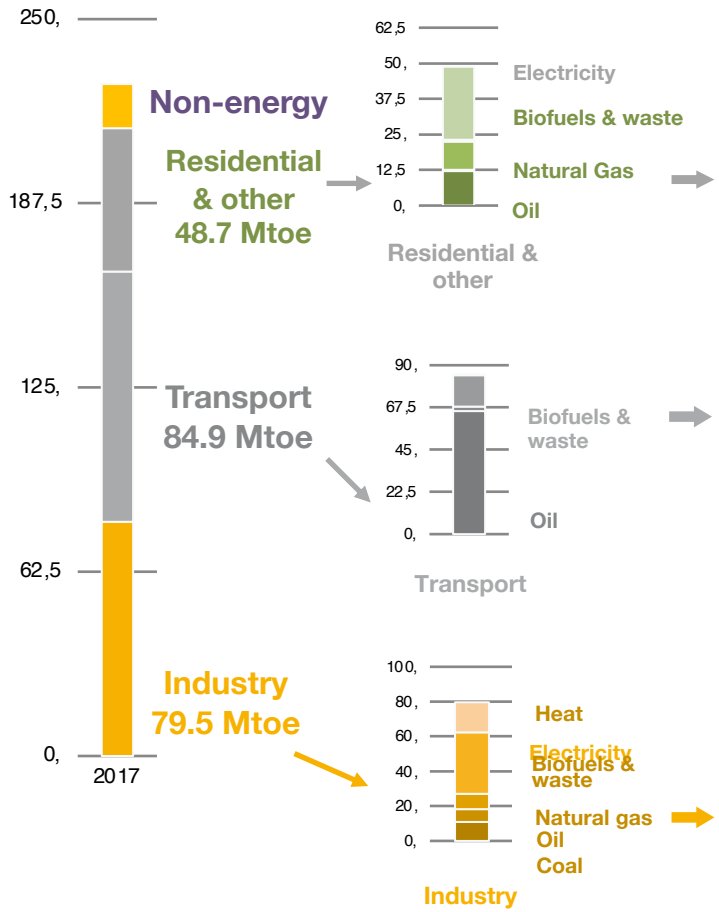
1.1 Energy system picture : key system realities



Brazil depends on its hydrocarbons and biofuel domestic production for its domestic industry and transport. Electricity is mostly generated by hydro.

1.2 System inertias & policy drivers

Brazil final energy consumption 2018: 224.7 Mtoe



Inertias
(by sectors)

Inertia1: electricity & biofuels duality

- Residential: 51.3% (25Mtoe)
  - **Electricity (46%), biofuels (26%),** oil (26%)
- Commerce & public: 25.7% (12.5Mtoe)
  - **Electricity (92%)**, gas (6%)
- Agriculture: 21.4% (10.4Mtoe)
  - Oil (46%), **biofuels (30%),** electricity

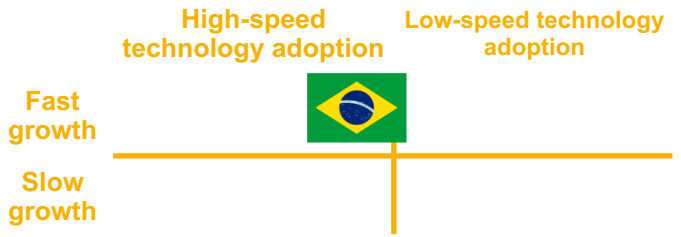
Inertia2: biofuel has a strong share

- Road : 92.8% (78.8Mtoe)
  - Oil (65.4%), **biofuels (20%)**

Inertia3: biofuels dominate all sectors except small steel

- Food : 29.7% (23.3Mtoe)
  - Biofuels (83%), electricity (10%), gas, oil
- Paper & print: 18.5% (1.14Mtoe)
  - Biofuels (73%), electricity (16%), gas, oil
- Iron & steel : 15.6% (12.4Mtoe)
  - **Coal (47%)**, biofuels (25%) electricity (17%), gas (9%)

Policy drivers
(on energy and/or sector)



Objectives : 43% GHG emissions reduction in 2030 compared to 2005 (Brazil has already decreased its GHG emission by 41% in 2012 compared to 2005).
Our view: serious ambiguity with the data published because they don't show the weight of deforestation in the reduction of GHG.
Timeframe : 2030-2050
Governance type : Federal Government, States, industry

Driver 1: Oil investments to maintain production to high level
- Total share mix concerned: 61.5% (138.4 Mtoe)
- Objectives: new offshore oil plants and production for exportations
- Targets for actors: industry

Driver 2: Nuclear reinforcement
- Total share mix concerned: 2% (4.1 Mtoe)
- Objectives: nuclear autonomy and independence, new nuclear power plant by 2025 (Angra III)
- Targets for actors: industry, private and public investments, mining

Driver 3: Bioenergy and RE development
- Total share mix concerned: 40% (90.8 Mtoe)
- Objectives: increase biogas participation by 18% in electricity mix, 28% RE (without hydraulic) in electricity mix in 2030
- Targets for actors: industry, farming

Driver 4: Energy efficiency
- Total share mix concerned: 31% (69.8Mtoe)
- Objectives: rise electrical system efficiency by 10%
- Targets for actors: power industry

Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)
Residential - Inertia1 : electricity & biofuels duality	**Nuclear reinforcement** **Bioenergy development** **RE Development**
Transport - Inertia3 : biofuel has a strong share	**Oil investments to maintain production to high level**
Industry- Inertia4 : Biofuels dominate all sectors except for small steel	**Energy efficiency** **Bioenergy development** **Nuclear reinforcement**

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1: rise of electricity production
- Inter-energy coupling: nuclear (4,1Mtoe) and biomass (9.7Mtoe) to support electricity production;
- Fear of a drop in hydroelectricity production because of climate change.

Coupling2: inter-use energy competition
- Demand competition between electricity and biofuels for industry equipment.
- *49.1 Mtoe (22%)*

Coupling3: a scapegoat forest
- Use of forest as a key factor for biomass production and GHG emissions reduction
- 90.8Mtoe (40%)

Coupling4: economic and demography coupling
- Rise of population (+ 20 millions between 2018 and 2030)
- Political agenda and poverty phase-out

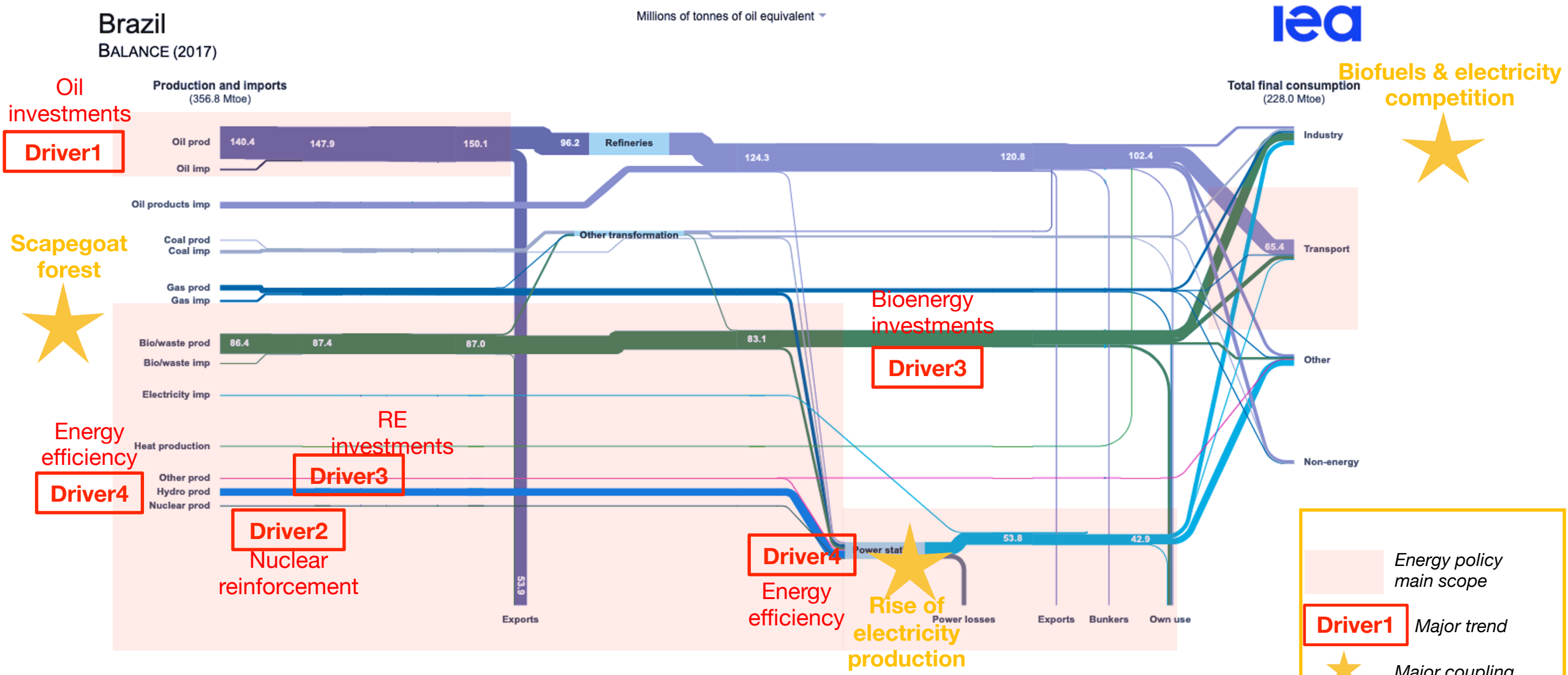
Structuring issues

Issue1: Deforestation dilemma
- Weight on total mix : > 40% (90.8 Mtoe)
- International and social pressure to stop deforesting
- Necessity to use the forest as a major source of energy

Issue2: Climate adaptation
- *Weight on total energy production: 73% (261 Mtoe)*
- Climate uncertainty jeopardizing energy production
- Sectors concerned: oil production, Hydro production, biomass production

Issue3 : Technological push to modernity
- *Weight on total energy production: 49% (175.9Mtoe)*
- Historic modernisation continuity
- Nuclearization, offshore oil plants, energy efficiency
- Rise of middle class & of personal cars

Strong investments on energy production at the expense of energy use investments



Top-of-the-chain industrial policies and couplings that involve uses and bottom-of-the-chain with intervention of climate and energy policies

Energy policy main scope

Driver1 *Major trend*

Major coupling

2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Brazil is world leader in RE use. 85% of the electric mix is clean with a dominant hydro share, and is likely to be completed by a nuclear base. RE development (solar, wind & biomass) will be key for diversification of the electric mix.

2. Brazil will keep investing & exploiting its O&G resources to finance its economy and fight social issues. Oil will be mainly produced for exportations. Oil exploration (especially in the new large pre-salt oil field) is to increase as Brazil ambitions to integrate OPEP.

3. Biomass use is likely to increase across sectors especially in industry & transport. However, deforestation being used for biomass production, the country may need to revaluate biomass role in the energy mix because of social controversies (biofuel production reduce available fields for food production) & international pressure.

4. Specific focus on biofuels to reduce GHG emissions. Investments in biodiesel, ethanol & biomethane are to increase for sustainable mobility.

Fuel, mobility & LCA policy

Concept plan for the future of mobility in Brazil - 2019

Principle based approach among which

- Increasing biofuels share in transport (**RenovaBio** program and **Cbios** carbon credit – financial instrument)
- Regulated share of biofuels for flexfuel vehicles B12 for biodiesel; ethanol E25). Though, share of biodiesel will be maintained at 11% this year because of lack of production capacity.
- Biokerosene promotion for aviation

2020: ROTA Program (law 13.755):

- Promotes investments in R&D for a more sustainable mobility and increase energy efficiency

No policy for electrification of mobility.

Mobility is not the priority for the government. Lack of policy in favour of major technological shit.

Messages

Brazil energy transition suffers from political disparities over time. Energy scenarios highly depend on political agenda.

Climate changes are already threatening Brazilian energy mix (droughts impact hydro & storms threaten offshore oil exploration). This could be an opportunity to invest massively into solar & wind energy & rethink deforestation policies.

Development of a sustainable mobility through use of biofuels and improvement of flexfuel vehicles.

Actualized mobility BAU scenario

1. No major technological shifts are expected at scale.

1. Ethanol use in transport is likely to increase in all sort of vehicles.

1. Industry led in transforming mobility technologies toward e-flex technologies. Absence of policies may compromise technology shift at scale.

1. Hybrid technologies based on ethanol, oil or gas are likely to increase in urban environment.

1. Private investments (Nissan, Toyota, FCA) for electrification based on ethanol (& H2) are increasing. Ethanol is seen as a key to develop new technologies such as ethanol fuel cell. **Nissan works on a e-bio fuel cell for SUV**.

2. From an energy transition scenario to a mobility scenario

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1. Brazil is world leader in RE use. 85% of the electric mix is clean with a dominant hydro share, and is likely to be completed by a nuclear base. RE development (solar, wind & biomass) will be key for diversification of the electric mix.

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Alternatives actualized energy BAU scenario

Biomass threatens ecosystems & food production:

- ***Electrification of the economy will likely replace biomass use across sectors*.**
- Need for a new strategy to achieve climate objectives.
- Massive RE investment will be needed to replace biomass both in industry & transport sectors.

Political agenda in favour of a more sustainable energy mix:

- Biomass use will decrease in favour of electricity in transport & industry sectors.
- Investment in solar & wind will be needed to increase electricity generation.

Actualized mobility BAU scenario

1. No major technological shifts are expected at scale.

1. Ethanol use in transport is likely to increase in all sort of vehicles.

1. Industry led in transforming mobility technologies toward e-flex technologies. Absence of policies may compromise technology shift at scale.

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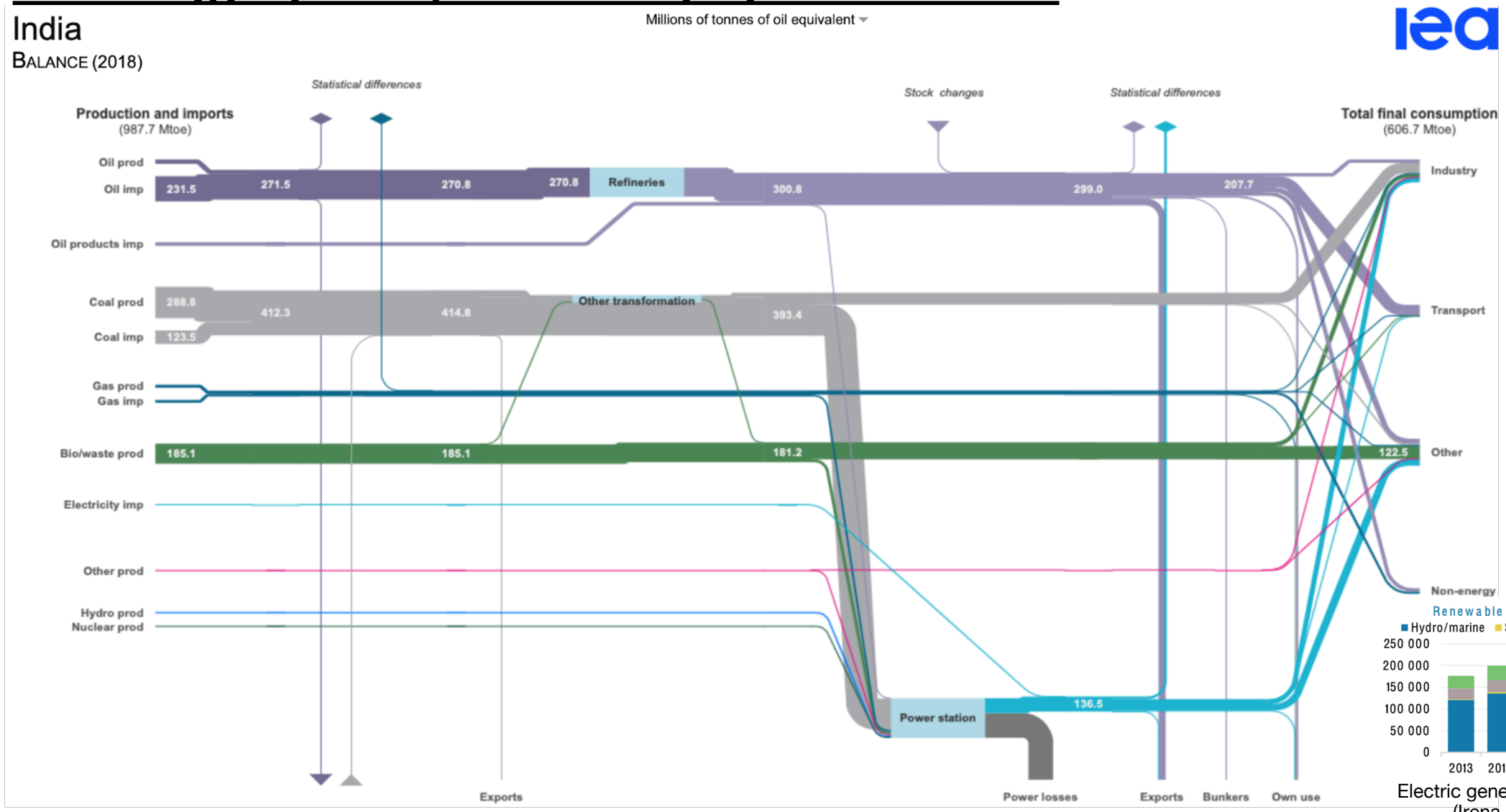
1. Private investments (Nissan, Toyota, FCA) for electrification based on ethanol (& H2) are increasing. Ethanol is seen as a key to develop new technologies such as ethanol fuel cell. **Nissan works on a e-bio fuel cell for SUV**.

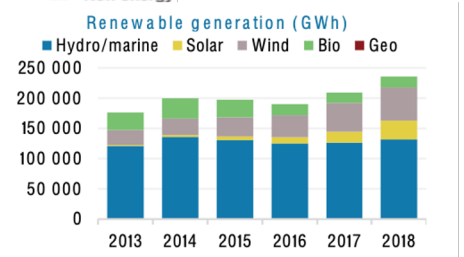
Alternatives actualized mobility BAU scenario

Government plans electrification of mobility to compete with established ethanol mobility:

- **Automotive industry will be able to invest massively in new technologies**.
- **EVs penetration rate could reach 20% in 2030** according toa study entitled “Diffusion of electric vehicles in Brazil from the stakeholders' perspective” (carried out by a public, private & third sector organization).
- **Would have a real impact on mitigating climate change** as electricity is already mainly generated from RE.

1.1 Energy system picture : key system realities



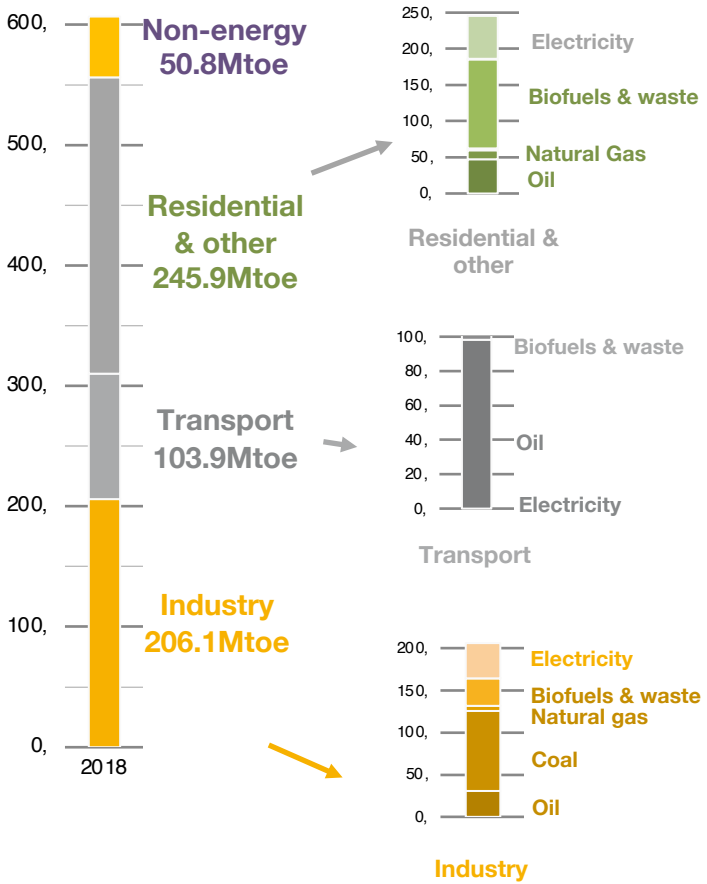


Electric generation from renewables
(Irena 2017 data, GWh)

India's energy system is largely based on the use of coal for power generation & industry, oil for transport and industry, and biomass for residential heating and cooking. Massive investments in wind and then solar increase the RE generation capacity.

1.2 System inertias

India final energy consumption 2018: 606.7Mtoe



Inertias
(by sectors)

Inertia1 : biofuels & waste dominate

- Residential: 71% (174.5Mtoe)
  - Biofuels & waste (66%), oil (16%), electricity (15%)
- Agriculture: 12% (29.4Mtoe)
  - Electricity **(62%),** oil (37%)
- Commerce & public: 10%(26.1Mtoe)
- **Electricity (36%), biofuels (27%),** coal (18%), oil (11%), gas (8%)

Inertia2 : oil dependent

- Road : 89,5% (93 Mtoe)
  - **Oil (96%),** gas (3%)
- Rail: 3,3% (4,4 Mtoe)
- **Oil (64%),** electricity (36%)

Inertia3 : coal equipment dominates

- Iron & steel: 30.5% (63 Mtoe)
  - Coal (46%), electricity (20%), biofuels (16%), oil (15%)
- Non-metallic minerals: 10% (20.9Mtoe)
  - **Coal (64%)**, oil (35%)
- Non-specified: 49.4% (101,9 Mtoe)
  - Biofuels (32%), electricity (27%), coal (22%), oil (14%), gas (6%)

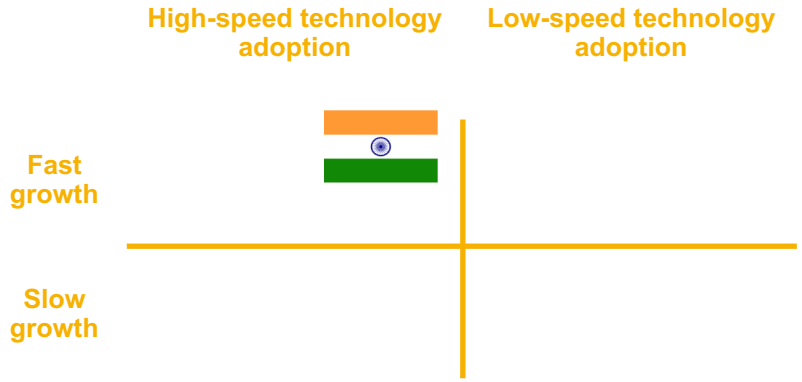
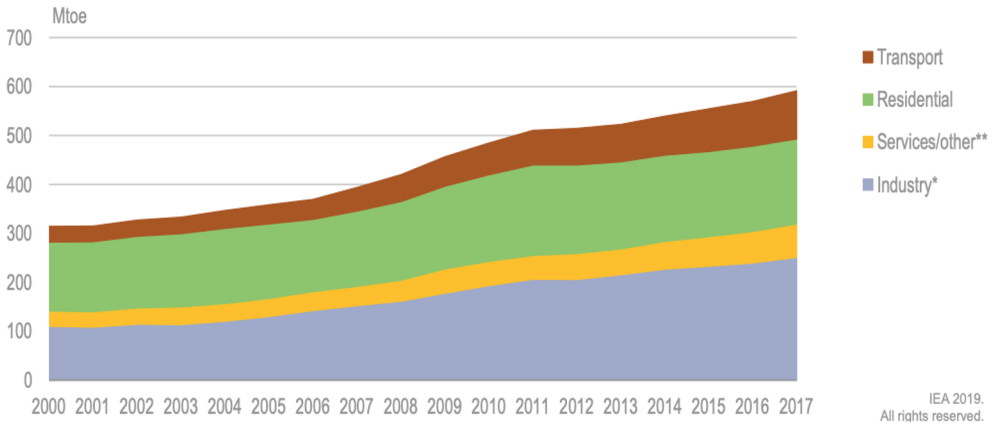


Figure 4.3 Energy TFC by sector, 2000-17



Long-term energy efficiency policies had effect in residential sector.
Example: access to power was given to more than 700 million people since 2000; innovative programmes such as replacing incandescent light bulbs with LEDs

Final energy consumption will increase in order to ensure India's economy development & facing poverty & inequalities.
Polluting energies such as firewood in residential have to be substituted by cleaner energies (electricity & LPG).

1.2 Policy drivers (on energy and/or sector)

Objectives : reduce the emissions intensity of the economy by 33-35% by 2030 from 2005 levels; reach 40% of power generation capacity from non-fossil fuels; create an additional carbon sink of 2.5-3 billion tonnes of CO2 equivalent
Our view: realistic ambition thanks to strong energy efficiency policies & RE investments.
Timeframe : 2022-2030
Governance type: central government, states, industry-led

Driver 1: Energy security & autonomy

- *Weight on total supply : 69% (683,8Mtoe = oil 271,5Mtoe + coal 412,3Mtoe)*
- **Objectives** :*National Electricity Plan (NEP) of 2018* plans to build 94 GW of new coal- fired capacity (mainly supercritical & ultra supercritical coal units) between 2017 and 2027. 22GW have been permitted & 50GW are under construction. ***NEP also plans closure*** of 48,3GW of end-of-life coal plants; ***decrease dependency on oil imports (decrease imports by 10% by 2022 compared to 2015;*** *increase gas share to 15% of the energy mix by 2030*
- **Coal as Indian energy mix base**: growing demand for coal but lack of production capacities increased imports necessity over the last 2 decades with a rebound in 2017 for meeting increasing demand for thermal & metallurgical coal. ***Issues for implementing a more sustainable coal industry*** profitability of the blocks to be auctioned, environmental issues, coal resources location often threaten protected zones;
- **Promotion of gas to reduce oil depend:** city gas distribution is one government priorities; Petroleum and Natural Gas Regulatory Board policy to connect more households to gas network

Driver 2: Energy efficiency as a major tool to meet growing energy demand & improve air quality

- **Objectives:** improve energy intensity & air quality, limit GHG emissions & use of biomass in residential cooking, increase electric system capacity & improve grid infrastructure
- **A structured policy framework & institution:** Ministry of Power for electricity sector, Bureau of Energy Efficiency set under the 2001 Energy Conservation Act implements & regulate policies & programs.
- **Missions & programs from the central government:** The Smart Cities Mission launched in 2016, NITI Aayog's draft National Energy Policy (2017); Atal Mission for Rejuvenation & Urban Transformation (for transport in cities); National Energy Efficient Buildings (2017), Street Light National Program
- **Implemented tools:** Achieve and Trade (PAT) ***for industry*** for energy performance targets & energy savings certificates; mandatory energy building codes (standards) & voluntary buildings scheme ***for buildings***; standards and labelling program ***for equipment & appliances*** since 2006; promotion of cleaner fuels & electric mobility ***for transport.***

Driver 3: RE investments for electricity generation

- *Weight on electricity generation: 13,4% (48,5Mtoe)*
- **Objectives:** 175GW of RE in 2022 100 GW solar, 60 GW wind, 10 GW biomass & 5 GW of small hydropower. (ambition increased in 2018 to 227GW for 2022) & 275GW by 2027; recent statement (2019) from PM announced a new 450GW target by 2030.
- **Grid-connected RE**: utility-scale RE relies on ***RE purchase obligations*** & RE electricity certificate accelerated depreciation for commercial & industrial users; 40GW rooftop target by 2022; exploring potential of offshore wind; biomass & co-generation for some industries
- **Off-grid solar PV investments**: both national & states level scheme to support uptake of off-grid electrification via PV. **2015:** Deen Dayal Upadhyaya Gram Jyoti Yojana was launched to support electrification in rural areas (via mini-grids); **2019:** KUSUM scheme is launched to support farmers to replace diesel pumps with solar PV pumps prosumers
- **RE for transport**: ***Ethanol*** blending program implemented by national oil marketing companies (4% today, 20% target by 2030). Biodiesel is at an early stage development (3,400 outlets in 7 states, 5% target by 2030).
- **Barriers for RE investments:** permitting & network expansion delays, lack of framework & sustainable business model for rooftop solar PV; commercial & technical electricity losses & therefore financial losses; grid connection, financial viability of DISCOMs, controversy on use of waters for big hydro project.

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)	Coupling (dynamics on energy-to-energy, energy-to-use and use-to-use)
Residential - Inertia1: biofuels & waste dominate	**RE investment** **Energy efficiency**	**Coupling1: energy addition in electricity mix** • *Growing population & growing demand for energy relative share of alternatives will increase thanks to massive investments but no energy substitution* • *RE share in the electric mix will rise: even though hydro share will decrease, wind & solar growth will take off & rely on strong ambition & investments. Weight of RE in electric mix: 13,4% (48,5Mtoe)* • *Nuclear role will remain marginal* • *Development of off-grid generation connected to PV rooftops in rural areas, & improvement of cogeneration biomass plants*
Transport – Inertia2: oil dependent	**Energy security** **Energy efficiency** **RE investments**	**Coupling2: fuel addition in transport sector to decrease pressure on imported oil** • *Transport final energy consumption is increasing significantly* • *Long term electric mobility push at national level, & state-level subsidies for EVs implementation* • *Gas & Biofuels (bioethanol & biodiesel) share will increase, particularly in biofuels producing states* • *Use of oil will remain dominant on the mid-term horizon* • *Weight on total use: 17% (103,9Mtoe)*
Industry- Inertia3: coal equipment dominate	**Energy security** **Energy efficiency** **RE investments**	**Coupling3: Alternatives substitutions (mainly gas & potentially hydrogen) in sectors such as industry & residential** • *Investments in 11 new LNG terminals (only 5 today) will enable increase of gas imports that also benefited from lower gas prices* • *City gas network aims to substitute oil use in residential* • *Gas equipment in industry are increasing (fertilisers & petrochemicals)* • *H2 potential is explored as a lower polluting alternatives in steel & iron industry via a direct electrification* • *Weight on total energy supply: 5.2% (52Mtoe)*

Structuring issues

Issue1: Meeting growing energy demand while mitigating climate change

- India is world 3rd biggest polluter after China & US. Need to be a global actor for climate mitigation.
- World's 2nd largest population behind China (will surpass that of China by 2030).
- GDP growth in 2018: +6.8%
- Coal is core of Indian energy mix but massive RE investments will limit coal sector growth.

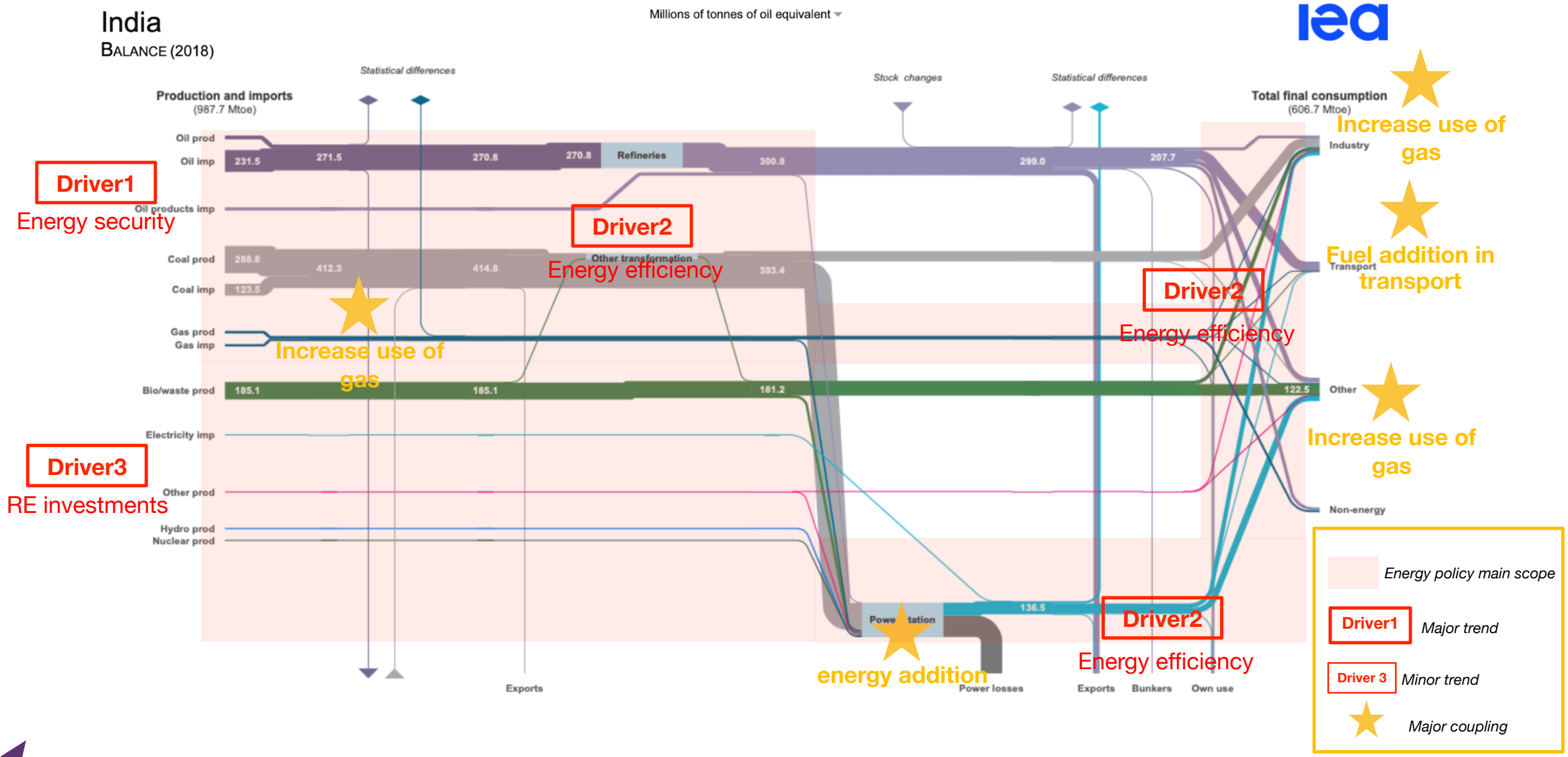
Issue2: Energy efficiency & framework is key to meet energy demand & social issues

- Energy efficiency is a long term policy that showed success by giving access to electricity across the country while improving energy intensity.
- It encompasses all sectors, particularly buildings, transport & industry, & power generation (integration & flexibility issues)
- Investing in energy efficiency is more efficient than investing in new energy plants.

Issue3: Urbanization & air quality issues

- Urban population in 2018: 35% is likely to increase over the next decades.
- Urbanization is challenging liveability in cities
- Air pollution in cities is a real public health issue Indian biggest cities (Delhi, Bombay) are world most polluted cities.
- Urbanization also challenges access to vital resources such as water, energy.
- Use of biomass in residential is highly polluting & harmful

1.4 Energy demand growth obliges ambitious upstream & downstream policies & investment for a sustainable energy transition



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. **Priority is given to meeting energy growing demand.** India has an unstructured framework to achieve its energy transition objectives. So far, programs lack of efficiency.

2. **Electricity use is to increase in every sector especially in residential & transport.** Coal will remain the base of the electricity mix with new supercritical & ultra supercritical coal plants. Massive grid-connected RE investments will complete the electricity base & decrease relative share of coal. Gas share will increase & nuclear role will remain unchanged in power generation.

3. **Coke coal use will increase faster than steam coal as** Indian industry majors make no real effort & coal will remain over used in medium/small size industry companies.

4. **Biomass share in residential is to decrease but pace will depend on government actions:** subsidies will have to be more efficient & well-targeted. Electrification in residential will increase via solar PV for cooking & charging batteries.

5. **Investments for a more flexible system will be needed** & will likely involve H2 potential for storage, grid-scale battery storage and battery storage from EVs, & decentralized rooftop solar PVs.

Fuel, mobility & LCA policy

Concept plan for the future of mobility in India

1) **Strong electrification mobility policy that aims to:**
- Limit air pollution in cities;
- Electrify 2 & 3 wheelers rapidly (penetration rate objectives in 2025: 34,5% for 2 wheelers, 63% for 3 wheelers)
- Promote shared mobility & public transport

2) **Promotion of biofuels at a national & state-level:**
- Fostering biofuels blending
- Promoting biofuels blending (20% for bioethanol & 5% for biodiesel by 2030)
- **Promotion of advanced biofuels is a necessity**

3) **In a longer term, exploration of hydrogen use for HDV & public transport:**
- Promotion of hydrogen blending (H-CNG) is seen as a first step toward H2 fuel cell mobility
- Exploring H2 potential for energy storage & fuel cell vehicles.

Messages

India energy transition is an opportunity to face social & economic issues such as energy access in rural areas, urban planification, air quality in cities &energy efficiency, *while responding to final energy demand growth*.

Transport is a key & fast growing sector in India's economy. It represents only 17% of energy total final consumption. However it has more than doubled in the past 10 years.

Developing a sustainable vehicle fleet via electric mobility has been an Indian policy since 2011 & is a major tool for the national energy transition policy. It is part of both energy efficiency & RE development ambition. *Nevertheless, mitigating climate change via electrification of mobility is already jeopardized by a lack of ambition in decarbonizing electricity generation.*

Covid-19 severe confinement policy in 2020 slowed down the economic growth. PM recently stated that coal will be key for boosting the economy. Government auctioned off 41 coal mines. *Self-sufficiency* appears as core for Modi's policy post-covid.

Actualized mobility BAU scenario

1. **Indian is a very attractive market for investors because of the economic growth & a rising middle class.**

1. **India has an ambitious framework that aims to establish a sustainable car fleet.** It is in line with China's policies for electric mobility. 2022 objectives for EVs is a first step toward electrification at-scale & will structure the market. In March 2019, more than 270,000 HEVs & EVs were recorded.

1. **Electric 2 & 3 wheelers are likely to be the first to develop & will push forward EVs market.** Electric SUV has shown some potential in cities.

1. **Shared mobility will develop to face urban congestion**. Electric rickshaws, taxis, buses & metro will continue to increase. A very ambitious urban planification is though needed to fight urban congestion.

1. **Biofuels such as bioethanol & biodiesel are likely to increase but at a slower pace than planed.** Biofuel producing states have their own policies to promote alternatives & blending.

1. **H2 blending is likely to increase for buses & HDVs**. Yet no major investment for H2 fuel cell vehicles development.

2. From a energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. ***Priority is given to meeting energy growing demand.*** India has a structured framework to achieve its energy transition objectives but will also depend on profitability of RE investments & political agenda.

2. ***Electricity use is to increase in all sectors especially in residential & transport.*** Coal will remain the base of the electricity mix with new supercritical & ultra supercritical coal plants. Massive grid-connected RE investments will complete the electricity base & decrease relative share of coal. Gas share will increase & nuclear role will remain unchanged in power generation.

3. ***Coke coal use will increase faster than steam coal.*** Indian industry majors are not shifting their equipment & coal is over used in medium & small size industry company.

4. ***Biomass share in residential is to decrease but pace will depend on government actions.*** Subsidies will have to be more efficient & well-targeted. Electrification in residential will increase via solar PV for cooking & charging batteries.

5. ***In a longer-term, investment for a more flexible system will be needed*** & are likely to involve H2 potential for storage, grid-scale battery storage and battery storage from EVs, & decentralized rooftop solar PVs.

KPIs that can impact energy scenario

Key factors that could have an impact on energy supply & use:

1) Coal regulation

2) Electricity tariffication & RE investment profitability:

- Electricity fare is the first KPI that influence both supply & electricity demand
- Central Electricity Regulatory Commission & Electricity Act 2003; focus on RPOs & RGOs (for coal/lignite thermal plants). **Increasing RPO/RGO rate will have an impact on RE development.**
- RE electricity is half cheaper than coal-fired power. Better policy needed to reduce the risk cost & attract investors.

3) Electricity transmission & distribution:

- Technical & commercial losses & DISCOMs profitability
- **Risk of bankruptcy & system inefficiency could jeopardize / slow down electrification of the economy.**

4) LPG prices & subsidies:

- **Better-targeted subsidies, especially for the poorest households, coupled with a new tariffication policy could accelerate shift toward LPG use in residential**

5) National autonomy in response to Covid-19 crisis. Modi's "self sufficiency" policy aims to increase use of coal in the electricity generation relying on Indian energy majors rather than on foreign investors in RE development.

Actualized mobility BAU scenario

1. ***Indian is a very attractive market for investors because of the economic growth & a rising middle class.***

1. ***India has an ambitious framework that aims to establish a sustainable car fleet.*** *It is in line with China's policies for electric mobility. 2022 objectives for EVs is a first step toward electrification at-scale & will structure the market base. In March 2019, more than 270,000 HEVs & EVs were recorded.*

1. ***Electric 2 & 3 wheelers are likely to be the first to develop & will push forward EVs market.*** *Electric SUV has shown some potential in cities.*

1. ***Shared mobility will develop to face urban congestion****. Electric rickshaws, taxis, buses & metro will continue to increase.*

1. ***Biofuels such as bioethanol & biodiesel are likely to increase.*** *Biofuel producing states have their own policies to promote alternatives & blending.*

1. ***H2 blending (H-CNG) is likely to increase for buses & HDV****. Major investments will be need for developing H2 fuel cells for mobility.*

KPIs that can impact mobility scenario

Key factors that could have an impact on mobility development:

1) Oil regulation (so far no ICEs policy in cities)

2) Electricity storage improvements could accelerate EVs development at 2 levels:

- EVs lithium-ion battery could be used for RE electricity storage in residential & public buildings.
- Better electricity storage will allow EVs development in more remote areas.
- Investments in H2 for electricity storage could accelerate electrification of mobility.

3) In order to increase the country's energy autonomy & decrease (in relative share) oil use in transport; investments in H2 blending & H2 fuel cell could increase.

4) A stronger regulation on biofuel production at a local level is needed

- To accelerate growth of biofuels share in transport. A more efficient regulation could enable to achieve blending's objectives at least at a local level.
- To increase advanced biofuels investments. Use of biofuels is controversial because of land use issues.

An overview of key messages by structuring issues

STRUCTURING ISSUES	MESSAGES	
ISSUE 1 Meeting growing energy demand while mitigating climate change	No national ambition to reduce coal use across sectors	Diversifying electricity mix through massive RE investments
	Powerful national energy companies have no ambition to decrease coal use.	Coal will remain dominant in the electricity generation Relative share of RE will increase
ISSUE 2 Energy efficiency & Demand side management	Improve energy intensity through labels & energy performance. Structured framework but lack of efficiency so far	Attempt to decrease energy consumption per point of GDP
	No major effort from the industries to decarbonize their activities	No evolution is possible because of the industrial structure
ISSUE 3a Urbanization & air quality in cities	Multiplication of national programs but lack of efficiency: - energy intensity explosion - urban congestion - urban planification is a major issue	
ISSUE 3b Use of biomass in residential in rural areas	Need to eradicate biomass use for cooking & heating in residential in rural areas *Awareness but so far failure*	
MOBILITY	Electric mobility policy would be inefficient for climate change mitigation if electricity generation is not decarbonized. EVs is seen as a potential way of energy storage	
	Promotion of alternative fuels such as advanced biofuels & exploring hydrogen potential. For now, lack of national & state-level framework.	

Macroeconomic messages towards mobility

India energy transition is an opportunity to face major social & economic issues such as energy access in rural areas, urban planification, air quality in cities & energy efficiency, while responding to final energy demand growth. So far, national programs lack of efficiency. ***Growing population & pollution in cities need urgently more structured & long term programs. Liveability has become a real issue.***

Transport is a key & fast growing sector in India's economy. It represents only 17% of energy total final consumption. However it has more than doubled in the past 10 years.

Developing a sustainable vehicle fleet via electric mobility has been an Indian policy since 2011 & is a major tool for the national energy transition policy. It is part of both energy efficiency & RE development ambition. ***Nevertheless, mitigating climate change via electrification of mobility is already jeopardized by a lack of ambition in decarbonizing electricity generation.***

Covid-19 severe confinement policy in 2020 slowed down the economic growth. PM recently stated that coal will be key for boosting the economy. Government auctioned off 41 coal mines. ***Self-sufficiency appears as core for Modi's policy post-Covid-19.***

3. Actor-mapping - Regulatory framework by major issues towards KPIs

	Message	Regulation content	Investment	KPI
Issue1 **Meeting growing energy demand while mitigating climate change**	**No national ambition to reduce coal use across sectors.** **Diversifying electricity mix through massive RE investments**	***National Electricity Plan (NEP)*** increase energy supply with coal & RE investments. ***Maintaining high investments into coal-based power*** for coal & lignite exploration & public enterprises (NLC India Limited; Coal India Limited; Singareni Colleries Company Limited) NEP plans to build 94 GW of new coal- fired capacity (mainly supercritical & ultra supercritical coal units) between 2017-2027 ***Massive RE investments***: 5 states (Karnataka, Tamil Nadu, Rajasthan, Andhra Pradesh & Gujarat) are already facing significant ***system integration challenges***, with solar & wind shares above 15% in the electricity mix For utility-scale renewables India relies on ***renewable purchase obligations*** (***RPOs***), **renewable generation obligation (RGOs**: for coal/lignite thermal plants) ***renewable electricity certificates*** (***RECs***): DISCOMs have to obtain a certain share from RE; regulation carried out by the **State Electricity Regulatory Commissions** (22% of RE in DISCOMs electricity purchase (10,5% from solar)). Promoting hydropower as renewable with Hydro purchase obligation (HPO, 2019) similar to RPOs. Competitive auction for solar PV (2010) & wind (2017) **KUSUM program (2020):** ensuring reliable day time power supply for irrigation, providing additional sources of income to the farmer, subsidies to solarise pumps ***fostering off-grid production*** **Grid Connected Rooftop Solar Programme**	Ministry of coal's budget for 2020-2021:**$2.6bn** Total O&G subsidies in 2019: +69% ($10bn) Ministry of New & Renewable Energy's 2020-21 budget: - $175m for wind - $338m for solar - $13m for small hydro - $1.7bn in Indian RE Development Agency	RE investment & integration Price signals
Issue 2 Energy efficiency & Demand side management	**Improve energy intensity through labels & energy performance** **Structured framework but lack of efficiency so far** **Attempt to decrease energy consumption per point of GDP**	**In residential**: ***Energy Conservation Building Code*** (ECBC, 2007) increase use of electricity in buildings ***Eco Niwas Samhita, Part – I (2018)*** energy conservation code with minimum building envelope performance standards; first step toward Eco Niwas Samhita Part II will involve material aspects & RE. **In industry**: ***Perform Achieve and Trade (PAT):*** aim to reduce energy consumption in energy intensive industries, through certification of excess energy saving which can be traded. ***National Programme on Energy Efficiency & Technology Upgradation in SMEs*** **Standard & labelling program**: energy performance labels on high energy end use equipment & appliances & lays down minimum energy performance standards **Decentralized energy efficiency program** ***State-Designated Agency***: Stand-Alone SDA to regulate & reenforce energy efficiency policy ***Demand Side Management*** State intervention to achieve energy demand reduction (especially in agricultural & municipal sector & for DISCOMs).		Energy consumption rate

3. Actor-mapping - Industry actions by major issues towards KPIs

	Message	Industry actions	Major Projects & structuring partnership	KPI
Issue1 **Meeting growing energy demand while mitigating climate change**	**Powerful national energy companies have no ambition to decrease coal use.** **Coal will remain dominant in the electricity generation** **Relative share of RE will increase**	**- Rapid growth in electricity demand (CAGR=7% between 2007 & 2017)** Indian majors are investing into cleaner coal plant (supercritical & ultra-supercritical) to increase coal production capacity. **Key actors:** NLC India Limited; Coal India Limited (CIL); Singareni Colleries Company Limited **CIL** plans to diversify its incomes sources by investing in solar power. Majors seek to balance their GHG emission by creating carbon sink(by planting trees) **National Thermal Power Corporation Limited** (NTPC) plans to decrease the share of fossil fuel in its energy mix (92% today). **Massive investments in RE from green Indian compagnies:** ***Greenko Energy Holdings***, ReNew Power, Adani Green energy, **Key actors for RE development:** Solar Energy Corporation of India (SECI), ReNew Power, Brookfield Asset Management (Canadian), EverStone (Asian), Lightsource (Europe)	**- Adani Power** is developing the 1.6GW Godda ultra supercritical thermal power project in Jharkand, **$2bn invested** **- NTPC**: plans for RE's share in 2032 to be 25% of the electricity generation: 936MW are in project & 2290MW are under implementation. **- CIL** wishes 20GW from solar in 10 years. **- Singari Colleries Company** is to invest $1.5bn in expanding new mines & in a 500MW solar project. - Between April-December 2019**:** $5.26bn were invested in RE by private companies; $8.4bn during 2019/2020 ***Most investments are into coal mines expanding.***	RE share growth in electricity generation Coal share in the electricity generation
Issue 2 Energy efficiency & Demand side management	No major effort from the industries to decarbonize their activities No evolution is possible because of the industrial structure	**- Industry majors are mainly public-utility companies.** Coal equipment dominate in industry. Efforts have been made to decarbonize fuels (with carbon capture) rather than shifting equipment. Efforts have also been made to create a steel circular economy with reuse & recycling projects. **Key actors:** Jindal Steel & Power; Tata Steel Limited (formerly TISCO); Steel Authority of India; JSW Steel Limited **The industry sector in India is mainly made up of medium & small regional companies that have less financial capacities to invest into new equipment.** **Washing of coal in industry sector to decarbonize use of coal.**	• No major investment to replace old industrial equipment. • Efforts have been made in circular economy to reduce carbon impact.	Investments in new equipment Use of alternative fuels (biomass & electricity)

3. Actor-mapping - Regulatory framework & industry action for issue 3 towards KPIs

	Message	Industry action, & regulation content & Program	Investment	KPI
Issue 3.a Urbanization & air quality in cities	**Multiplication of national programs but lack of efficiency:** - **energy intensity explosion** - **urban congestion** - **urban planification is a major issue**	**Urbanization in India:** More big cities to come: **1951**: 3 cities above 1 million inhabitant → **2011**: 53 cities → **2031**: 70 cities **6 out 10 most polluted cities in the world are from India** (Ghaziabad 1.7m inhabitants; Delhi 19m; Noida 600k; Gurugram 900k; Lucknow 2.6m; Bandhwari 8.6k) **Transformation of the economy structure:** Agriculture contribution to India's GDP is steadily declining (15.9% of GDP in 2019). Program for more sustainable cities: - The Smart Cities Mission (2016): electrification of cities & energy efficiency program - *Atal Mission for Rejuvenation & Urban Transformation:* public transport development & improving liveability in cities. - ***Improving city gas network***: Petroleum & Natural Gas Regulatory Board launched a new city gas distribution project in April 2018→ It aims to add 20 million households to the city gas network & 4 600 CNG stations for vehicles by 2026. - ***Ujjwala scheme*** (2017): It targeted 50 million new LPG users by providing a subsidy (INR1,600) to women in households classified as below poverty line **Mobility transformation in cities: *2011:*** *National Mission on Electric Mobility;* ***2013:*** *National Electric Mobility Mission Plan 2020*→ **Objectives:** 15% of EVs sales in 2022. 2018:*:National E-Mobility Program* for public sector; shared mobility promotion	Atal Mission for Rejuvenation & Urban Transformation: $7.1bn for 5 years from 2015 to 2020. State-level under-priced electricity is the most costly individual subsidy policy in India, estimated at $9.5bn.	Access to cleaner energy Air quality in cities
Issue 3.b Use of biomass in residential in rural areas	**Need to *eradicate* biomass use for cooking & heating in residential in rural areas** ***Awareness but so far failure***	**Current situation in rural areas**: ***Rural population in 2019***: 65% - **Energy used in residential in rural areas:** about ***80% of rural households*** in India use biomass fuel for cooking (***19% of urban households*** use biomass fuel for cooking, majority uses LPG); only 11% of households had access to LPG in rural areas in 2011 (2011 Census), & 65% in urban areas. - **Biomass can no longer be used in residential*:*** Chronic exposure to biomass smoke-generated indoors can cause health effects such as chronic obstructive pulmonary disease, tuberculosis, cataract & adverse pregnancy outcomes, low birth weight, & infant mortality (National Center for Biotechnology Information) **Policies to shift from biomass to alternatives:** - ***Promoting LPG for cooking*** → subsidies from the government (INR 162.5 for the purchase of one LPG cylinder in 2018 in New-Delhi); Pradhan Mantri Ujjwala Yojna (PMUY) scheme in May 2016 to provide LPG to a large number of poor households (providing a free cylinder) - ***A large portion of LPG subsidies is believed to go to higher-income households, while poor households still face affordability problems.*** - ***Promoting off-grid electrification*** solution with solar PV for cooking & charging → Jawaharlal Nehru National Solar Mission (2010) → 2000MW of off-grid solar by 2022. → International development: World Bank (in the 1990s), UK's Department for International Development, Asian Development Bank (ADB) invested in the off-grid solar company Simpa Networks **Issues for implementing LPG:** LPG cost comparing to cheap/accessible firewood infrastructure; supply chain management.	Total subsidies to promote LPG for cooking in 2013-14:$5.9bn; shared by the government, & O&G majors (Indian Oil Corp. Ltd; Bharat Petroleum Corp. Ltd; & Hindustan Petroleum Corp. Ltd) → DBTL for LPG cooking is the largest LPG subsidy since 2016	LPG accessibility in rural areas LPG prices Solar PV implementation in rural areas

3. Actor-mapping – Industry actions & regulatory framework for mobility towards KPIs

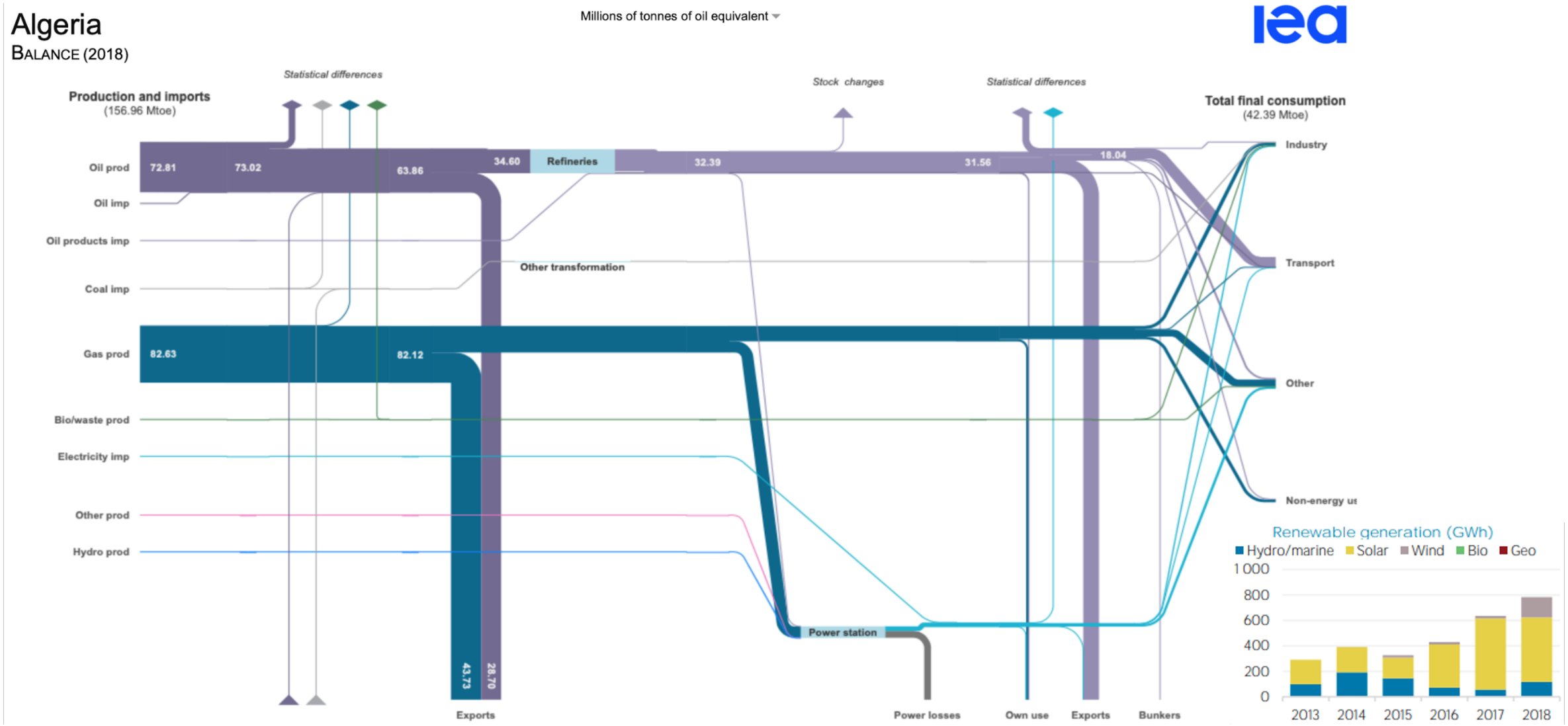
Message	Automotive industry action, & regulation content & Program	Investment	KPI
Electric mobility policy would be inefficient for climate change mitigation if electricity generation is not decarbonized. **EVs as a potential way of energy storage**	***2011: National Mission on Electric Mobility*** ***2013: National Electric Mobility Mission Plan 2020*** Objectives: 15% of vehicles sales to be electric by 2022. **Incentive program**: Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) ***State-level programs*** for EVs development (Karnataka, Telangana, Delhi, Andhra Pradesh & Maharastra), including electric buses 2018 the National E-Mobility Program for public sector. **2019: Union Budget:** Tax exemptions for EV manufacturing plants; tax deduction for EV loans **Major Subsidies for EVs:** - Concessional tax rate on electric two-wheelers and three-wheelers ($220m) 2 & 3 wheelers manufacturers are shifting toward EVs. 34,5% penetration in 2025 for 2 wheelers & 63% for 3 wheelers. - Faster Adoption & Manufacturing of EVs(FAME) II scheme: strong focus on public transport and shared mobility **Major private investors for electric mobility:** *Hyundai, Hero, Mahindra* *Hyundai investment in Ola for EVs development.* **The Government is working on a GW Cell Manufacturing Plan**. This plan is currently underway and it seeks to invite 50GWH of cell manufacturing capacity in India by 2025. ***Increasing adoption of EVs will need to be coupled with better storage technology, improving the capacity of the grid to utilize RE for EV charging*** *(The International Institute for Sustainable Development)*	- EV subsidies have grown over 11 times since 2017 ($249m in 2019) - **$2,48bn** R&D in the automotive sector in India. - FAME : budget of 1.4bn for 3 years. - **Hyundai** investment for India mass market: $200m & $300m in Ola.	EVs penetration rate & charging points development Greening electricity generation
Promotion of alternative fuels such as advanced biofuels & exploring hydrogen potential. Lack of framework.	***Promotion of biofuels*** ***2018: Ministry of Petrol & Natural Gas:*** *new target for biofuels blending (20% ethanol blending, 5% biodiesel blending by 2030)* ***BioEthanol (made with sugar cane juice, sugar and starch crops) share is not increasing as expected)*** ***Local initiatives for biodiesel blending*** *there are around 3 400 outlets in seven states that offer B5 diesel. But biodiesel is at an early stage at national level.* ***Promotion of gas for HDV & buses*** **September 2020**: inclusion of H-CNG as an automobile fuel (H2 blended;18%of H2). **October 2020**: inauguration of a H-CNG plant & launch of 50 buses running on H-CNG in New Delhi. ***Exploring Hydrogen potential:*** Solar manufacturing & H2 generation project (July 2020). Union Power Minister R.K Singh stated that government's target is to develop 3GW (each) of solar module and cell manufacturing capacity. The government is to come up with a plan for generating solar power which would be used to generate H2. H2 would power city public transport. ***Yet no specific investments***		Fuel blending rate & biofuels production at state level Hydrogen infrastructures (energy, mobility)

IV) Countries with complex political-economic situations

They combine real reformist agendas at times, but these come up against particular interests or lobbies. An energy transition policy is more or less enforced depending on the period.

Algeria, Argentina, Morocco, Poland, Romania, South Korea

1.1 Energy system picture : key system realities



Electric generation from renewables
(Irena 2017 data, GWh)

Strong dependency on hydrocarbon exports. While natural gas energy is key to electricity generation, renewable solar energy has risen during the last decade, and wind energy is starting to develop.

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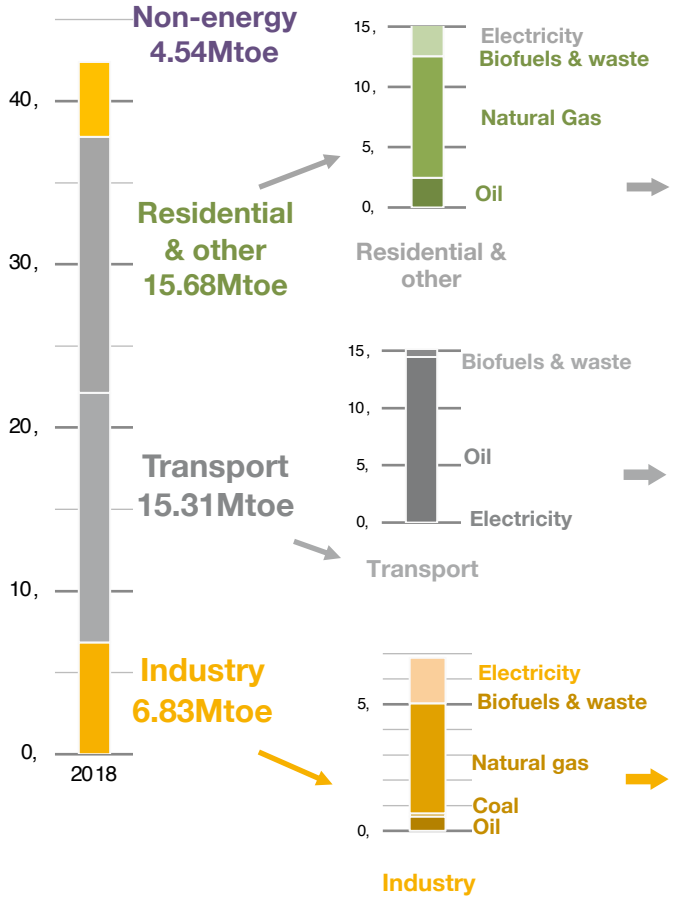
1.2 System inertias & policy drivers

Algeria final energy consumption 2018: 42.37Mtoe



Inertias
(by sectors)

Inertia1 : gas/electricity duality

- Residential: 81.8% (12.84 Mtoe)
  - Gas (70%), Electricity (17%), **oil (13%)**
- Commerce & public: 3.6% (0,57 Mtoe)
  - Electricity **(47%), gas (53%)**
- Agriculture: (0.17 Mtoe)
- **Electricity (59%),** oil (24%), **Gas (18%)**

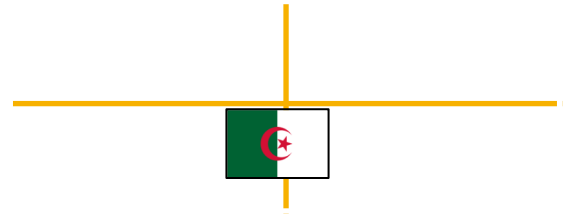
Inertia2 : oil dependency

- Road : 93% (14.21 Mtoe)
  - **Oil (100%)**
- Pipeline: 5.2% (0.79 Mtoe)
- **Oil (95%),** Natural gas (5%)

Inertia3 : gas equipment dominates

- Non-metallic minerals: 33% (2.2 Mtoe)
  - Gas (88%), Electricity (11%), oil (1%)
- Construction: 26.2% (1.79 Mtoe)
  - **Gas (69%)**, oil (22%), electricity (9%)
- Non-specified: 19.5% (1.33 Mtoe)
  - **Electricity (75%)**, oil (13%), **gas (11%)**

Policy drivers
(on energy and/or sector)



Objectives : climate neutrality by 2050, world lead in climate change
Our view: ambitious but well adapted energy transition for climate change mitigation
Timeframe : 2030-2050
Governance type: government, industry-led, Climate Change Council

Driver 1: Maintaining hydrocarbon production to high level

- Weight on total supply: 87% (37.17 Mtoe)
- Objectives : create new partnerships between Sonatrach & international energy companies to explore new domestic resources
- Increasing use of gas in sectors such as transport to decrease GHG emissions

Driver 2: RE investments

- Weight on electricity generation: 0.42% (0.07Mtoe)
- Objectives: diversifying electric mix and exploiting solar potential for electric generation
- Plan for 22,000 MW from RE in 2030 (for domestic consumption & exportations), mainly from solar & wind

Driver 3: Energy efficiency

- Weight on total supply: 32% (8.6 Mtoe)
- Producing as much as goods and services with less energy
- Objectives: generic notion that encompasses three strategic sector: buildings, industry & transport

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)
Residential - Inertia1: electricity/gas duality	Hydrocarbon production
	RE investment
	Energy efficiency
Transport – Inertia2: oil dependent	Hydrocarbon production
Industry- Inertia3: gas domination	Hydrocarbon production
	Energy efficiency

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1: inter-energy coupling in transport

- *Energy addition in transport: gas share will increase*
- *Promotion of cleaner energy such as gas will increase LPG & NG in transport.*
- *Weight on transport supply mix: 5% (0.69Mtoe)*

Coupling2: RE addition in the electric mix

- *Investment in RE will relieve pressure on gas for power generation. Gas share for electricity production was 98%.*
- *Massive investments in solar for power generation.*
- *Weight on electricity supply: 0.3% (0.06Mtoe)*

Coupling 3: electricity production at local level

- *RE investment will enable withdrawn localities to produce their own electricity*
- *In certain localities, electricity share in residential, will compete with gas share.*
- *Weight on final consumption in residential: 17% (2.13Mtoe)*

Structuring issues

Issue1: Hydrocarbon exploitation uncertainty post 2030

- Hydrocarbon exploitation is core for energy security.
- Lack of visibility concerning domestic resources for after 2030
- Mega conglomerate Sonatrach is to join force with multinational energy companies to look for & exploit new domestic resources
- *Weight on total supply: 87% (37.17Mtoe)*

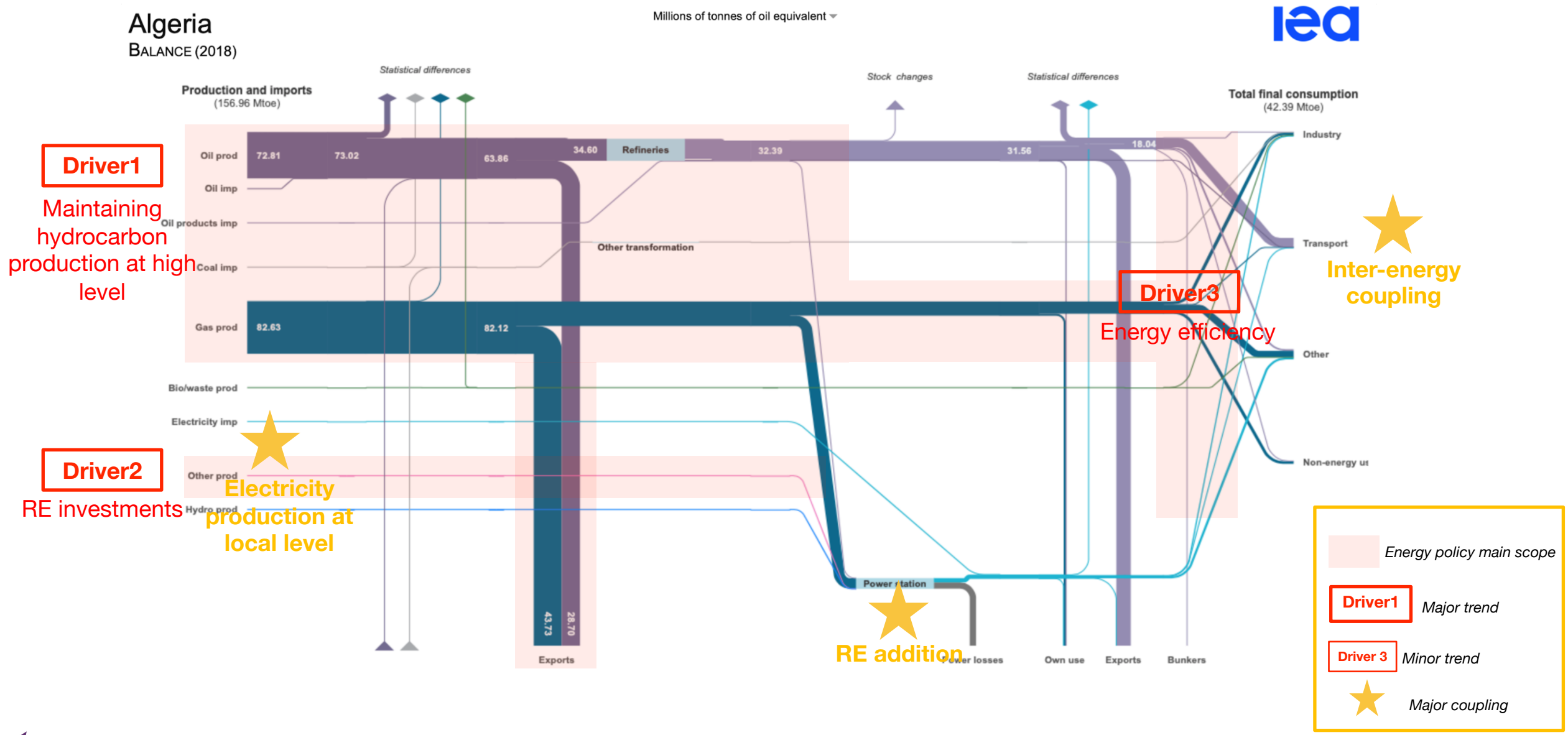
Issue2: hydrocarbon sector is core for Algeria's economy & is used to fight social issues

- Unemployment rate & cost of living are rising.
- Hydrocarbon exportations give the economy major financial resources.
- Social tension after opening resource exploration to foreign companies.

Issue3: Threat from climate change

- Direct consequences from climate change: desertification & land degradation are increasing
- Rainfall fell by more than 30% over the decade, compromising hydraulic generation

1.4 Energy policies focus on hydrocarbon while opportunities in RE are increasing for electricity generation



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Gas will play a major role to respond to growing energy demand (+7%/year) & decrease GHG emission. It will be massively used in every sector. LPG & NG use is expected to become more widespread in transport.

2. Uncertainties concerning hydrocarbon resources is an opportunity to invest in RE. Many projects are already operational such as the first hybrid solar/gas power plant in Hassi R'mel (150MW capacity) and are expected to be developed and produced on a large scale throughout the country.

3. Local projects are also operational & provide electricity to several municipalities. Solar capacity is likely to increase in rural areas.

Fuel, mobility & LCA policy

Concept plan for the future of mobility in Algeria:
Promotion of lower polluting fuels.
Promotion of LPG/C & NG/C to decrease share of gasoline & diesel vehicles.
Plan to convert 200,000 cars into LPG by 2021.
Taxis should first to benefit from this policy.
Decreasing fuel imports for transport & polluting ICEs (>7L/100km).

Recently (May 2020) promotion of EVs.
- For now it concerns manly EVs production for exportation to European market.
- Imports of used HEVs policy.

Weak signals concerning investments in potential EV market in Algeria from car manufacturers.

Lack of concrete policies for a more sustainable mobility. For now just a preparatory phase.

Messages

Algerian energy sector is destabilised by political issues in the Sonatrach.

Covid-19 consequences on hydrocarbon economy is an open gate for alternatives to develop as shown by the reactivation of Desertec project.

Recent statements from the government suggest that mobility could benefit from the needed shifts.

European shift toward electrification of mobility will have an impact on the car industry in Algeria.

Actualized mobility BAU scenario

1. **No major technological shift is likely to happen in mobility. Share of gas will increase at the expense of diesel & gasoline. Public transport already uses a high share of gas.**

2. Covid-19 & European market may accelerate the ambition for electric mobility. Massive investments & subsidies will be needed for new infrastructures & for promoting EVs.

Other possible scenarios

More probable actualized energy BAU scenario

1. Belgium energy transition plan is limited because of the strong dependency on energy imports & lack of domestic resources. Lack of investments in RE of gas infrastructure make nuclear phase-out complicated. 2 nuclear reactors will still be running waiting for alternatives

2. Engie investments in gas-steam turbines for electricity generation show that gas will be core for the transition in the mid-term. However, in the long term, RE capacity should increase and lead toward a low carbon economy. Major investments in energy storage will be needed. H2 development will be an opportunity for electricity storage.

3. Cogeneration & heat networks (using gas or biomass) are likely to increase, but important investments have to be made.

Secondary actualized energy BAU scenario

1. **Nuclear phase-out is effective by 2025.**
2. **5,9MW from nuclear have to be substituted by RE or gas for electric generation.**

- **Lack of RE capacity on the short term. Massive use of gas to avoid pressure on electric system**
- **Two possibilities for gas plants:**

1) Implementation of small gas plants for local consumption, no need for major investments, & ***easily closable***	2) Major investments in big gas-steam turbine for a central production & distribution. ***Long term investments***
- *Could enable a transition towards RE for power generation on the longer term* - *Heating networks & cogeneration is an opportunity*	- *Long term investment will compromise feasibility of GHG objectives* - *Ensure energy security & power generation* - *On a longer term, possibility to use infrastructure for H2 storage & transportation*

Other scenario for mobility

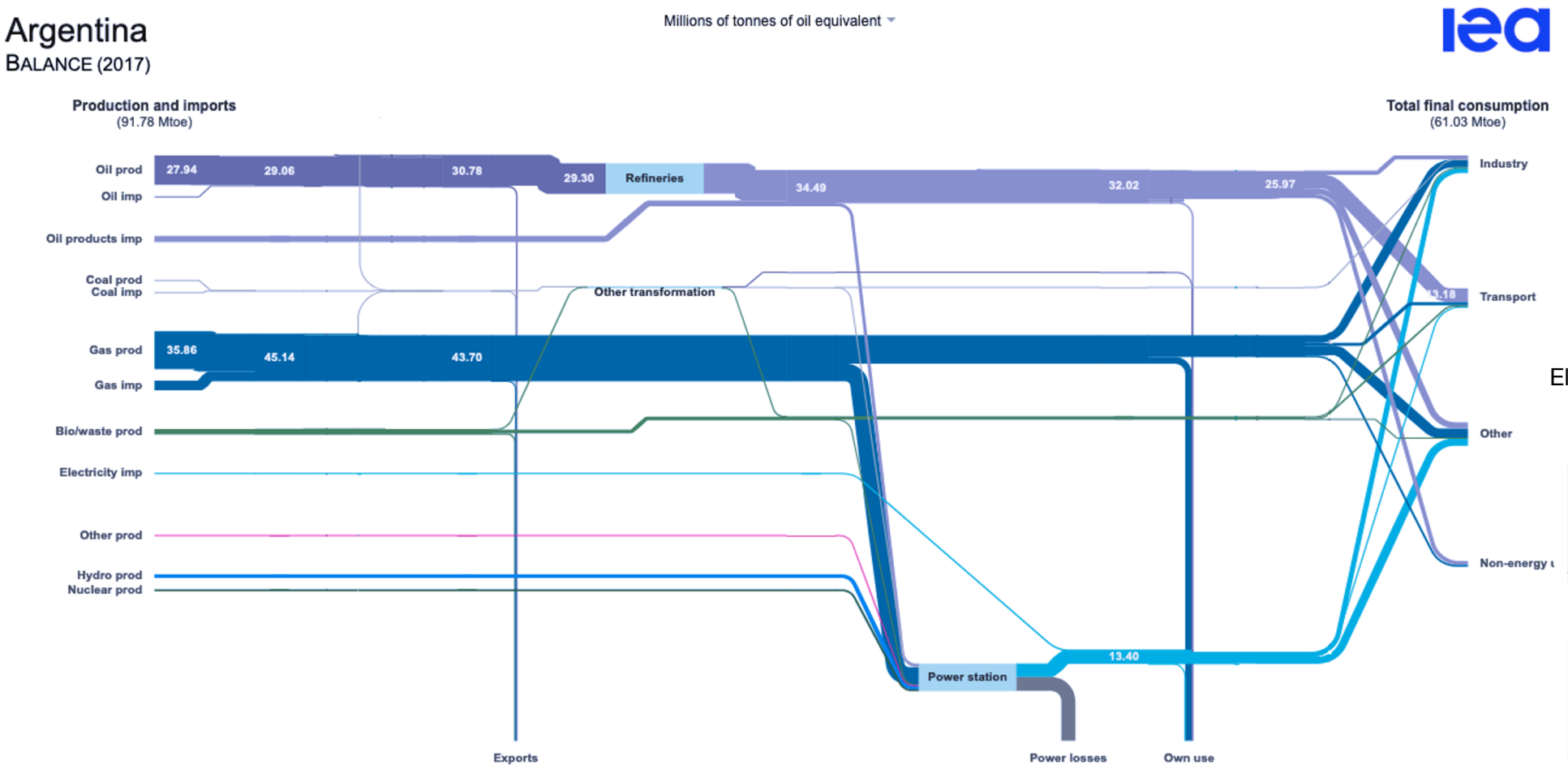
1) **EU pushes forward electrification of mobility:**

- **Integration of electrification in the PNEC**
- **Implementation of more efficient subsidies** for EVs from the federal government and from the regions.
- **Grid operators** invest massively on charging point
- Creation of a possible **EVs market**.
- Municipalities will be the first to shift toward electricity vehicles

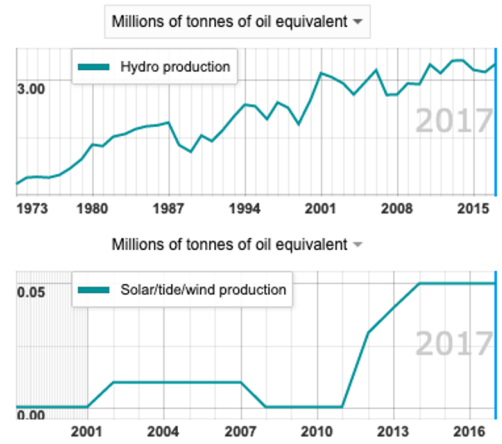
2) **Industry-led for electrification of mobility:**

- Industry will rely on public transport in cities that banned ICE.
- Charging points will increase in & between cities with an active role of grid operators.
- Efficient subsidies need for EVs personal car market development.

1.1 Energy system picture : key system realities



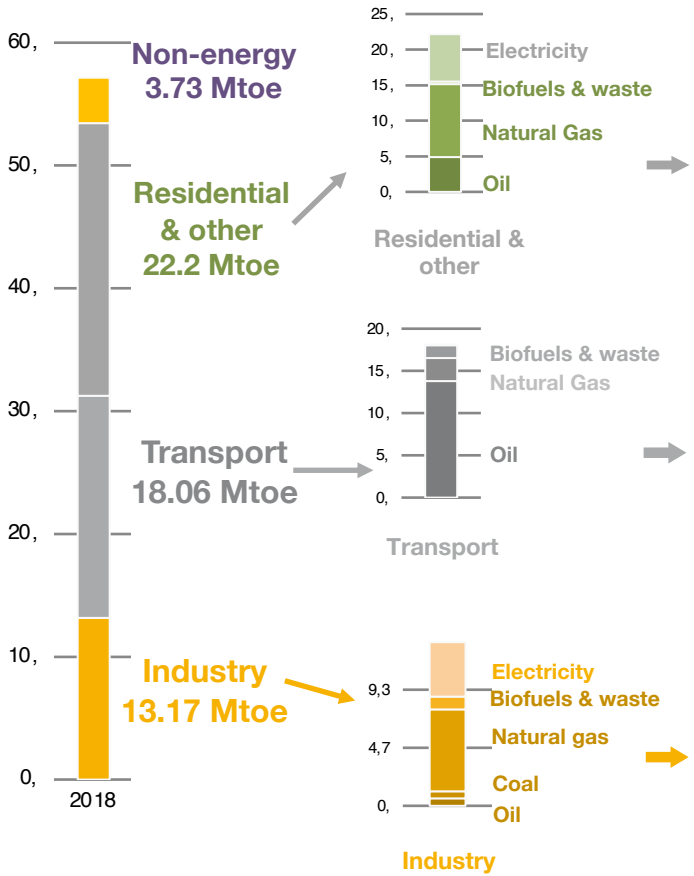
Electric generation from renewables (IEA 2017 data, Mtoe)



Argentina does not depend on neither exports nor imports of hydrocarbons. Natural gas dominates the electricity mix and will be a huge inertia for the residential and industry sectors.

1.2 System inertias & policy drivers

Argentina final energy consumption 2018 : 57.16 Mtoe



Inertias
(by sectors)

Inertia1: gas/electricity duality

- Residential: 63,5% (14,1Mtoe)
  - Gas (62%), Electricity (27%), oil (9%)
- Commerce & public: 20,8% (4,63Mtoe)
  - Electricity (60%), gas (30%), oil (7%)
- Agriculture: (3,38Mtoe) Oil (98%), electricity (2%)

Transport - Inertia2: oil dependency
Inertia 3: efforts in gas transportation

- Road : 90% (16,41Mtoe)
  - Oil (79%), **gas (12%), biofuels** (9%)

Industry - Inertia3: gas dominance

- Non-specified: 22% (2,90 Mtoe)
  - Gas (38%), biofuel (36%), oil (21%)
- Food and Tobacco: 20% (2.64 Mtoe)
  - Gas (59%), electricity (41%)
- Iron and Steel: 14% (1,89 Mtoe)
  - Gas (46%), electricity (28%), coal (27%)

Policy drivers
(on energy and/or sector)

Objectives : reduce GHG emissions by 18% in 2030, respect international agreements
Our view: adapted objectives, though would need a strong political structure in order to be achieved
Timeframe : 2030-2050
Governance type: government, industry-led

Driver 1: Decrease fossil energy consumption

- Weight on total supply: 36.8% (10.66 Mtoe)
- Objectives: decrease oil consumption from 31% to 26% of total energy mix by 2030 & maintaining natural gas consumption at high levels

Driver 2: RE Investments

- Weight on total supply: 8.7% (7.83 Mtoe)
- Objectives: 25% of RE (wind + solar) + 29% of hydro in the electricity mix in 2030
- Grid operators will have to face a technology gap to implement RE in the electrical network

Driver 3: Energy efficiency

- Weight on total use: 32.7% (18.73 Mtoe)
- Objectives: improve energy efficiency in public infrastructures and residential equipment

Minor driver 4: Nuclear reinforcement

- Weight on total supply: 2% (1.8 Mtoe)
- Objectives: renovate old nuclear plants and open 2 new nuclear plants by 2030, increase nuclear electricity production from 2% to 13% of electricity mix by 2030
- Public investments and subsidies will be key

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)	Coupling (dynamics on energy-to-energy, energy-to-use and use-to-use)
Residential - Inertia1: gas/electricity duality	**Energy efficiency** **RE investments** **Nuclear reinforcement**	Coupling1: inter energy-use coupling: gas is key to face energy demand growth • Gas will remain high in sectors such as industry & residential • Gas will substitute oil • Weight on total supply: 43.91Mtoe (49%)
Transport – Inertia2: oil dependency Transport – Inertia3: efforts on gas transportation	**Decrease fossil energy consumption**	Coupling2: electricity generation greening in relative share • RE will substitute oil & coal • RE (hydro included) & nuclear will relieve pressure on gas for electricity production • Weight on total supply: 5.3 Mtoe (22%)
Industry- Inertia4: gas equipment dominates	**Nuclear reinforcement** **RE investments** **Energy efficiency** **Decrease fossil energy consumption**	Coupling3: a greening mobility to face urban issues • Biogas share especially biomethane will increase while relative share of oil will decrease • Urban population: 90%, urban mobility will change to face public health issues in big cities Coupling4: Uncertainty on relevant regulation for RE development • RE development will depend on an uncertain regulation to compensate for low hydrocarbon prices

Structuring issues

Issue1: Lack of electricity supply infrastructures for RE implementation

- *Weight on total energy supply: 19.3% (11.07 Mtoe)*
- Diversification of electricity supply through RE and nuclear investments but lack of supply infrastructures, hence an unexploitable potential
- Sectors concerned: industry, residential and other

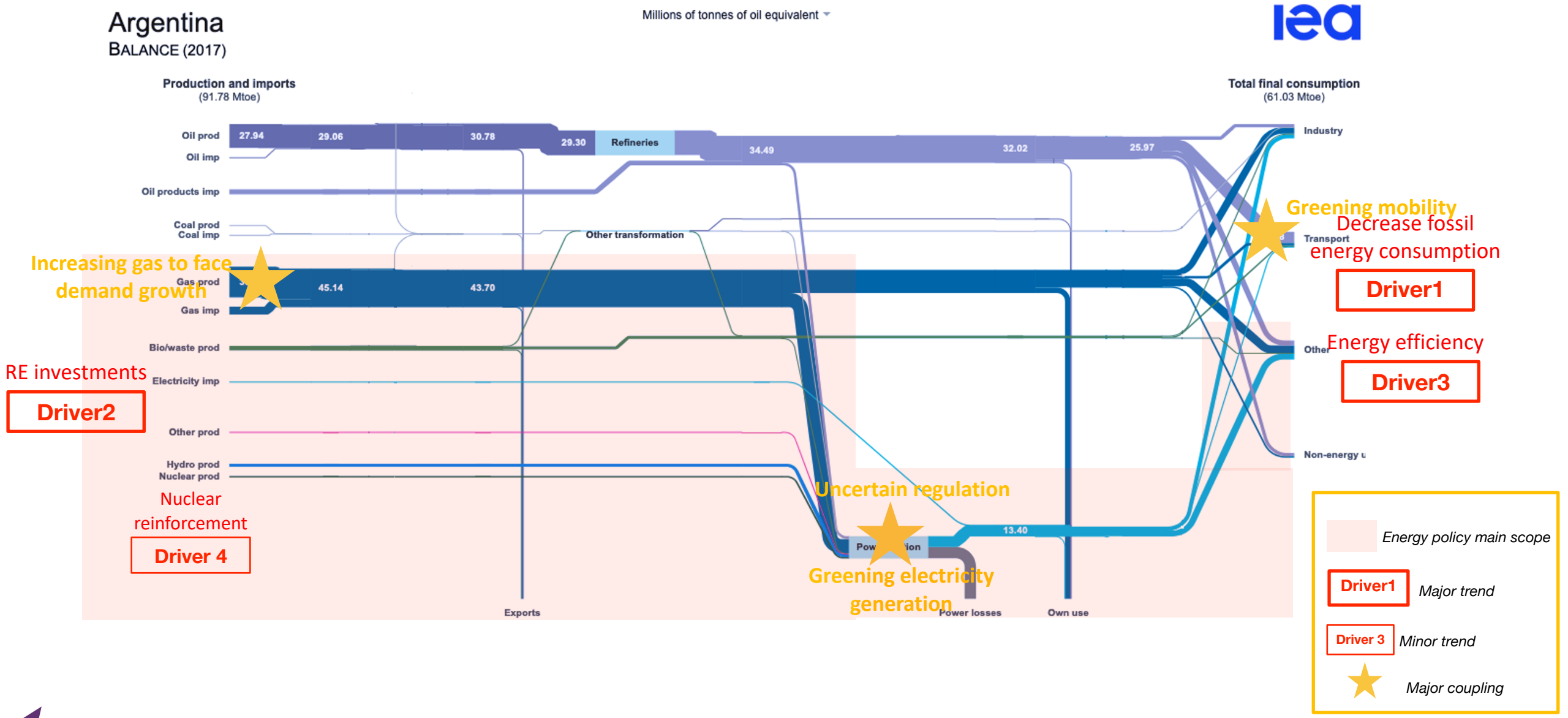
Issue2: Political role in energy transition

- *Weight on total use: 84.3% (43.16 Mtoe)*
- Low fossil energy prices and lack of government measures do not facilitate investments in RE

Issue3: Energy efficiency as a major tool to achieve international agreement

- Every sector is concerned
- Efficiency of implemented policies
- Action at the local level: need of municipality cooperation

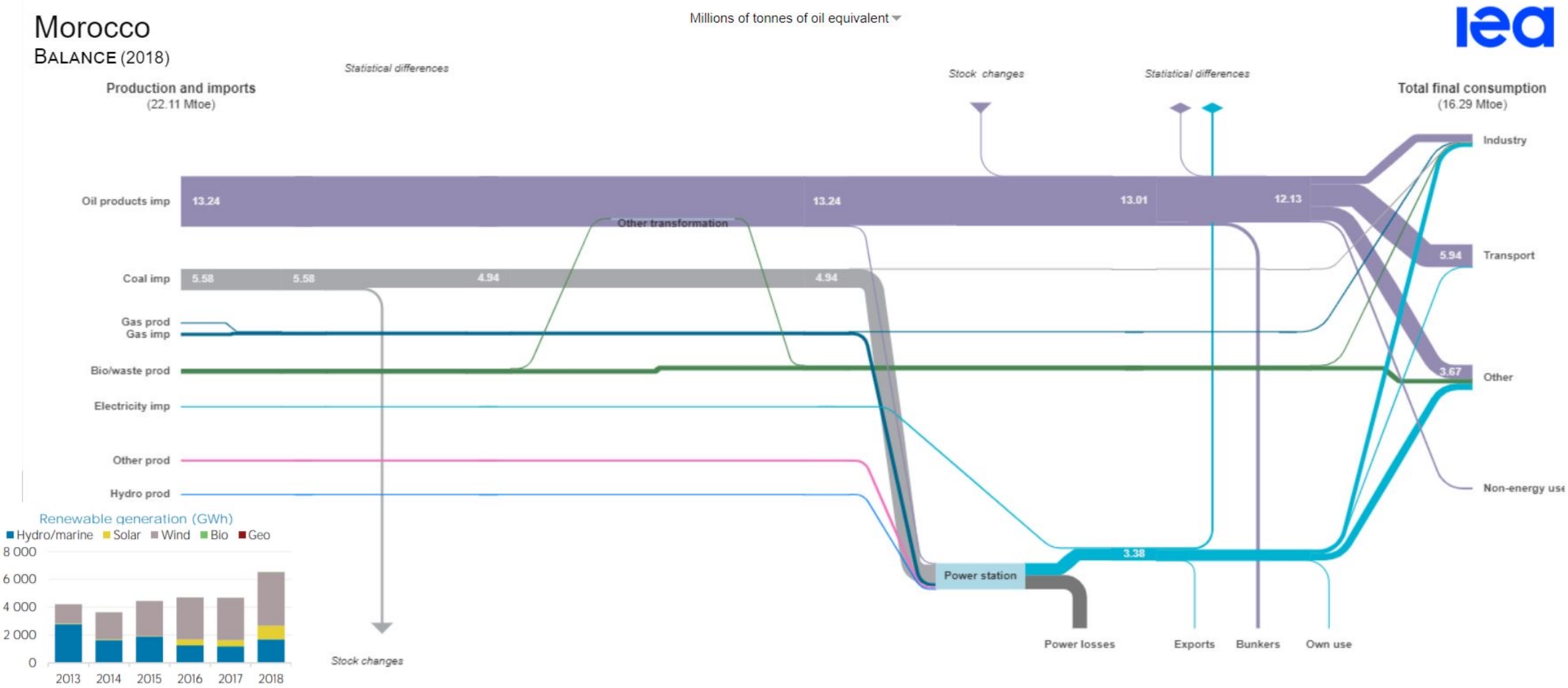
1.4 Argentina energy transition relies and gas use, investments in RE and energy efficiency



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario	Fuel, mobility & LCA policy	Messages	Actualized mobility BAU scenario
1. Argentina will leverage current investment pipeline focused on gas production. Stable gas prices will support the staggering economy.			1. Flex-fuel gas vehicle is the government objective.
2. In this investment sequence, to solve local air pollution, gas mobility will be promoted while gas will be greened through biomethane development and grey H2.	**Mobility is not yet a government priority.**	Mobility policy is only focused on gas mobility through the concept of flex-fuel.	2. Investments in O&G support this objective but there is no sign of downstream industrial policy or R&D.
3. In a second phase, CCS will help decarbonize grey H2. Depending on governance restructuration, renewable investment may boom again to support gas mix.	No specific LCA regulation on mobility.	No LCA policy in mobility	3. For the current investment cycle, mobility shift will be funded with international development projects.

1.1 Energy system picture - Key system realities



Electric generation from renewables (Irena 2018 data, GWh)

Our analysis : Oil dominates all end-use sectors creating major dependency on imports from Saoudi Arabia. Coal is key to electricity generation and solar and wind are soaring in electricity mix

1.2 Energy policy agenda - Main objectives and pathways

	High-speed technology adoption	Low-speed technology adoption
Fast growth		
Slow growth		

Objective : industrialise Moroccan economy with green energy sources to enter EU market

Timeframe : 2040

Governance type : Bureaucracy

Driver 1 : end-uses efficiency

- Total share mix concerned : 8% (1.3 Mtoe)
- Objectives : 1.3 Mtoe/year avoided in 2030
- Targets for actors : industries, developpers, households

Driver 2 : electricity generation greening

- Total share mix concerned : 23.4% (2.79 Mtoe)
- Objectives : emission reduction of 17%- 42% is expected by 2030
- Targets for actors : electricity generation, solar & wind development

Driver 3 : Industry process greening

- Total share mix concerned : 20.7 % (3.31 Mtoe)
- Objectives : no specified objective
- Targets for actors : industries, coupling with electricity generation

Minor drivers :

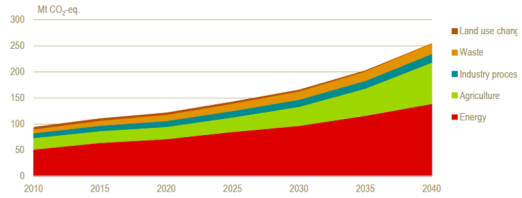
- Driver 4 Vehicle fleet renewal scheme : *unknown objectives - fleet companies, households, regulation*

Policy targeting couplings

- Germany-Morocco agreement on green H2 cooperation: 2 Power-to-X projects - *still unknown objectives*

Country energy policy illustration

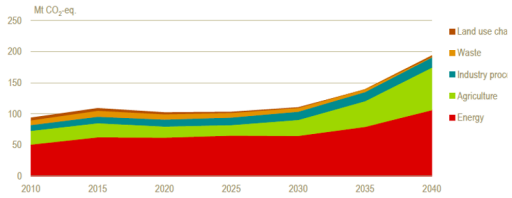
Figure 3.7 Morocco's GHG emissions by source in the baseline scenario



Notes: "Energy" - Energy use in the end-use sectors (buildings, transport, industry, agriculture, etc.) and energy transformation (power generation etc.); "Agriculture" – N_2O and CH_4 emissions from agricultural soil and agricultur processes such as fermentation and animal manure.

Source: Government of Morocco, Third National Communication to the UNFCCC, 2016.

Figure 3.8 Morocco's GHG emissions by source in the non-conditional scenaric



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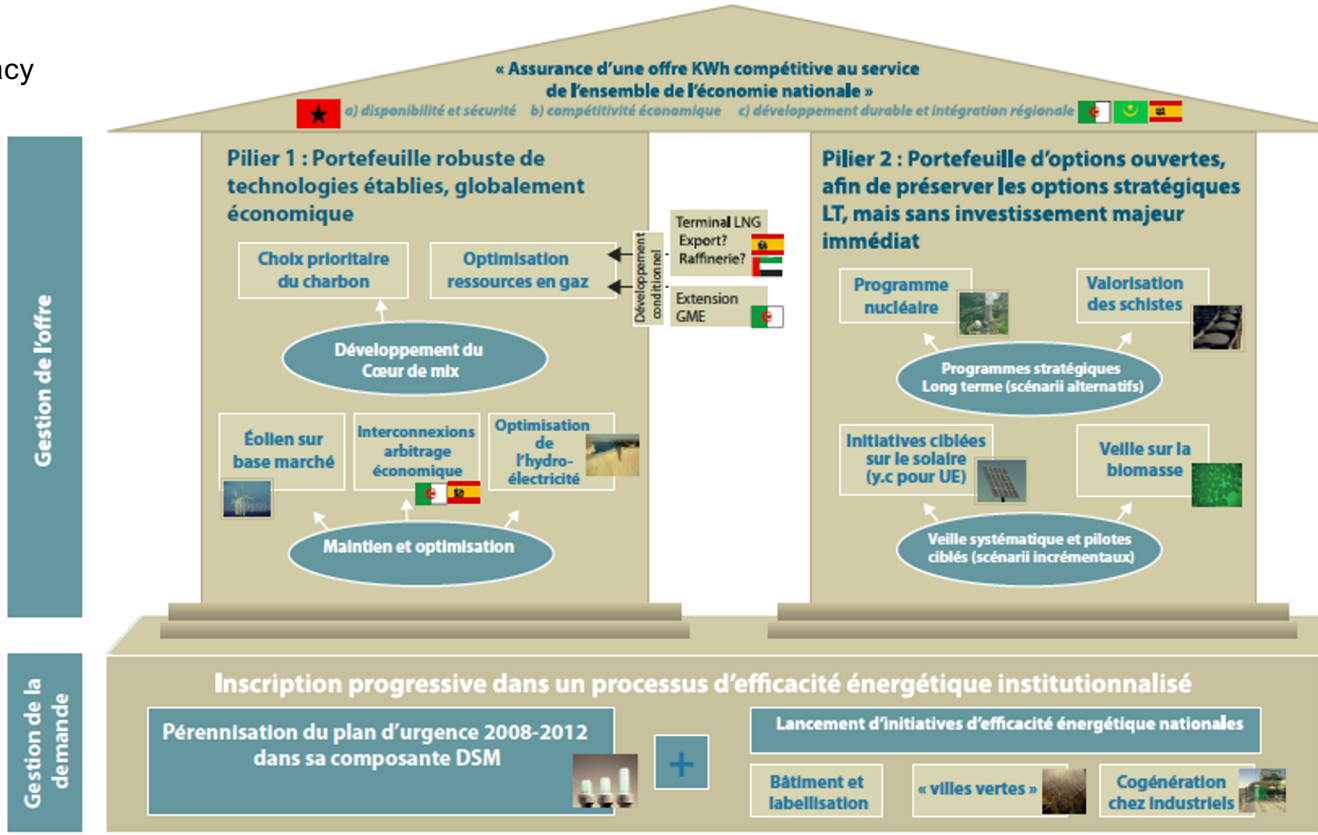
Source: Government of Morocco, Third National Communication to the UNFCCC, 2016.

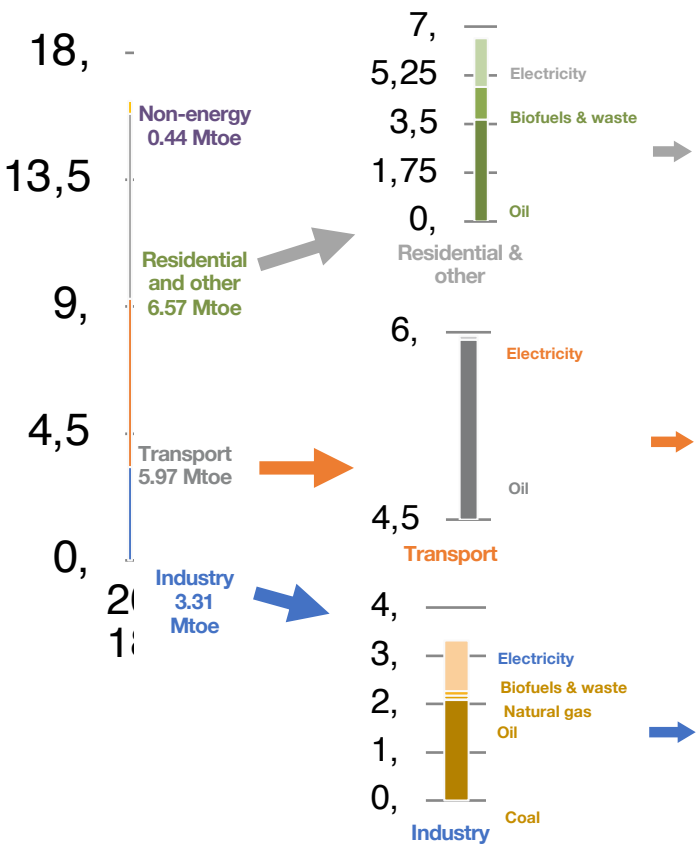


Source : National Energy Strategy (2011)

Morocco has a comprehensive energy transition plan but set main actions to be a green development leader in Africa : 1) end-uses efficiency 2) electricity generation greening and 3) industry process greening
In the new report the government define a new energy strategy to consist to become a regional and then international hub of competitive and carbon-free energy

1.3 Coupling analysis - Coupling and gaps in transition pathway

Country final energy consumption 2018 : 16.29 Mtoe



Inertias
(by sectors)

Residential - Inertia1 : oil dominance
Inertia 2 : Biofuels used in commerce

- 6,57 Mtoe
- Residential : 61.64% (4.05 Mtoe)
  - **Oil** (63%), electricity (24%), biofuels & waste (13%),
- Commerce & public : 19,8% (1.29 Mtoe)
  - **Biofuels&waste** (51%), electricity (37%), oil (12%)
- Agriculture & force : 18.6% (1.22 Mtoe)
  - **Oil** (76%), electricity (24%)

Transport - Inertia2 : oil dependent

- 57.97 Mtoe
- Road : 99.0% (5.90 Mtoe)
  - Oil (100%)
- Rail : 0.7% (0.04Mtoe)
  - Electricity (75%), oil (25%)

Industry - Inertia3 : industry 1 coal dependent

- 3.31 Mtoe
- Top 3 energy intensive sectors
- Non-metallic minerals : 45.3% (1.50 Mtoe)
  - **Oil** (79%), electricity (13%), biofuels (6%)
- Mining&Quarrying : 19.9% (0.66 Mtoe)
  - **Oil** (59%), electricity (38%), gas(0,02%)
- Food&Tobacco : 11,48% (0.38 Mtoe)
  - **Oil** (55%), electricity (39%), coal (5%)

Policy driver
(on energy and/or sector)

Drivers directly concerning residential

- End-use efficiency: objective 0.9 Mtoe/year avoided in building sector (Driver1)
- Electricity generation greening acts as coupling (Coupling1)

Drivers directly concerning transport

- Vehicle fleet renewal scheme (Driver 4)

Drivers directly concerning industry

- End-use efficiency:
  - objective 0.4 Mtoe/year avoided in industry (Driver 3)
  - No specified measures are taken

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1 : electricity generation greening

- Inter-energy : 100% renewable additional green capacity target on stable coal-based electricity production
  - electricity generation : 3.34 Mtoe (coal 66%, oil 14%, gas 13%)
  - renewable accounts 6% and is expected to rise up

Coupling2 : Power-to-X developments

- Inter-energy stimulation : renewable electricity and gas – green hydrogen and production of green molecules as ammonia
  - to capture between 2% and 4% of global demand

Structuring issues

Issue1 : oil dominance on mix

- Share in total mix : 79% (12.74 Mtoe)
- Coupling with electricity in industry and residential : substitutability
- Sector concerned: All

Issue2 : electricity greening

- Share in total mix : 17.5% (2.82 Mtoe)
- Coupling : additionality with coal production
- Sector concerned: Industry, residential

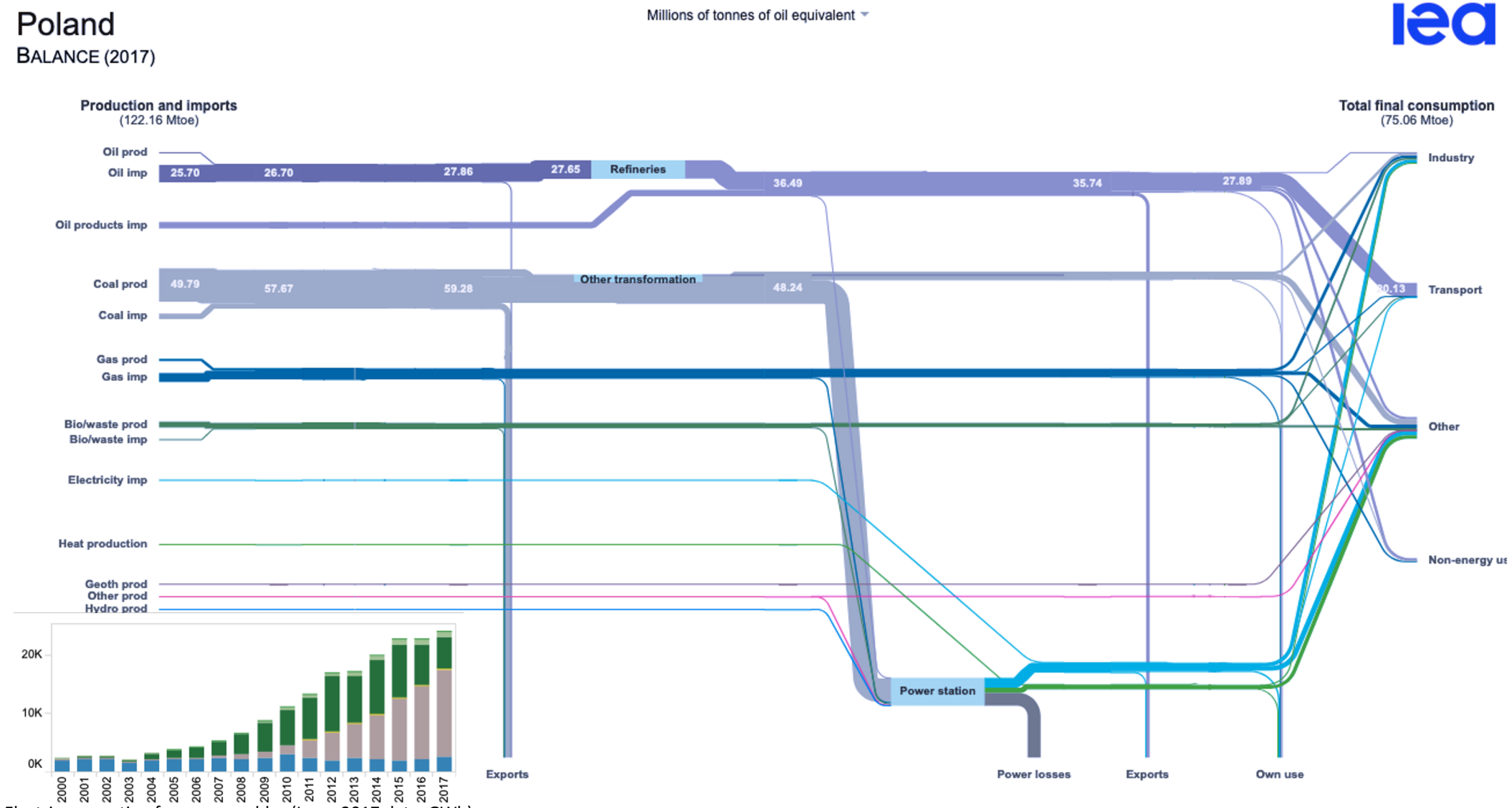
Issue3 : end-use efficiency

- Share in current mix : 8% (1.3 Mtoe)
- Coupling with oil: efficiency in demand and substitutability with electricity
- Sector concerned: industry, residential

Our analysis : stable fossil base + target 100% additional green capacity (Coupling1) **and gas/electricity stimulation logic through Power-to-X and H2 development** (Coupling2)

Structuring issues that will condition scenarios
1) oil dominance on every sector, 2) electricity mix greening and 3) end-use efficiency

1.1 Energy system picture : key system realities

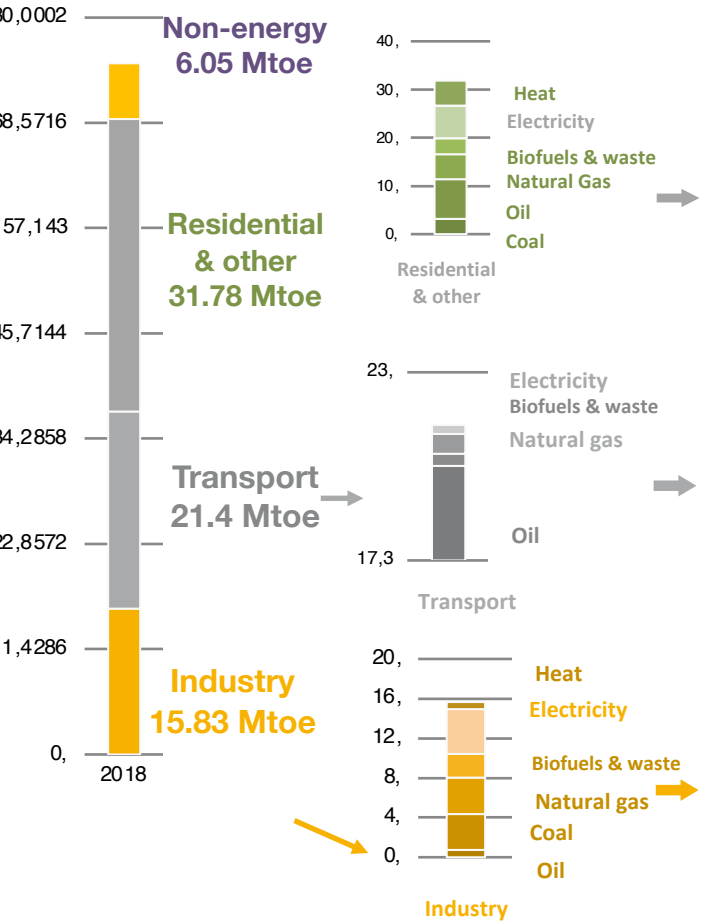


Electric generation from renewables (Irena 2017 data, GWh)

National coal is key to Poland energy mix and its national autonomy from gas imports. We can monitor RE investment since the country entered the EU in 2004.

1.2 System inertias & policy

United Kingdom final energy consumption 2018: 128.9 Mtoe



Inertias
(by sectors)

Residential - Inertia1: households and agriculture coal dependency

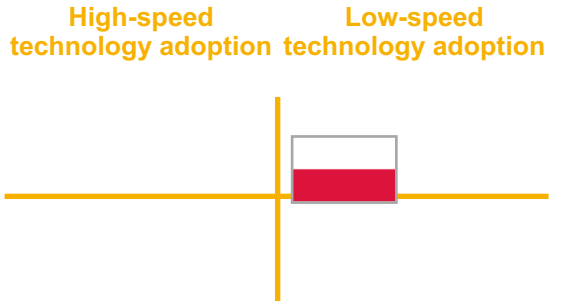
- Residential : 62.6% (19.9Mtoe)
  - **Coal (33%),** Heat (20%), gas (18%)
- Commerce & public : 26% (8 Mtoe)
  - Electricity (50%), gas (18%), heat (14%), coal (8%)
- Agriculture & forest : 12% (3.9Mtoe)
  - Oil (56%), **coal (25%),** biofuels (13%)

Transport - Inertia2: oil dependency

- Road : 96.4% (20,01 Mtoe)
  - Oil (97%), biofuels (3%)

Industry - Inertia3: chemicals coal dependency
Inertia4: large share of biofuels

- Non-metallic minerals : 18.8% (2.98 Mtoe)
  - **Gas** (36%), biofuels(23%), **coal**(21%), electricity (16%)
- Chemical : 17.4% (2.76Mtoe)
  - **Coal**(44%),electricity(27%)
- Food & Tobacco: 13% (2.06Mtoe)
  - Gas(35%), **coal**(28%), electricity(28%)



Policy drivers
(on energy and/or sector)

Objectives : climate neutrality by 2056-2067
Our view: unstructured transition
Timeframe : 2070
Governance type : public investment led policy

Driver 1: Energy security through diversification

- Weight on total supply: 12% (15 Mtoe)
- Objectives: diversify energy sources to stop possible dependance on Russian gas while ensuring the pursuit of the steadiest growth in the EU
- LNG terminals are being built to import Northern Sea gas. Improving coal plants for a mid term vision. Electricity imports are increasing from EU countries

Driver 2: Energy efficiency

- Weight on total supply: 46% (57 Mtoe)
- New generation coal units are being built. New supercritical process are used to reduce the use of lignite and thus improve air quality.

Driver 3: Coal phase-out and RE/nuclear investments for substitution – 2040 horizon

- Weight on total supply: 29% (38 Mtoe)
- Concession to the EU energy climate policy coupled with lower demand for coal and Covid-19 crisis led the government to invest massively into nuclear (€33bn) & RE (€29bn)

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)	Coupling (dynamics on energy-to-energy, energy-to-use and use-to-use)
Residential – Inertia1: Households and agriculture coal dependency	**Nuclear and RE investments** **Gas diversification**	Coupling1: inter-energy electric base addition • Electric base will rise with residential equipment and tertiary sector with nuclear energy use • Weight on total supply: gas (23.4 Mtoe) + imports (1.8 Mtoe) + nuclear (17 Mtoe) = 42.2 Mtoe (15.8%)
Transport – Inertia2: Oil dependency		Coupling2: inter-energy electric peak substitution • LNG and small RE will substitute to pipeline natural gas for electric peak • Weight on total use: 25.8 Mtoe (20%)
Industry – Inertia3: Chemicals are coal dependent	**Energy efficiency**	Coupling3: steady industrial growth • Maintaining a steady growth trajectory through industrialization is key to Poland national project
Industry – Inertia4: Large share of biofuels		**Coupling4: social coupling middle-class prosumer development** • Middle-class tend to invest in line with social movements and German culture influence

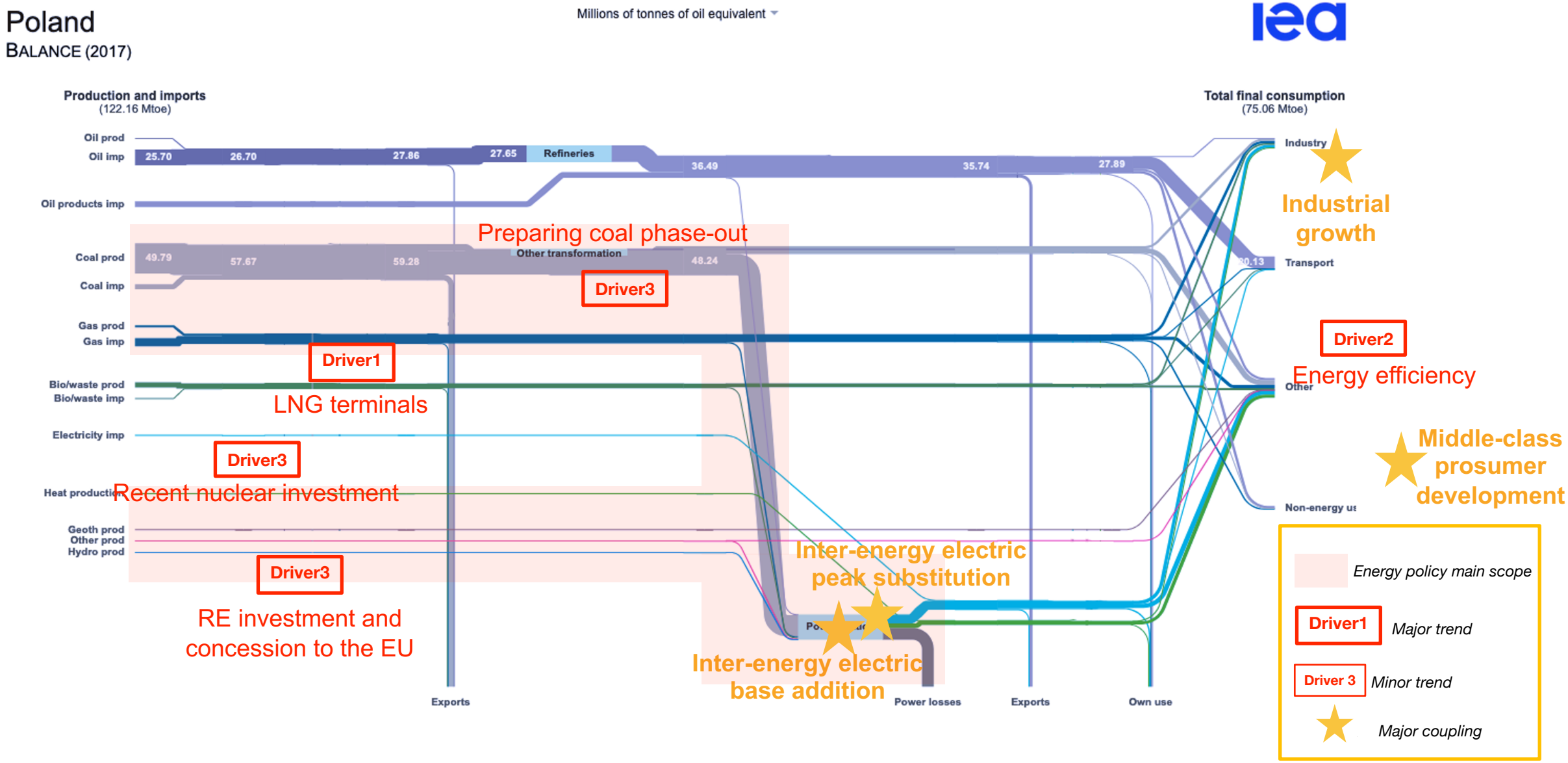
Structuring issues

Issue1: controversial coal legacy
- *Weight on total energy supply: 20% (25.8 Mtoe)*
- Coupling with gas
- Sector concerned: industry, mobility residential and other

Issue2: energy growth & security
- *Weight on total energy use: 50%*
- Sectors concerned: industry, construction, transports, power

Issue3: EU *conflictual* integration via energy-climate
- Poland is seen as a European latecomer in terms of energy transition
- Recent coal phase-out policy (2020)
- Need to benefit from EU funding for green energy development

1.4 Uncertainty concerning coal legacy, European pressure for RE development & energy security oblige Poland to diversify its energy mix



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Poland will pursue upstream investments on coal until 2025 while profitability decreases to maintain industrial growth trajectory. Households coal heating will carry on.

2. Weak signals from middle-class behaviour and EU investment is structuring a next phase for RE. **H2 will probably be a field preparation work for some industry (energy storage).**

3. Sustainable mobility will be part of the efforts package to meet a proxy EU climate target.

Fuel, mobility & LCA policy

5 February 2018 Act on electromobility and alternative fuels:

- incentives to promote purchase of electric car;
- development of charging points & refuelling infrastructure (charging point & CNG, LNG refuelling stations)
- Framework for H2 potential, with use of current NG pipelines.

It transposes Directive 2014/94/EU

Development of electromobility & EVs via ElectroMobility Poland, a public company established on the initiative of state-owned energy companies. Objective: 1 million EVs in 2025.

Promotion of shared mobility

EU Circular Economy Action Plan (section 3.2 Vehicles and batteries)

- Revision of the Battery Directives
  - Ban on non-rechargeable batteries
  - Recycling rates for all batteries (target still undefined)
- End-of-life vehicles package to promote material reuse

Messages

Promotion of sustainable mobility via ambitious electromobility objectives. Electromobility is a structured concept developed by the government & energy majors.

Use of Poland industrial capacity for producing batteries to develop a domestic car industry.

Be in phase with European dynamisms for mobility.

Actualized mobility BAU scenario

1. Role of municipality is key to implement infrastructure for electromobility. Public vehicles and public transportation is likely to be first to shift to electricity.

1. Urban mobility's culture relies on public transport. Capacity of shared mobility is to increase in cities.

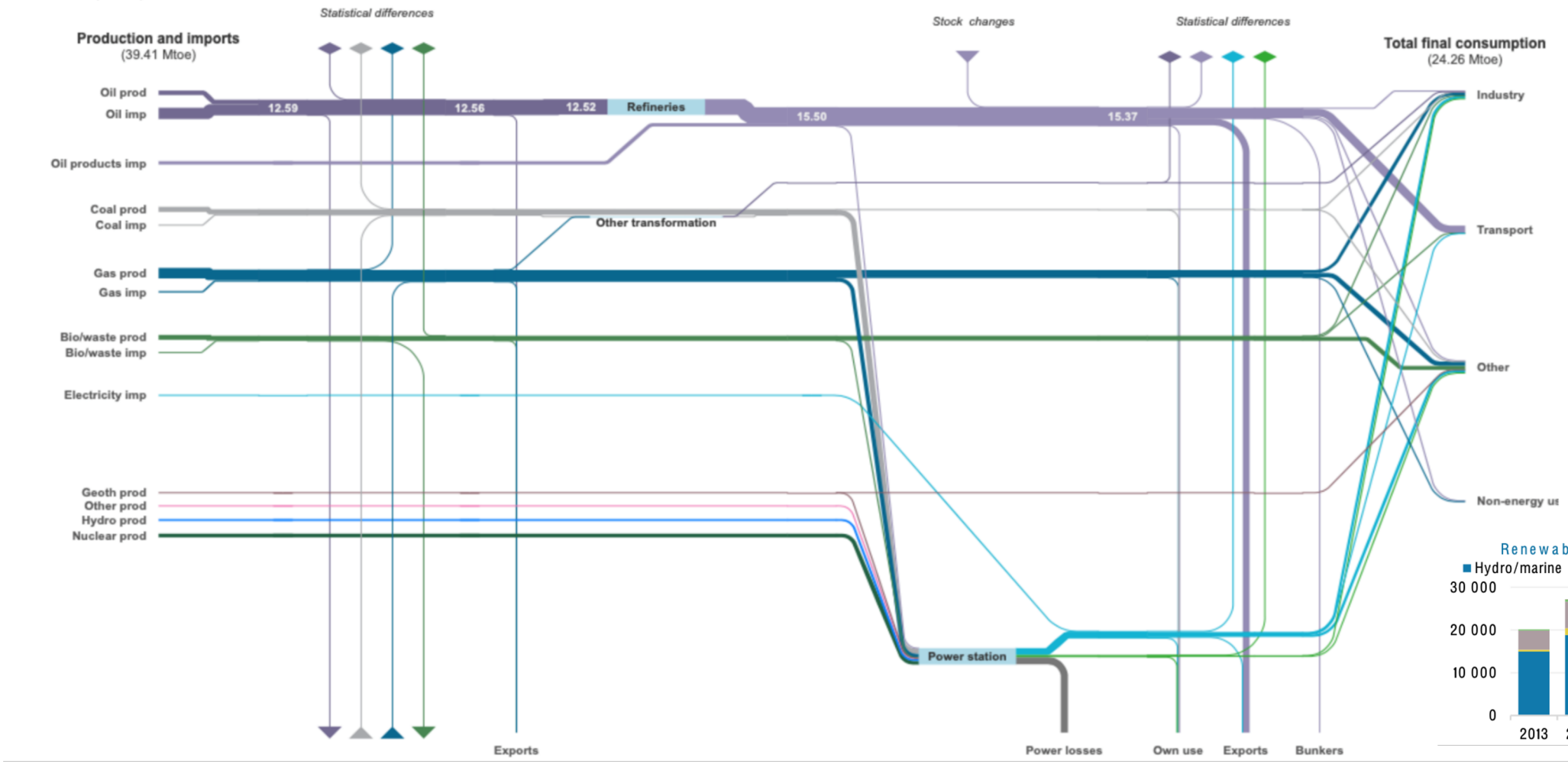
2. EVs are to increase but lack of infrastructures will compromise EVs development. Objectives are not likely be reached by 2025.

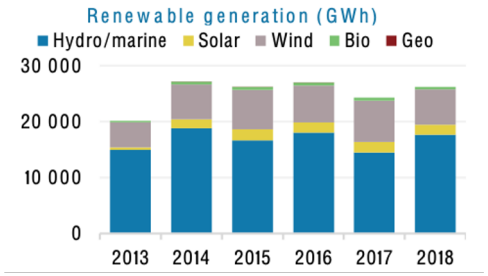
1.1 Energy system picture : key system realities

Romania

BALANCE (2018)

Millions of tonnes of oil equivalent



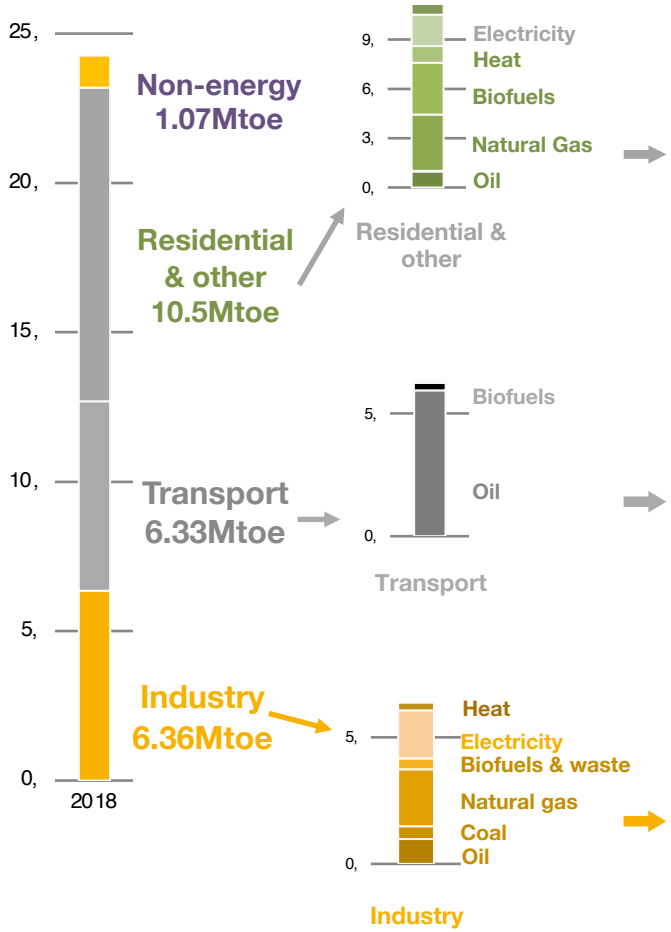


Electric generation from renewables (Irena 2017 data, GWh)

Romania energy mix relies on gas & coal production & oil imports. Nuclear production has a high share in the electric mix. RE production is not increasing.

1.2 System inertias & policy drivers

Romania final energy consumption 2018: 24.26Mtoe



Inertias
(by sectors)

Inertia1: gas dominance
Inertia2: biofuels share is high in residential

- Residential: 73.5% (7.72Mtoe)
  - Biofuels (39%), gas (33%), electricity (14%), heat (10%)
- Commerce & public: 19% (1.96Mtoe)
  - **Gas** (41%), **electricity (38%),** heat (9%), biofuels (6%)
- Agriculture: (0.55Mtoe) Oil (65%), gas (20%), electricity (11%)

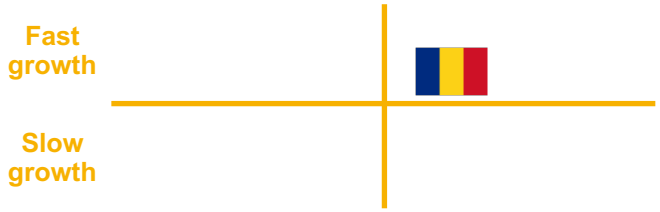
Inertia3: oil dependency despite relatively high share of biofuels

- Road : 96% (6.05Mtoe)
  - Oil (95%), **biofuels (5%)**

Inertia4: gas/oil equipment duality
Interia5: steel-making still running on old coal equipment

- Chemical & petrochemical: 22% (1,43Mtoe)
  - **Gas (41%), oil (22%),** electricity (20%), heat (13%)
- Non-metallic minerals: 17% (1,11Mtoe)
  - **gas (33%), oil (28%),** electricity (20%), biofuels (13%), coal (6%)
- Iron & Steel: 15% (0,96Mtoe)
  - **coal (44%),** gas (34%), electricity (22%)

Policy drivers
(on energy and/or sector)



Objectives : reducing GHG emissions by 9% from 2020 to 2030 (in 2020: - 34.7% from 2005)
Our view: cautious objectives, in line with the minimum EU requirements
Timeframe : 2030
Governance type : central government, 41 counties and one city with special status

Driver 1 : Gas investments to substitute coal in the long-term

Weight of coal and gas on total energy supply: 37.07% (14.61 Mtoe)

- Developing new gas-fired capacities with total installed capacity of 1,400 MW
- Investment in tapping natural gas resources in the Black Sea area & in gas storage capacity
- Closing two uncompetitive coal mines by 2021 but no clear framework for coal replacement

Driver 2 : RE investments

Weight of renewable energy on total energy supply : 15.96% (6.29 Mtoe)

- Objective: 30.7% of renewable energy in gross final energy consumption (vs. 24.5% in 2017)
- Target share of RE: 50% in electricity, 14.2% in transport, 33% in heating and cooling
- Wind: + 2,302 MW & solar: + 3,692 MW additional installed capacity from 2020 to 2030

Driver 3 : Energy efficiency

Target energy savings in the residential sector, industry sector and transport sector.
Weight of these sectors on total energy consumption: 84.23% (20.41 Mtoe)

- Objective: decrease the growth in final energy consumption to achieve 27.7 Mtoe by 2030 (vs. 23.53 Mtoe in 2018)
- Focus on cooling & heating systems: 50% of gross final energy consumption in 2030

Minor driver 4 : Electromobility

Weight of electricity in final consumption for the transport sector: 1.42% (0.09 Mtoe)

- Road transport: increase the use of RE by 24% from 2020 to 2030, promote the use of biofuels & electricity, renew the vehicle stock
- Rail transport : increase RE by 108% & triple the length of the high-speed rail network by 2030

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)
Residential - Inertia1: gas dominance	**Gas investments**
Residential – Inertia2: biofuels share is high	**Energy efficiency**
	RE investment
Transport – Inertia3: oil dependency despite relatively high share of biofuels	**Electromobility**
	Energy efficiency
Industry- Inertia4: gas/oil equipment duality	**Gas investments**
	RE investment
Industry- Inertia5: steel-making still running on old coal equipment	**Energy efficiency**

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1: maintaining use of coal while gas & RE infrastructures remain insufficient
- *Weight of coal on total supply: 12.5% (4.92Mtoe)*
- *No framework or timeframe for reducing coal use*
- *Coal will still be used until gas and RE ensure sufficient large-scale production*

Coupling2: RE addition in the electricity mix
- *Renewable energy (2.41Mtoe) will supplement coal (4.29Mtoe) in the electricity mix*
- *Relative share of RE may increase, but coal and gas (3.01Mtoe) will remain the electricity generation base*

Coupling3: inter-use competition for electricity
- *Weight of electricity on total use: 16.2% (3.9Mtoe)*
- *Power generation will rise while mobility will electrify, in conflict with current uses*
- *There will be a competition between sectors for the access to electricity*

Coupling4: energy efficiency of electrified uses & electrification of mobility
- *Energy efficiency policy could relieve pressure on the electric system*
- *It would enable to limit the final consumption of electricity of current electrified uses*
- *Current power generation could be used for electrification of mobility*

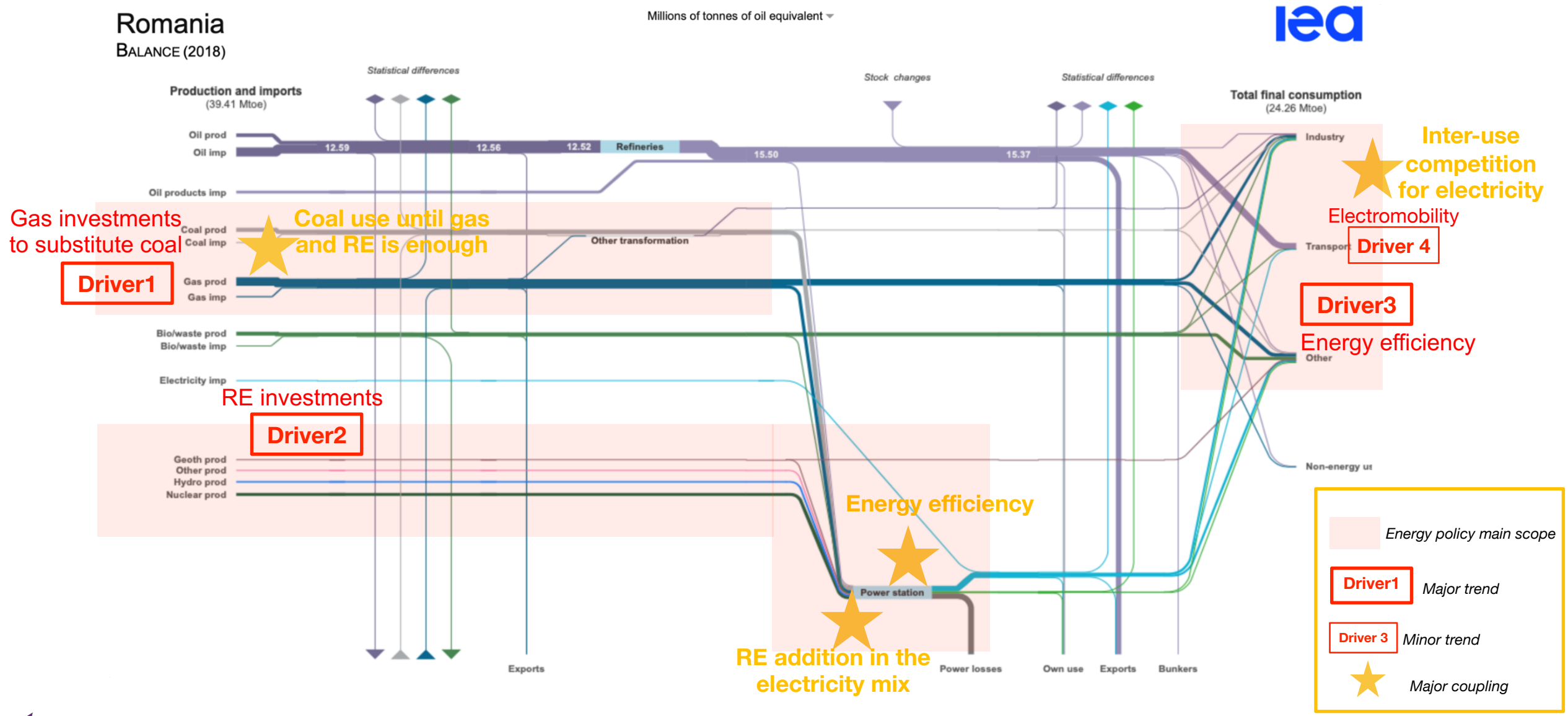
Structuring issues

Issue1: coal will remain important until at least 2030
- Coal will remain a significant share of the electricity mix
- Almost all coal power plants in Romania are state-owned and supported by the state
- Two counties are dependent on the coal industry: 28,600 jobs at stake
- The emissions of these industries are still above the legal limits
- *Weight on total supply: 12.5% (4.92Mtoe)*

Issue2: EU integration
- EU funding are the main source of investments for the development of Romania's RE
- European partnerships needed for energy exploration: associate with Bulgaria, Hungary and Austria for taking over the natural gas from the Black Sea shore
- Respecting the European regulations and recommendations in order to benefit from financial aids

Issue3: Energy efficiency
- Notion that relies on European Commission energy efficiency model
- Notion that encompasses energy savings, building renovation & public sector exemplarity
- Controlling oil imports & hydrocarbon uses for electricity generation

1.4 An advanced transition which focuses on new forms of energy production



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Romania's energy transition follows EU directives. Romania is a long-term hydrocarbon producer which makes the country relatively energy autonomous. ***No concrete coal phase-out policy for now.***

2.Nevertheless, coal use for electricity generation is likely to decrease at the profit of cogeneration gas plants. Gas + recent American investments ($8bn from AECom, October 2020) into 2 new nuclear reactors (500MW) will shape the base of the electricity mix.

3. Electrification of the economy will also rely on RE increasing capacities for electricity generation. Onshore wind has become cheaper than any other energy for electricity generation & is likely to increase. Solar is also likely to increase significantly.

4. Mobility via electromobility concept, is core for energy transition policy in Romania. It concerns particularly light vehicles & public transport vehicles.

Fuel, mobility & LCA policy

Concept plan for the future of mobility in Romania**: long term strategy for European integration**

1) <u>Electromobility program for light vehicles & urban public transport</u>

- implementation of charging points across country, specially on the Sibiu-Pitesti Motorway (motorway connection from the EU western border to the Black Sea ports); EXT-E project.
- tax reductions & exemptions for the purchase of EVs (100% exemption) or HEVs (50%), in particular for companies' fleets (example: exemption of parking fees in Bucharest Municipalities in 2016).

DIR. (UE) 2019/1161 - Clean Vehicle Directive - published in 12 July 2019)
Rabla Pus Program: €9200 subsidies for EV & 4000€ for HEV purchase.
October 2020, Electric-up program: strong subsidies for PV solar & charging points development

2) <u>Promotion of biofuels to decarbonize transport:</u>

- introduction of advanced fuels in road transport
- Fostering investments in advanced ethanol production

No specific LCA regulation on mobility.

Messages

Electromobility concept is a major tool for improving energy efficiency & decreasing GHG emission in Romania. Electromobility concerns especially urban mobility.

Efforts toward a more sustainable mobility are part of the EU integration policy. Most of funding for electric mobility infrastructures are from EU.

No concrete coal phase-out policy would compromise RE development in the electricity mix & decrease the impact of the electrification of the economy for decreasing GHG emissions.

Actualized mobility BAU scenario

1. Romania is planning electrification of mobility from upstream. EU directives & municipalities policies will be key to implement new EVs. EVs fleet could reach 300,000 vehicles in 2030 with 25,000 charging points across the country.

2. Electric PCs & LCVs are core of the electrification strategy & could reach a penetration of 18,7% according to APIA (Automotive Manufacturers & Importers Association) in 2025.

3. Buses will also electrify in cities. APIA forecasts a penetration rate of 33% by 2030. Buses will also use alternatives fuels such as bioethanol or hydrogen.

4. Municipality policies also promote micro-mobility with electric scooter for rent in Bucharest & Timișoara. Taxi license policies also encourage EVs & aim 50% of electric taxis by 2030.

5. Alternative fuels (biofuels & hydrogen) for HDVs are likely to develop in the longer term.

2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. Romania's energy transition follows EU directives. Romania is a long-term hydrocarbon producer which makes the country relatively energy autonomous. ***No concrete coal phase-out policy for now.***

2.Nevertheless, coal use for electricity generation is likely to decrease at the profit of cogeneration gas plants. Gas + recent American investments ($8bn from AECom, October 2020) into 2 new nuclear reactors (500MW) will shape the base of the electricity mix.

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4. Mobility via electromobility concept, is core for energy transition policy in Romania. It concerns particularly light vehicles & public transport vehicles.

Actualized energy BAU scenario

1. **Neighbour countries such as Poland have recently announced a coal phase-out policy for 2030-2040. In order to follow European directives, Romania may also reveal such policy. Coal phase-out policy will have to involve:**

- **Increased efforts on electricity efficiency** in order to reduce the overall demand for electricity (and thus coal) for current uses
- **Massive investment to increase RE** capacity for electricity generation. RE capacity have been stable for the last years & will have to increase to substitute coal.
- **Increased use of gas across sectors**. Investment in cogeneration gas plants will have to accelerate.
- **Coal phase-out will concern only electricity generation**. Coal will remain used in industry such as iron & steel while major investments will have to be made to shift equipment toward electricity or gas.

Actualized mobility BAU scenario

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4. Municipality policies also promote micro-mobility with electric scooter for rent in Bucharest & Timișoara. Taxi license policies also encourage EVs & aim 50% of electric taxis by 2030.

5. Alternative fuels (biofuels & hydrogen) are priority for HDV on a longer term.

2nd Actualized mobility BAU scenario

1. A coal phase-out policy will not have an impact on demand for electric mobility.

2. Energy efficiency will increase the availability of electricity for EVs.

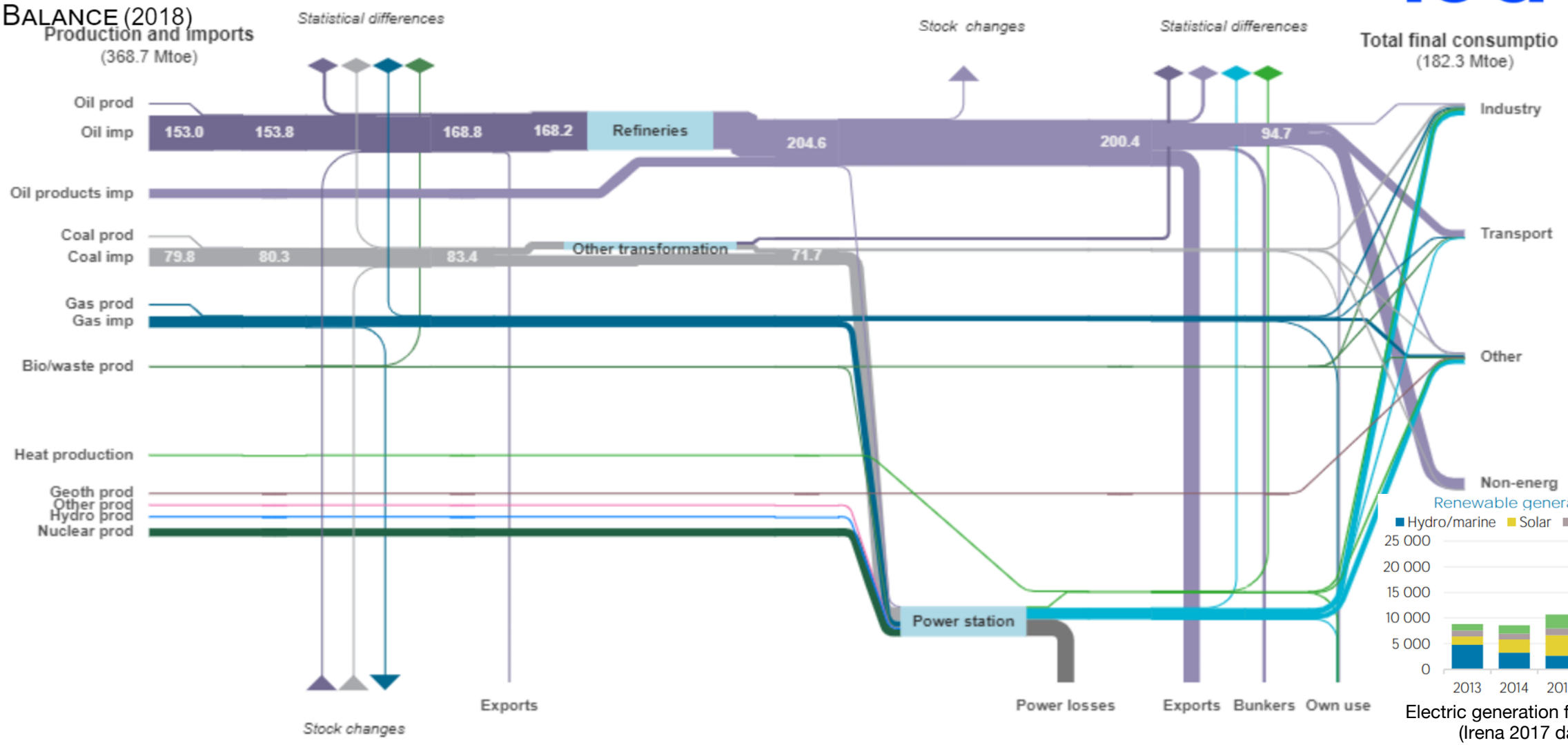
3. A coal-phase out policy will make electrification of mobility even more coherent as RE share in the electricity mix will mechanically increase.

1.1 Energy system picture : key system realities

Korea

BALANCE (2018)

Millions of tonnes of oil equivalent

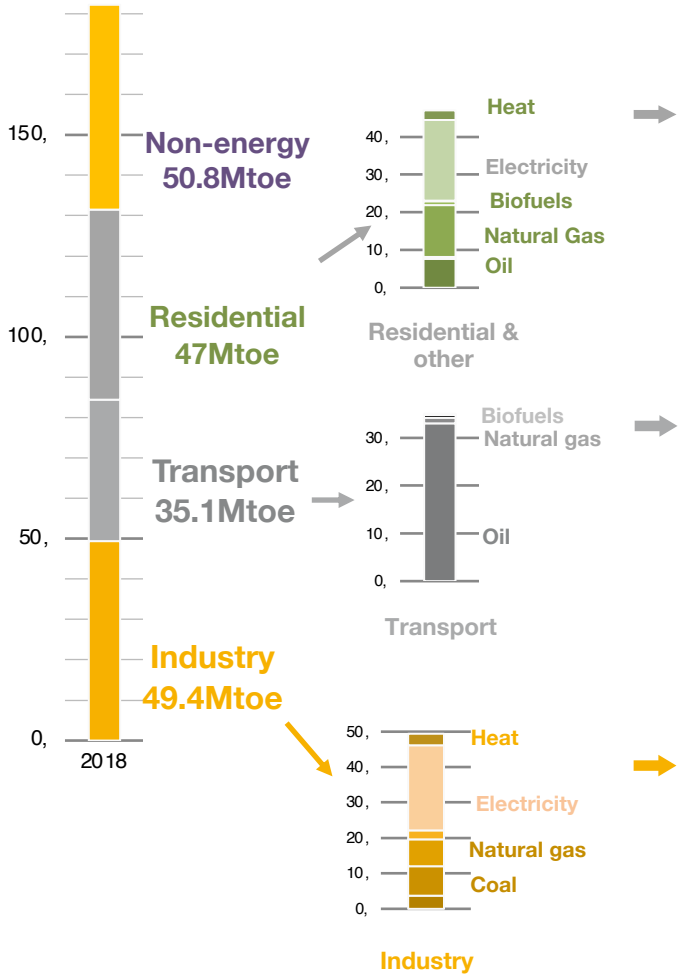


Electric generation from renewables
(Irena 2017 data, GWh)

Despite some minor domestic productions of oil, coal, gas and nuclear energy, South Korea remains largely dependent on primary energy imports. RE is significantly increasing since 2014 thanks to biomass & solar investments.

1.2 System inertias & policy drivers

South Korea final energy consumption 2018: 182.2 Mtoe



Inertias
(by sectors)

Inertia1: gas & electricity duality

- Residential: 45.5% (21.4Mtoe)
  - Gas (44%), electricity (27%), oil (16%), heat (9%)
- Commerce & public: 45.5%(21.4Mtoe)
  - Electricity **(66%)**, **gas (19%),** oil (9%), biofuels (4%)
- Agriculture: 3.4%(1.6Mtoe) **Electricity (75%)**, oil (19%), biofuels (6%)

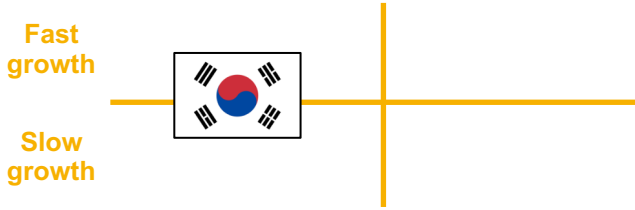
Inertia2: oil primacy, gas importance

- Road : 94.3% (33.1Mtoe)
  - Oil (95%), **gas (4%)**, biofuels (1%)

Inertia3: coal & electricity duality

- Iron & steel: 24.3% (12Mtoe)
  - **Coal (46%), electricity (40%),** natural gas (13%)
- Chemical & petrochemical: 18% (9Mtoe)
  - **Electricity (51%),** heat (23%), gas (12%), oil (9%)
- Machinery: 16% (8Mtoe)
  - **Electricity (86%),** gas (13%)
- Non-metallic minerals: 11% (5.2Mtoe)
  - **Coal (44%), electricity (21%),** biofuels (13%), gas (12%), oil(10%)

Policy drivers
(on energy and/or sector)



Objectives: carbon neutrality by 2050 & INDC: GHG emissions' reduction by 37% from BAU in 2030 (- 14% achieved in 2016)
Our view: very ambitious objectives but vague plan to reach them
Timeframe: 2030-2040
Governance type: central government, 9 provinces

Driver 1: Energy efficiency

Weight of industry, residential & transportation on total consumption: 58.1% (105.9 Mtoe)

- Objective: reduce energy consumption by 18.6% below the BAU level by 2040, therefore with a final energy consumption slightly below that of 2017
- Energy intensity from 2017 to 2040: -21% in industry & -38% in buildings
- Building & Factory Energy Management System installed to monitor energy consumption
- Use of advanced energy efficiency technology (V2G, Virtual Power Plants, big data, AI, IoT)

Driver 2: Increasing gas to reduce nuclear & coal

Weight of nuclear & coal on total energy supply: 31.2% (115.1 Mtoe) vs. gas: 13.5% (49.9 Mtoe)

- Objective: nuclear phase out (no set date) & greater role of gas in generation and transport
- Power generation in 2030 (vs. 2017): 19% gas (17%), 36% coal (45%), 24% nuclear (30%)
- Nuclear: no further extensions to the lifespan of aged reactors & no new reactors constructed

Driver 3: RE development

Weight of RE on total energy supply: 2.37% (8.8 Mtoe)

- Objective: 20% of RE in 2030, 30-35% in 2040 (8% achieved in 2018)
- Number of Renewable Energy Facilities: from 220,000 in 2018 to 1.9-2.7 million in 2040
- Increase renewable capacity from 11.3 GW (2017) to 58.5 GW (2030), 88% solar & wind

Driver 4: Electrification & "hydrogenisation" of uses

Weight of the transport sector on total energy consumption: 19.3% (35.1Mtoe)

- Objective: 8.3 million EVs & 2.9 million hydrogen vehicles by 2040 = 50% of registered vehicles
- Produce 6.2 million H2 vehicles (FCEVs) for the world in 2040 (vs. 1,800 in 2018)
- Industrial use of H2 from 207 MW to 14 GW, household use from 7 MW to 2.1 GW & H2 annual supply from 130,000 tons to 5.26 million tons in 2040 in comparison to 2018

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias (by sectors)	Policy driver (on energy and/or sector)
Residential - Inertia1: gas & electricity duality	**Energy security** **Energy efficiency** **RE development**
Transport – Inertia2: oil primacy, gas importance	**Energy efficiency** **Electromobility**
Industry- Inertia3: **coal & electricity duality**	**Energy security** **Energy efficiency** **RE development**

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1: addition of LNG and RE in the electricity mix
- *Power supply composition: 46% coal, 27% nuclear, 20% gas & 3.4% RE (2018)*
- *Because of an overall decrease in energy consumption, gas & RE increase can mechanically result in decreased use of nuclear & coal*
- *But to have the ability to absorb RE, need to invest in upgrading the grid*
- *Coal, nuclear & gas will remain the generation base while gas and RE infrastructures are insufficient*

Coupling2: limitation of inter-use competition for electricity thanks to energy efficiency
- *With energy efficiency, the increase in power demand up to 2030 (+15.3 GW) should be inferior to the increase in total installed capacity (+ 56.7 GW)*
- *This will relieve pressure on the electricity system despite coal & nuclear reduction in the long-term and allow electrification of uses*
- *Flexible & complicated nuclear and coal phase out policy will ensure sufficient production in the short-term*

Coupling3: transport & industry equipment shift towards hydrogen technologies
- *Massive investments in the hydrogen industry*
- *Hydrogen addition in the energy mix*
- *Expansion of the use of H2 in industry & transport*
- *Decrease in oil imports, but oil and electricity should remain the basis for mobility in 2040*

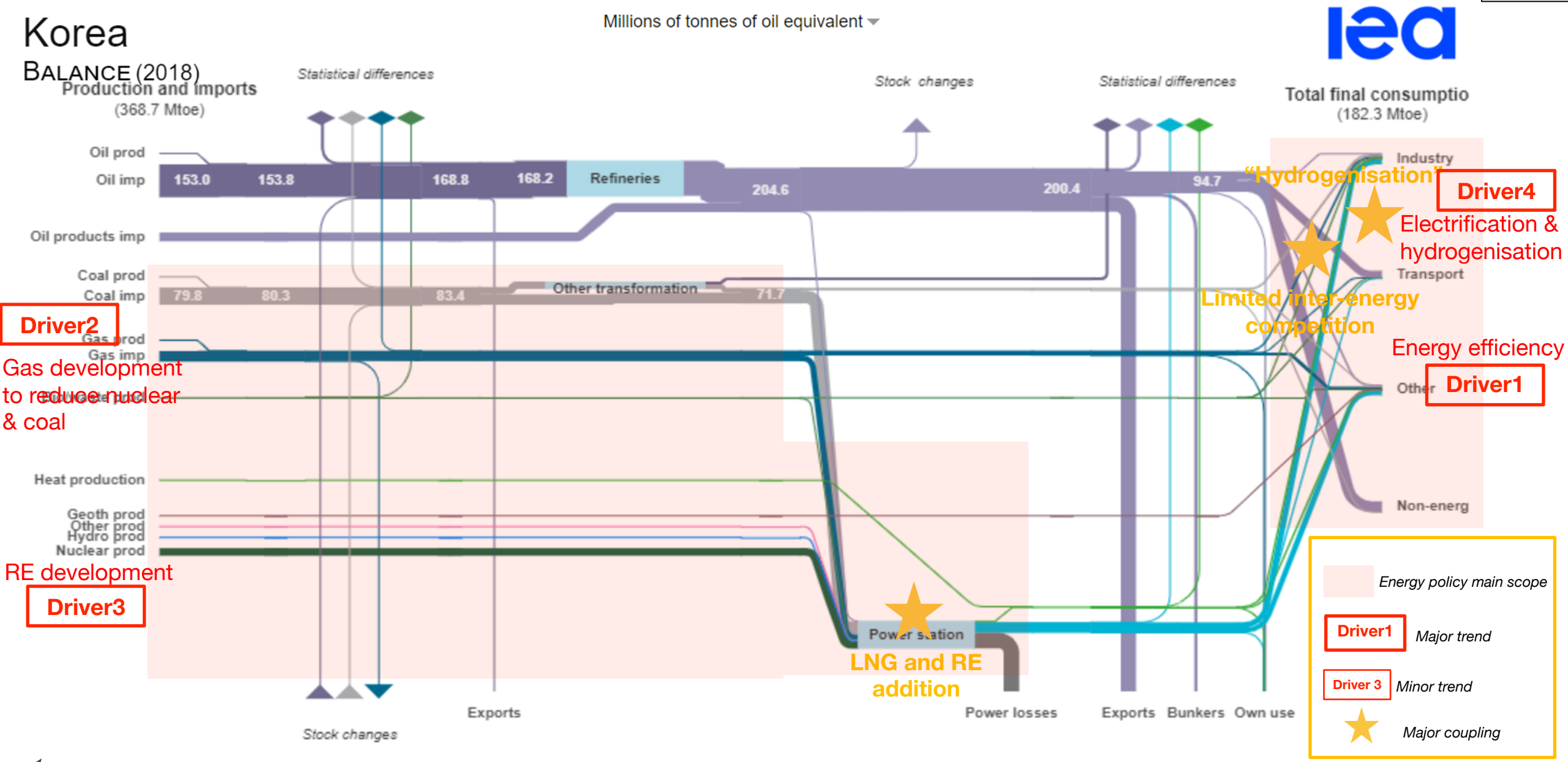
Structuring issues

Issue1: Energy autonomy & hydrogen potential
- *Weight of imports on total supply: 88% (323Mtoe)*
- South Korea lacks domestic resources, hence it must rely on imports
- Lack of available lands and low levels of solar radiation for RE
- Cooperation for energy in the region (e.g.: Northeast Asia Super Grid project with China, Mongolia, Japan, Korea and possibly Russia)
- Investment by Korean companies abroad (e.g.: Korean Gas Corporation in 13 countries in 2020)
- As the leader in the hydrogen industry, Korea will be able to ensure greater energy independence

Issue2: Energy efficiency for decreasing coal
- Notion that encompasses energy savings, building renovation & public sector exemplarity
- Korea is the 9th biggest energy consumer in the world
- Energy efficiency will go through intelligent and automated advanced technologies
- Making gas & RE investments able to compensate for coal & nuclear reduction in the long-term

Issue3: Nuclear legacy
- *Weight of nuclear on total supply: 9.4% (34.8Mtoe)*
- Northeast Asia trauma of the Fukushima nuclear power plant, coupled with Korean nuclear industry crises (blackout of a plant & corruption scandals)
- Societal debates: a significant share of the population in favour of retaining nuclear power & fear on undermining the industry

1.4 Focusing on energy efficiency & cleaner energies to reduce coal & nuclear consumption



2. From an energy transition scenario to a mobility scenario

Actualized energy BAU scenario

1. **South Korea's energy transition plan is challenged by the country's massive energy consumption**. Its dependency on energy imports & lack of domestic resources make it hard to phase nuclear and coal out of the energy mix.

2. **Increase in the relative share of gas**. KOGAS's 2018 investment plan of USD 9 billion by 2025 to expand its LNG capacity complements the country's plans to shut 30 coal-fired plants that reach 30 years of service by 2034, 24 of which will be converted to LNG. However, 7 new coal units are currently under construction with a combined capacity of 7.26GW. Thus, **the absolute use coal is unlikely to change in the short-term**.

3. **Change of the whole system around hydrogen** through massive investments in H2 production, transportation, storage, power & other technologies by various actors (Hyundai, Hanwha Energy, KOGAS).

4. **Decreasing relative share of nuclear in the long-term**. The country is still building 2 reactors but will not invest in nuclear anymore in the future.

5. **RE increase in the electricity mix** will occur through investments such as the construction of a 133 MW hybrid solar-wind power plant.

6. **Oil imports will remain stable** until mobility electrifies and hydrogen develops on a large-scale.

Fuel, mobility & LCA policy

Objective: one car in five is a BEV or FCEV by 2025.

Promotion of electric mobility

- 2020: KRW 4.5 trillion (€3.2 billion) for EVs subsidies
- Subsidy for a BEV in 2020: KRW 8 million (€5,000)
- Expansion of EV charging stations: 500,000 by 2025 (vs. 60,000 today)

Promotion of hydrogen mobility

- 2020: KRW 2.6 trillion (€1.8 billion) for the H2 vehicle industry ecosystem.
- Government subsidy for a FCEV in 2020: KRW 22.5 million (€16,000)
- 2019: establishment of 13 companies to build around 100 refilling stations (HRS) by 2022
- Objective: replace 40,000 buses & 80,000 taxis by H2-powered vehicles, deploy 30,000 H2 trucks by 2040.

Development of alternative buses**:**

- LNG-powered buses: 58 in 2000 vs. 27,422 in 2018
- Electric buses: 143 in Seoul by the end of 2020
- H2 buses: available in 2019 for the police

Korea targets mobility as a major means of economic growth rather than for decarbonizing the economy.

No LCA regulation on mobility.

Messages

South Korea recently exposed ambitious objectives that would reverse the whole energy system, which is unlikely to occur in the short-term.

Korea's GHG emissions can be reduced by limiting the country's overconsumption. Hence, the government focuses on energy efficiency & demand management.

Besides its importance for GHG emissions reduction, transportation also represents a major opportunity for economic growth. Massive and frequent investments are likely to lead to rapid adoption of electric and hydrogen LDVs & HDVs.

Therefore, transforming transportation towards a more sustainable mobility is one of the government priorities.

No LCA policy in mobility

Actualized mobility BAU scenario

1. **Important shift in mobility is likely to happen in the short-term (before 2030) thanks to investments in R&D, development of adequate infrastructure and incentivizing government policy.**

2. The Koreans will firstly go forward an electrification of the mobility before progressively adopting the hydrogen model.

3. Shift to electricity & H2 will apply to both public and private LDVs & HDVs.

3. Hydrogen technologies in mobility will develop not only for the domestic market, but also to reach foreign markets overseas. Korea will become the reference in H2 transportation.

Other possible energy/mobility scenarios

Actualized energy BAU scenario

1. South Korea's energy transition plan is challenged by the country's massive energy consumption. Its dependency on energy imports & lack of domestic resources make it hard to phase nuclear and coal out of the energy mix.

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6. **Oil imports will remain stable** until the mobility electrifies and hydrogen develops on a large-scale.

Alternative actualized BAU energy scenarios

Phase out of nuclear or coal occurs in the mid-term:

Less energy available in absolute terms

- Forced reduction of final energy consumption
- Intense inter-use competition for electricity between the industry, transport & residential sectors

1) Nuclear phase out

- 2020: 24 nuclear reactors, total capacity 23.2 GW
- Faster RE development: increasing the capacity to 60.5GW by 2030 (15GW installed in 2016)
- Fostering H2 development & innovations for greater energy autonomy
- In the short-term and until gas, RE & H2 are able to compensate for the loss of nuclear energy: GHG emissions increase due to sustained use of coal & larger dependence on imports due to reduced capacity of domestic production

2) Coal phase out

- Even with drastic energy savings, nuclear phase out will not be possible. Use of nuclear energy may even have to increase.
- Reduction of GHG emissions
- Lack of electricity will foster hydrogen & RE development and innovations
- Increasing relative share of domestic production as we erase coal imports

- Less electricity available
- ? Faster development of hydrogen?

Alternative mobility BAU scenario & KPIs

1. A coal or nuclear phase-out policy will not have an impact on demand for electric mobility. On the contrary, it will make electrification of mobility more coherent as RE share in the electricity mix will mechanically increase.

1. As H2 development accelerates, H2 technologies in transportation will fast become available and spread on the whole territory.

3. **KPIs to follow for electricity generation**: share of coal, gas, nuclear, RE will impact the coherence of the electrification policy in mobility

4. **KPIs to follow on hydrogen production**: domestic production of grey, blue or green H2 & potential imports of green hydrogen will impact the coherence in mobility policy

2018 energy consumption in transport: 94% oil, 3.45% natural gas, 1.7% biofuels and 0.85% electricity.

In case of a nuclear or coal phase out in South Korea, mobility will shift to hydrogen in the mid to long-term with a shorter intermediate step of electrification.

V) A country out of categories with a clear national will

Despite differentiated provincial kinetics, there is a basic trend towards long-term homogenization reconfirmed by the recent objectives to 2060. China represents a crucial element for achieving the Cop-21 climate objective, as the country accounts for 51% of global coal consumption. The important share of industry in China's economy (48% of final energy consumption in 2018) accounts for a complex transition in which energy security is the priority.

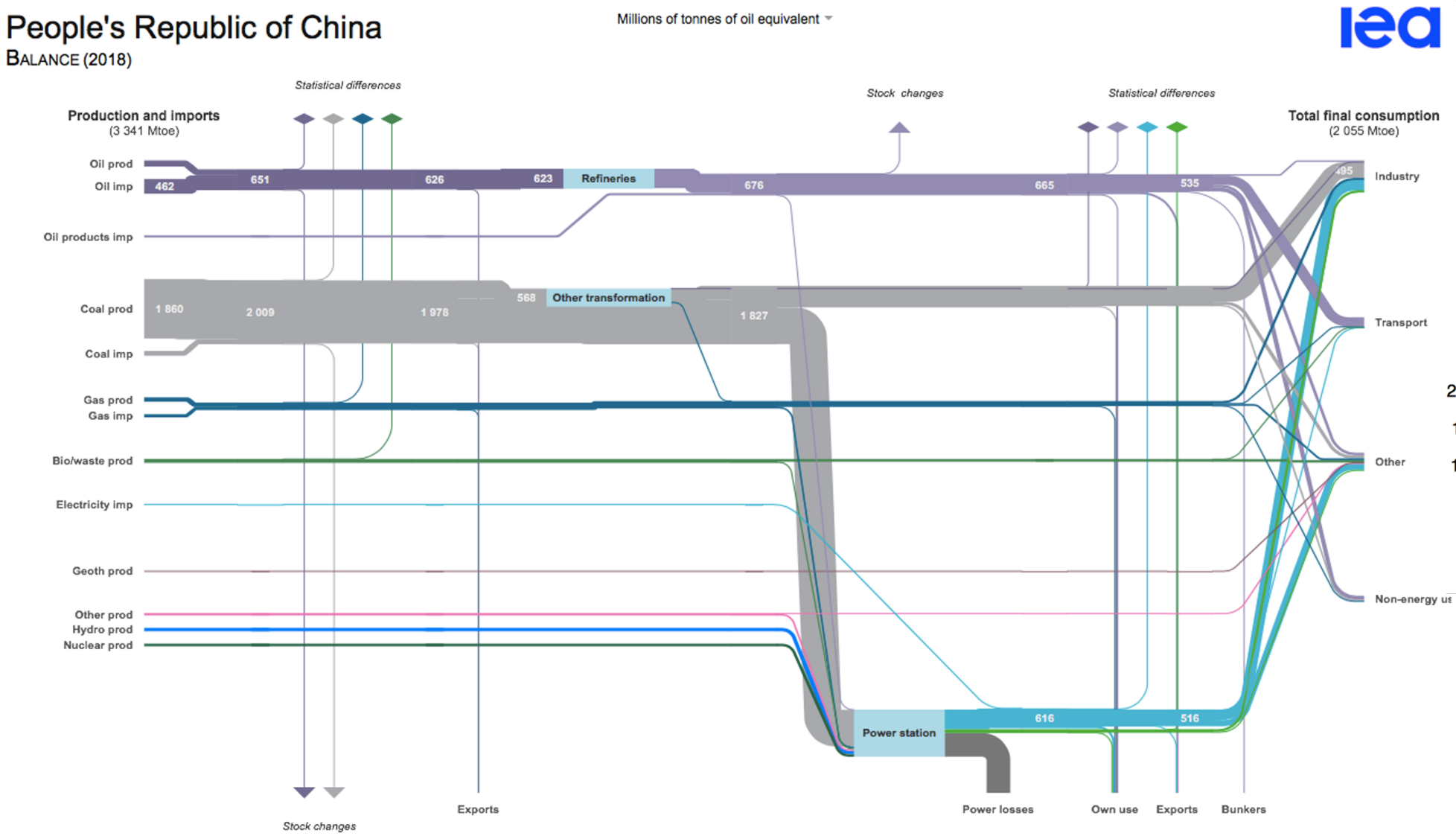
China

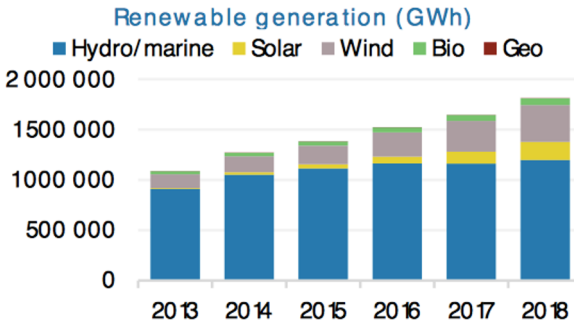
III) CHINA

Actualized energy scenario	Actualized mobility scenario
2030 - Transitional maintenance but modernization of coal-fired power plants for energy security and economic growth. Massive investments in gas, RE & nuclear for coal substitution. 2010-2019 China's renewable energy investments were about USD 800 billion, more than total Europe (UNEP, 2019). Zero carbon 2050-60: Massive investment in RE + CCS hydrogen. Continued development of nuclear power.	2019, 5.6% of new vehicles sold were electric. Entry into a post-subsidy phase of electric vehicles. Target of 25% NEV by 2025 (electric, fuel-cell). Investments in hydrogen for heavy-duty vehicles, buses and commercial vehicles 2030.
Alternative energy scenario	**Alternative mobility scenario**
Efficient energy efficiency policies accelerate decarbonation & electrification To relieve pressure on the grid & enable faster increasing RE in the electricity mix. **By 2030, shift toward green H2 possible for industry & heavy/collective mobility uses.**	Relieve on the electric system due to better energy efficiency will accelerate shift toward electric mobility.

1.1 Energy system picture : key system realities

https://www.iea.org/sankey/#?c=People's%20Republic%20of%20China&s=Balance



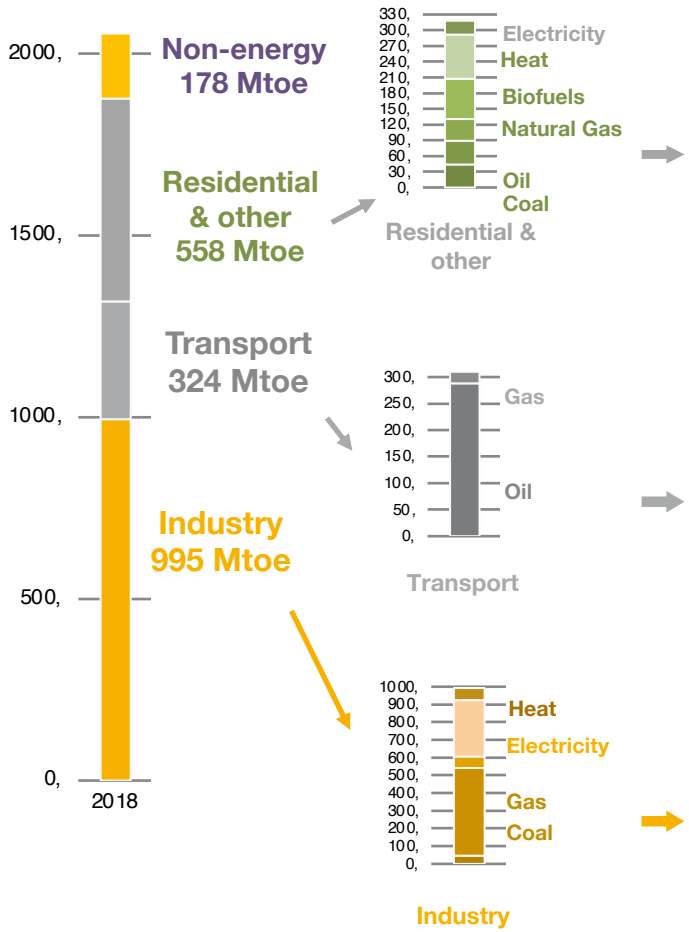


Electric generation from renewables (Irena 2017 data, GWh)
https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/China_Asia_RE_SP.pdf

Primary energy supply depends largely on coal and oil, though RE and Gas is increasing. Final consumption mainly by industry, only 24% via electricity.

1.2 Energy system picture : final uses analysis

China final energy consumption 2018: 2055 Mtoe



Inertias
(by sectors)

Inertia1 : electricity dominates
Inertia2: coal, oil and biofuel shares are relatively balanced

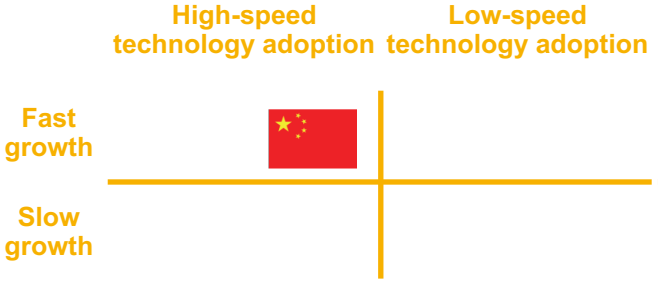
- Residential: 61% (345Mtoe)
  - Biofuels (22%), electricity (24%), oil (13%), coal (13%), gas (12%)
- Commerce & public: 16% (91Mtoe)
  - **electricity (40%), coal (19%),** oil (18%), gas (15%)
- Agriculture: 8% (45Mtoe)
- Oil (42%), coal (31%), electricity (24%%)

Inertia3 : oil dependent

- Road :80% (262Mtoe)
  - Oil (89%), **gas (8%),**

Inertia4 : coal/electricity duality
Interia5: steel-making still mainly running on coal equipment

- Chemical & petrochemical: 20% (208Mtoe)
  - **Coal (40%),** electricity (26%), heat (18%)
- Non-metallic minerals: 18% (181Mtoe)
  - **coal (135%), electricity (17%)**
- Iron & Steel: 24% (247Mtoe)
  - **coal (75%),** electricity (20%)



Policy drivers
(on energy and/or sector)

Objectives : Paris Agreement + peak of CO2 emissions by 2030, carbon neutrality by 2060
Our view: clear objectives that pave the way for global progress, but roadmap still vague and insufficient to limit global warming to 2°C.
Timeframe : 2025, 2030, 2060
Governance type : central government (CCP General Secretary), 22 provinces.

Driver 1 : Phase out coal and oil in the long-term

Weight of coal on total energy supply: 61% and oil: 20%.

- Almost completely phase out coal by 2050 to reach its carbon neutral goal by 2060
- Gas and RE replacing coal : consumption growth 2010-2019 : coal = 1.3%, NG = 11.9%, RE = 9%

Driver 2 : RE, H2, gas and nuclear investments

- In 2030 : reach a non-fossil fuel (renewables and nuclear energy) share of 25% in primary energy
- Raise combined wind and solar power capacity to 1,200GW in 2030
- RE: current 8.5% => 17% under 14° Five-Year Plan => 26% by 2030 => 60% by 2050
- Nuclear: current 2% -> 10% by 2035 -> 28% by 2050
- Green H2 from 3% in 2019 to 70% in 2050 : by 2030, shift toward green H2 possible for industry & heavy/collective mobility uses.

Driver 3 : Energy efficiency

- >70% of energy use by industry has mandatory efficiency policies
- The national Emission Trading Scheme push energy-efficiency tech
- Urban area - biomass heating replace coal
- Projects : 2019 buildings efficiency invt $30 bn, 2019 RE heat equipment invt $12 bn

Minor driver 4 : electrification of mobility

- In 2018, “China Automobile Low Carbon Action Plan (CALCP)”
- By 2030, 1) under current policy scenario – M1 and BEV will reduce full life-cycle emission by **19.9%** and **18%** respectively; 2) under low carbon scenario : by **27.5%** and **32.8%**.

1.3 Coupling analysis - Coupling & issues in transition pathway

Inertias
(by sectors)

Residential - Inertia1 : electricity dominates

Residential – Inertia2 : coal, oil and biofuel shares are relatively balanced

Transport – Inertia3: oil dependency

Industry- Inertia4 : coal/electricity duality

Industry- Inertia5 : steel-making still mainly running on coal equipment

Policy driver
(on energy and/or sector)

Gas investments

Energy efficiency

RE and nuclear investment

Electromobility

Energy efficiency

Gas investments

RE investment

Energy efficiency

Coupling
(dynamics on energy-to-energy, energy-to-use and use-to-use)

Coupling1 : replace use of coal by alternative sources

- Modernisation of coal sector towards gas with CCS.
- Share of electricity will increase in every sector especially in industry. Industrial equipment may shift toward gas & electricity.
- Urban area – centralised heating system (gas) replace coal
- Rural area – developing biogas system to reduce raw coal
- Green H2 from 3% in 2019 to 70% in 2050
- Nuclear to represent 10% of energy mix by 2035 & 28% by 2050

Coupling2 : From energy diversification by 2030 to accelerated greening by 2060

- Fossil growth slows down except natural gas.
- Wind & solar grow fast but still small compared to coal-fired power.
- Nuclear as alternative resource: 10% of energy mix by 2035, 28% by 2050
- By 2060 RE will substitute coal in electricity generation

Coupling3: greening mobility and electrification of uses

- Active policy & massive investments towards sustainable, smart and shared mobility.
- Electricity and H2 will substitute oil in road mobility, with also increasing public supporting infrastructure (charging station, smart grid).
- Competition in electricity demand – industry, residential & electric mobility.

Structuring issues

Issue1 : crucial stake of China

- With 24% of global energy consumption and 51% of global coal consumption, China is a crucial stake in achieving climate change goals.
- China has clear transition targets and is actively promoting green energy and electrification, limiting carbon emission, developing strategic industries of new energy vehicles and hydrogen economy.
- Current policies are not sufficient to reach the objective of the COP-21. Further acceleration in climate policy is a must.
- The energy transition is a national ambition, but the carbon neutrality by 2060 objective will require more investment and structural changes

Issue2: Energy efficiency

- Efficient energy efficiency policies accelerate decarbonation & electrification => relieve pressure on the grid & enable faster increasing RE in the electricity mix.
- Relieve on the electric system due to better energy efficiency will accelerate shift toward electric mobility.

Issue3 : regional disparities

- Regional disparities raise difficulties of integrated and efficient national energy/electricity systems.

Issue4 : energy security

- 50% energy weight of industry greatly challenges a transition prioritizing energy security.

Energy & mobility trajectories in China – points of focus

Actualized Energy scenario Points of Focus

The energy transition is a national ambition, but the carbon neutrality by 2060 objective will require more investment and structural changes.

- Fossil energy will decrease. Gas as transitional source for electricity in industry and residential.
- Non-fossil electricity share 31% in 2019.
- Coal-fired power peak by 2030, then slow decline.
- Coal-to-liquid/coal-to-gas, CCS to ”green up” coal uses. Heavy industry coal-dependent for a while.
- Massive investment in RE & nuclear will electrify uses. RE & nuclear: 60% & 28% of the energy mix by 2060 in an accelerated scenario.

Impact of climate mitigation

- Peak CO2 emission will be achieved earlier around 2025 (+2.6% in 2019)
- Non-fossil share 20% in 2030 will be achieved, even reaching 25%-30%

Actualized mobility scenario Points of Focus

The decarbonization of mobility is one of the pillars of the energy transition. Mobility is thus prone to major technological changes.

- Target: by 2025, the yearly sales of NEVs & connected intelligent cars will reach 25% and 30% respectively.
- Sustainable mobility will benefit from a greening electricity if the energy transition is achieved in time.
- Electrification of mobility in massification; stage; national policy changing from subsidy support to market competition.
- “Hydrogenization”: demonstration projects, sustained by national and regional programs and investments.
- Initiative in LCA Annual Report under international collaboration.

Possible trajectories turnpoints

Increasing economic weight of «light» industry (ICT, AI, big data)
Relocation of heavy industry GVC
Energy efficiency
Smart and integrated grid
National carbon trading market

Risks for a car manufacturer

- Need to be a proactive actor
- Strong domestic competition and very different demands big cities/rural zones
- Ongoing electrification rivalries: mobility – residential – industry