

Designing National Energy and Air Quality Strategies:

A Case Study of Cuba

Why Cuba?

Cuba is an Island under Embargo

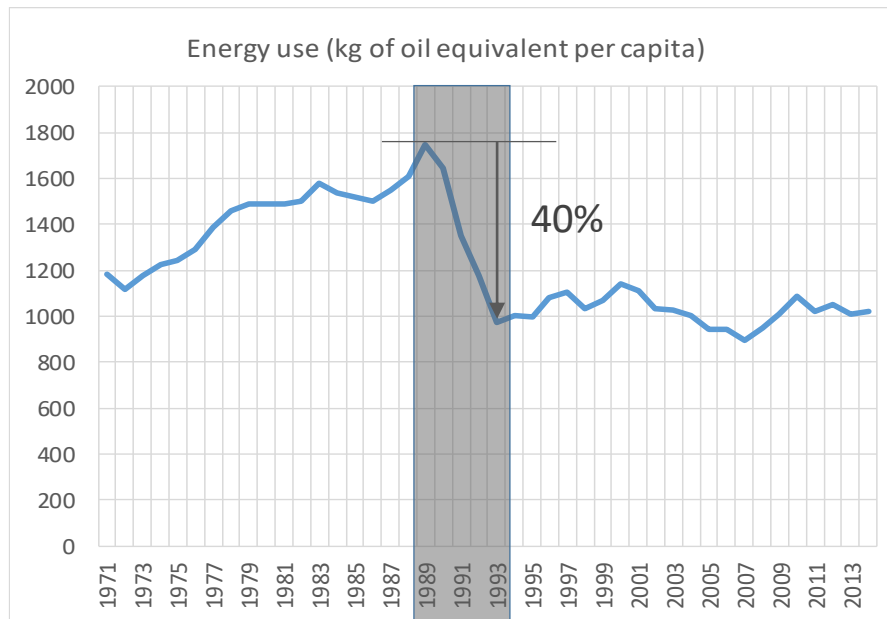


1959: The Cuban socialist revolution succeeds.

The American trade embargo and the support of Soviet Union are set up.

1991: Soviet subsidies and trade exchanges are stopped.

In **4 years**, **the energy consumption** has fallen by more than **40%**, GDP by 35%, industrial production by 80% and foreign trade by 75%.



What are the Embargo Implications ?

The Cuban inhabitants had to deeply change their life style to adapt to the new conditions , in all sectors of activity.

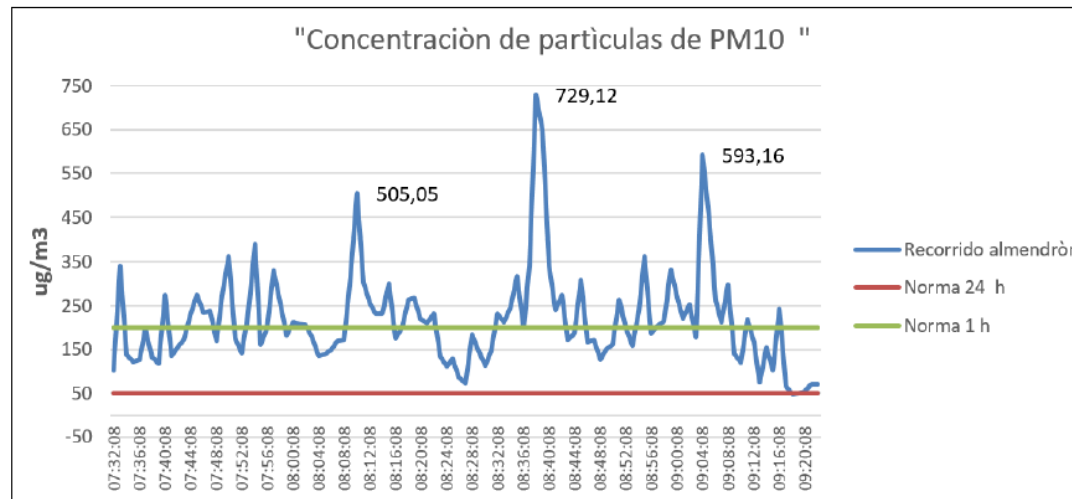


What are the Embargo Implications ?

Slow renewal of technologies



Obsolete technologies generate environmental problems: example of air quality

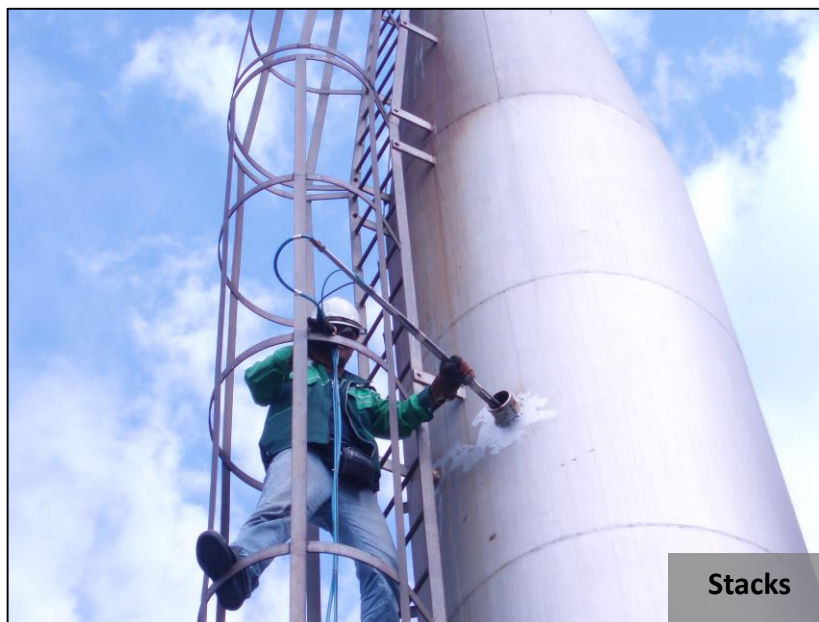


Air Quality Study

Air Quality Study: Emissions

Emissions from industrial and energy sectors

The emission factors for the industries had already been estimated using measures by the Cuban Ministry of Energy (Cubaenergia).



Air Quality Study: Emissions

Emissions from the transport sector

Emission factors for vehicles were not estimated using measurements.

A measurement campaign have ben organized in the framework of our project.

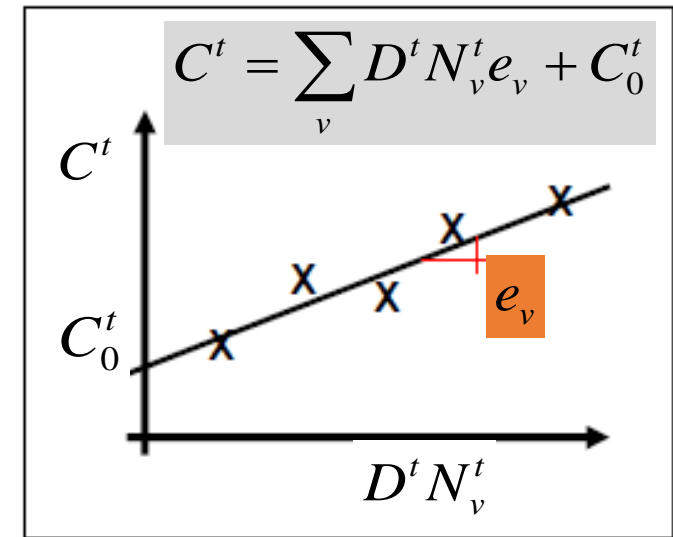


Measurements of concentrations



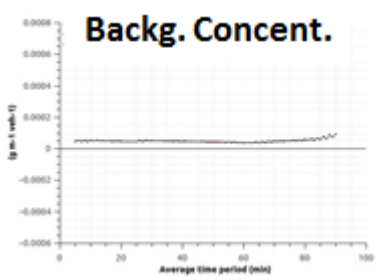
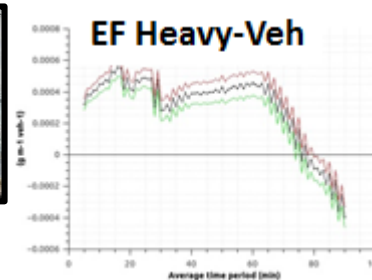
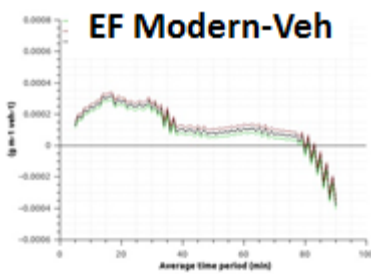
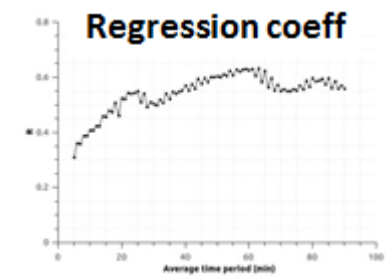
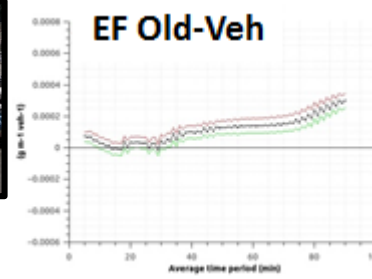
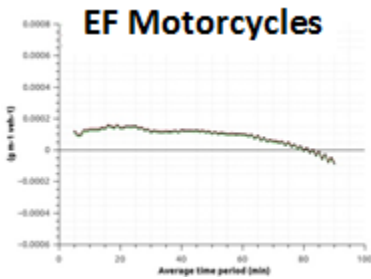
15'000 US\$

Traffic counting



Bulk emission factors

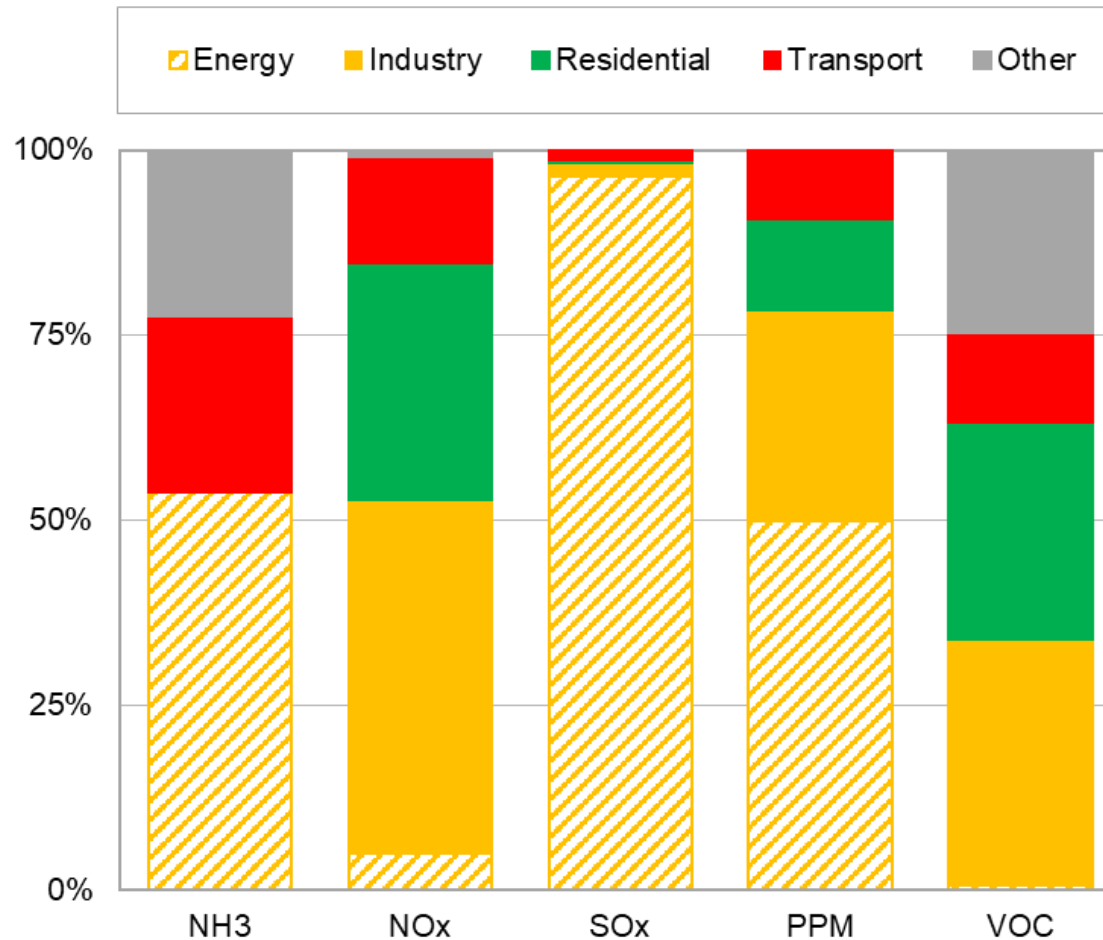
Air Quality Study: Emissions



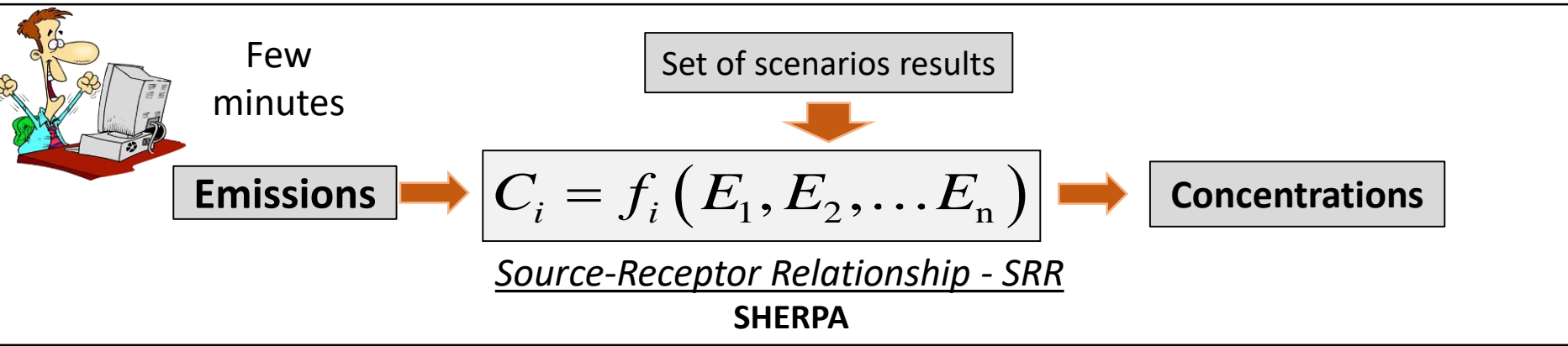
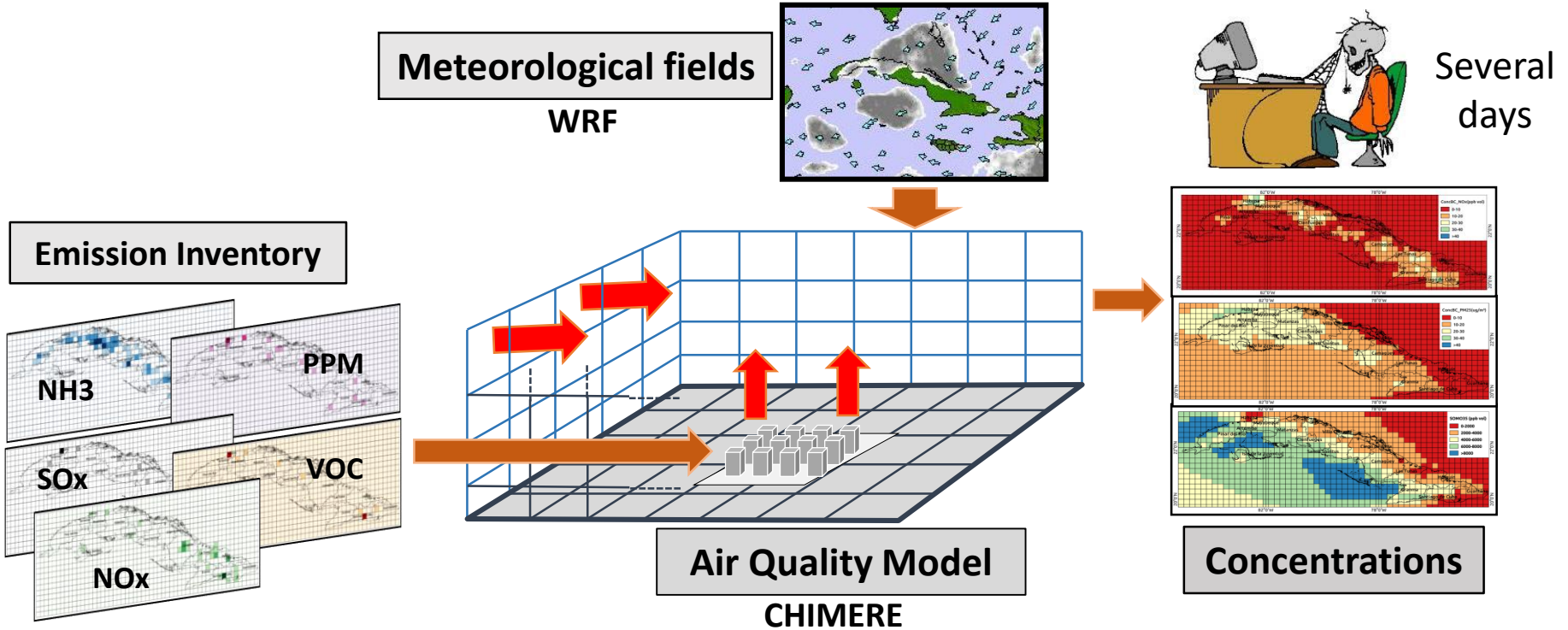
	Emissions (mg/km)	Std. Dev 95% Confid	Emis. (mg/km/pers)	Concent. (µ/m3)
Motorcycles	111.8	2.7	55.9	4.4
Modern vehicles	91.3	11.2	22.8	9.6
Old vehicles	124.2	18.5	31.1	26.7
Bus	413.8	31.25	3.5	14.9

1. Identification of time-averaging
2. Principal Component Regression (PCR) instead of Multi Linear Regression (MLR)

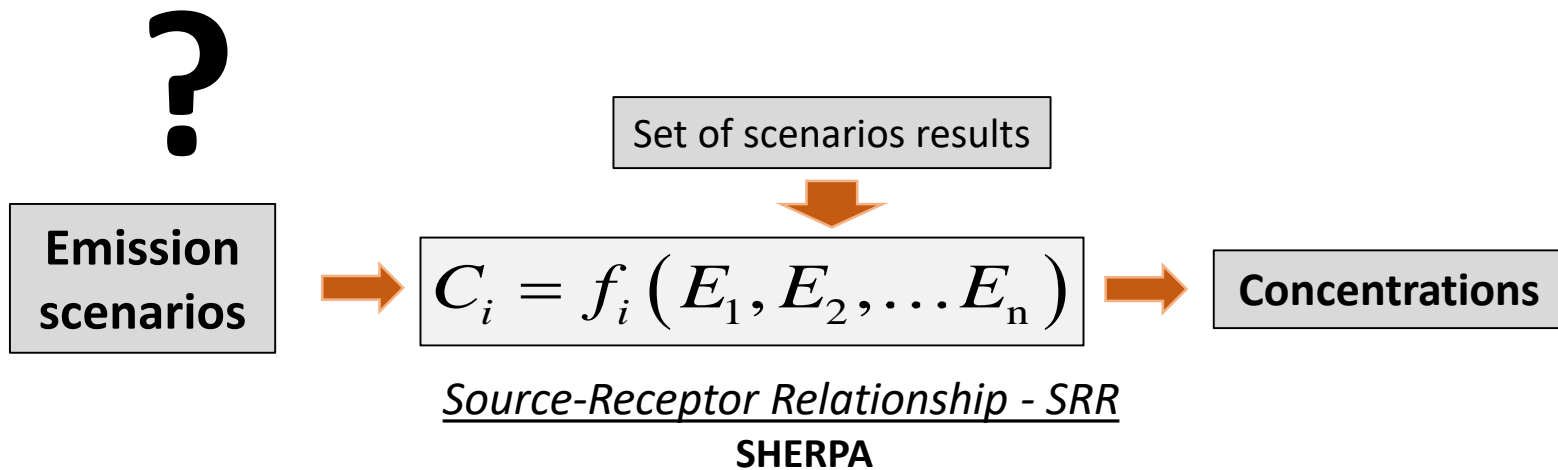
Air Quality Study: Emissions



Air Quality Study: Numerical Simulations



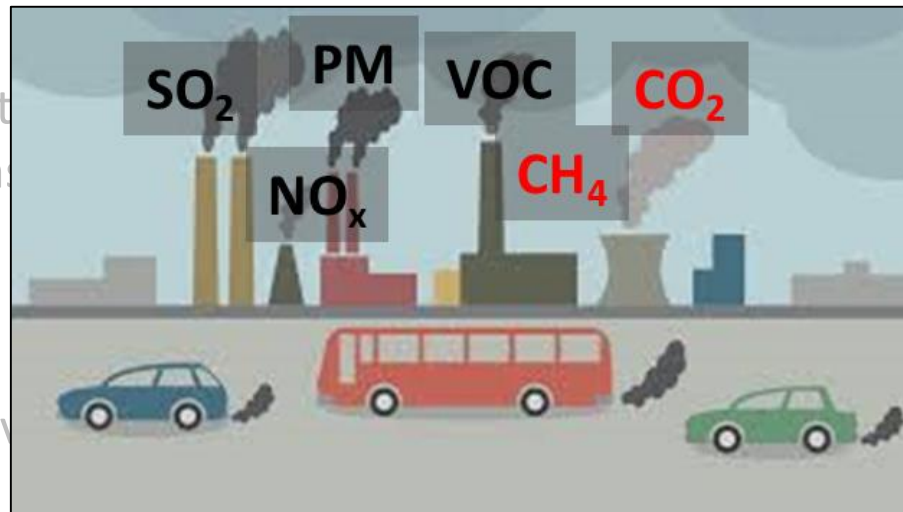
Air Quality Study: Abatement Strategies



Design of Strategies

Why should Air Quality, Climate and Energy Strategies be coordinated?

- ❑ Air quality and Climate issues both arise from our energy usage (fossil fuels)

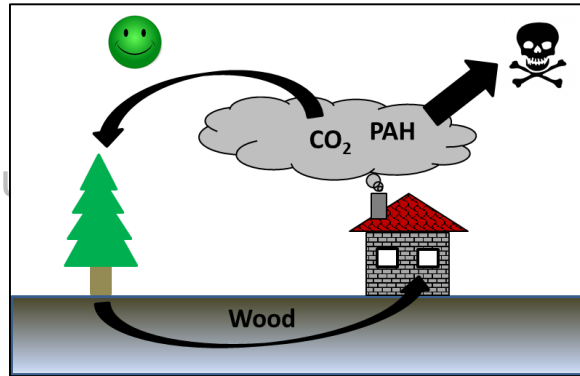


- ❑ Although air quality and climate issues both arise from our energy usage, there are exceptions. For example, nuclear power produces CO₂ but not air quality pollutants, and natural gas produces air quality pollutants but not CO₂. However, there are co-benefits, such as reducing SO₂ emissions from power plants also reduces CO₂ emissions.

- ❑ Decision makers have to consider the trade-offs between air quality and climate change.

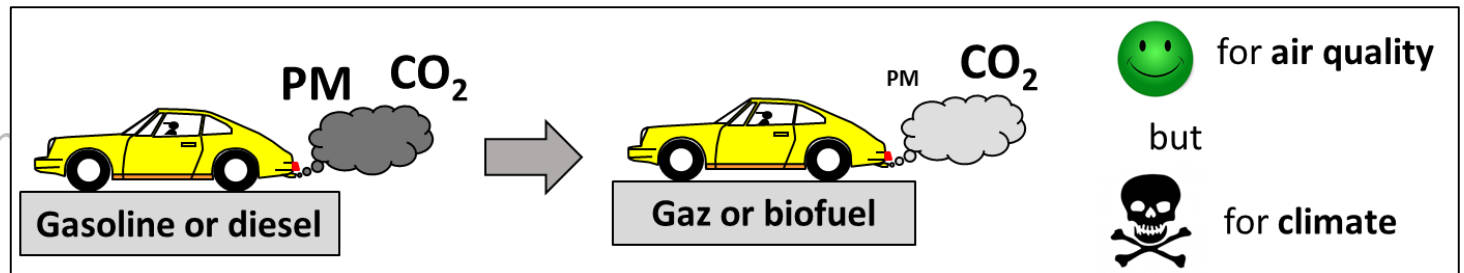
Why should Air Quality, Climate and Energy Strategies be coordinated?

- Air quality and Climate issues are linked to energy usage (fossil fuels)



- Although air quality and climate measures generally lead to co-benefits, there are exceptions.

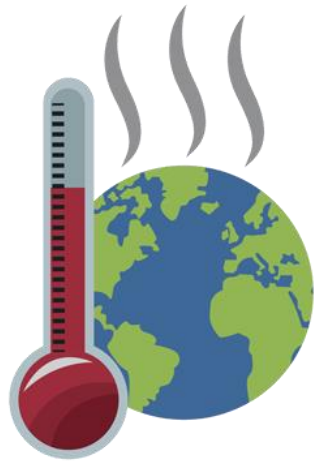
- Decision making



Why should Air Quality, Climate and Energy Strategies be coordinated?

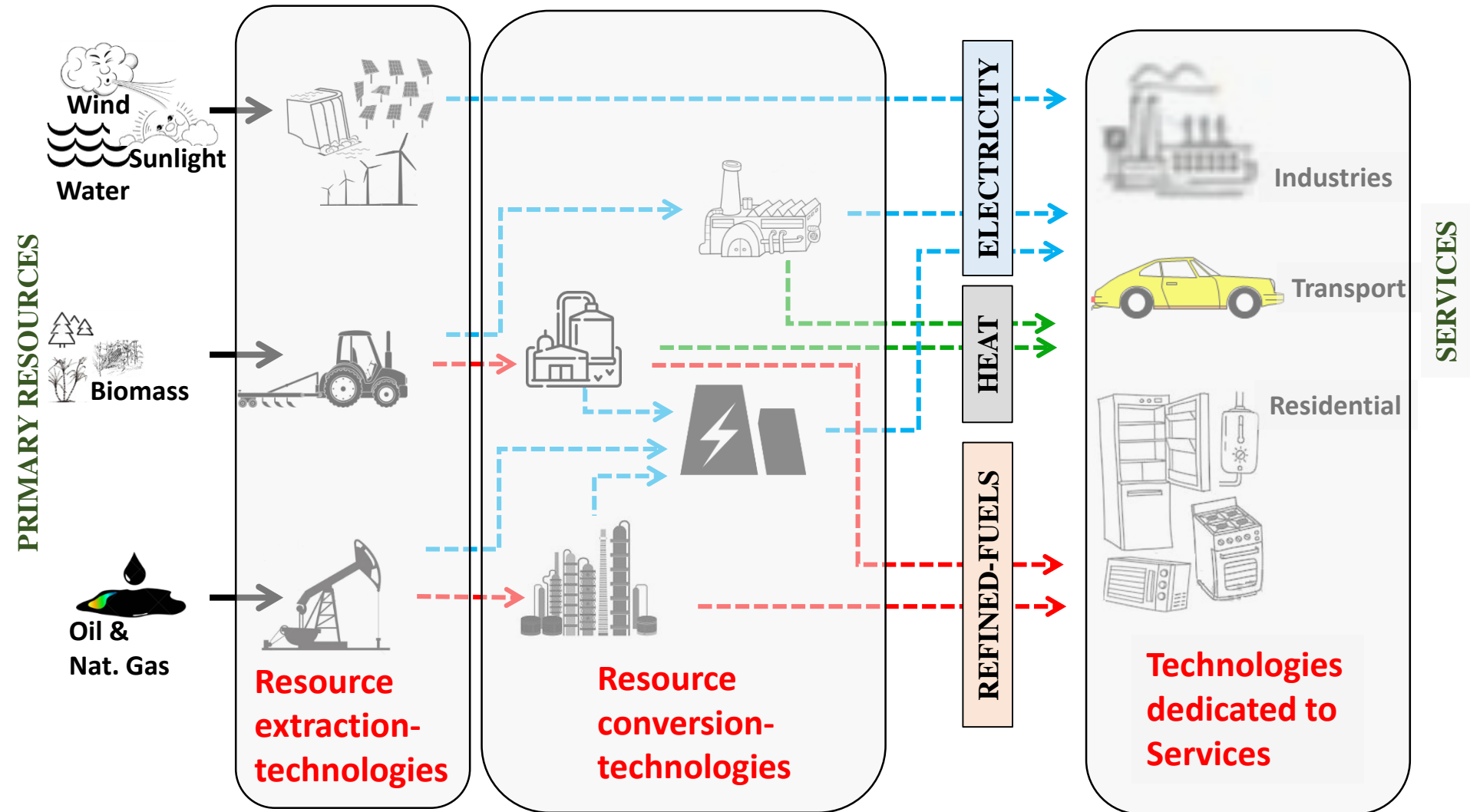
Air quality and Climate impacts from our energy usage (fossil fuels)

All the quality air ons.

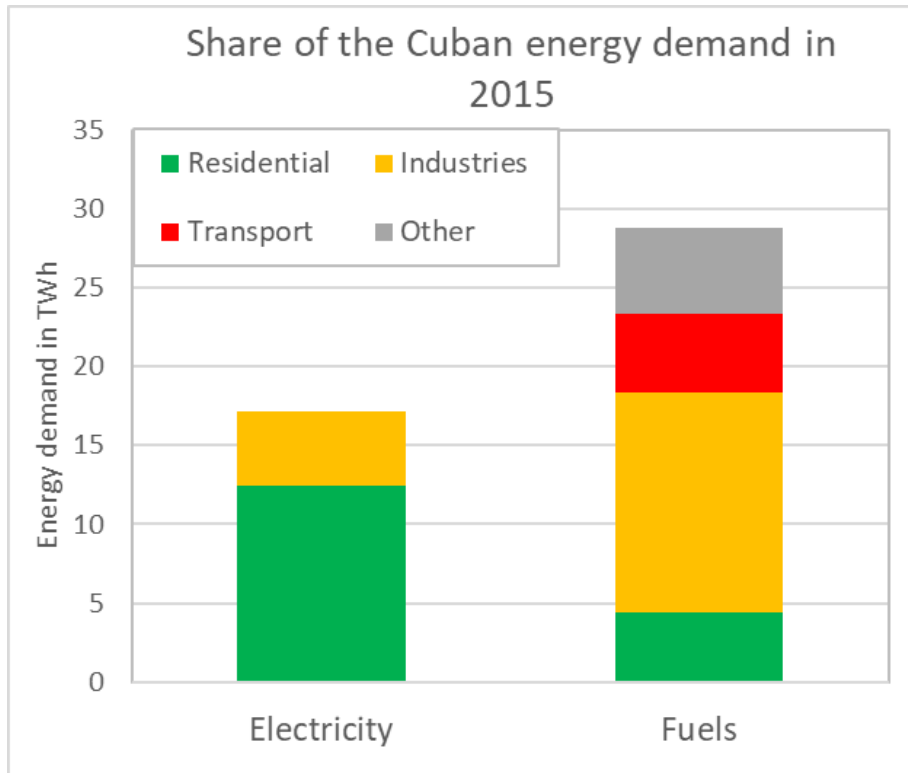


Decision makers have their own agenda.

Energy Strategies



Energy Demand in 2015



	Electricity	Fuels	Total
Residential	27%	10%	37%
Industries	10%	30%	41%
Transport	0%	11%	11%
Other	0%	12%	12%
Total	37%	63%	46 TWh

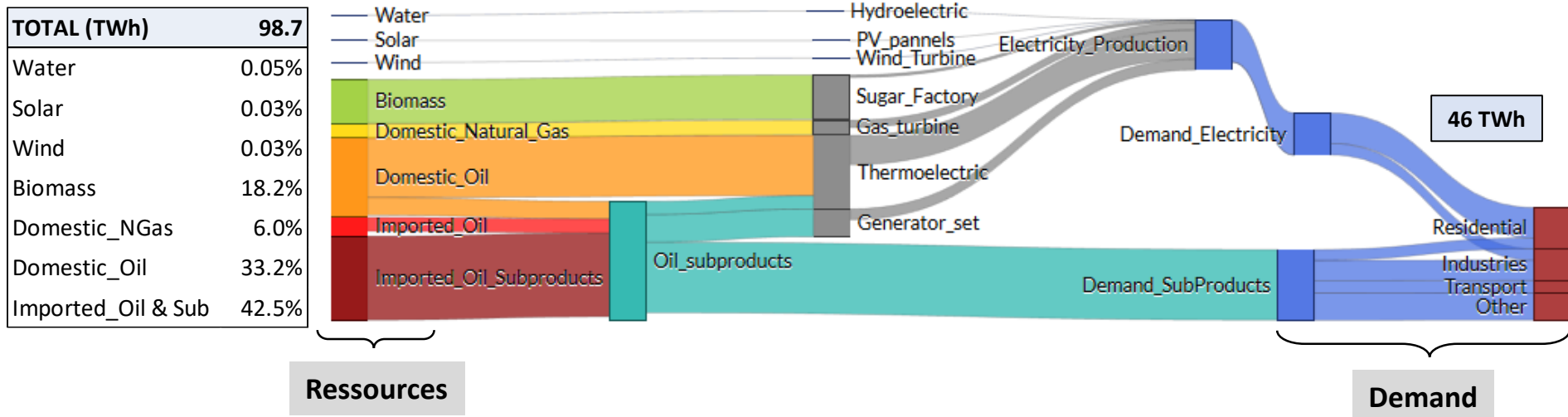
The residential demand is shared between **private buildings (65%)** and **public buildings (45%)**.

Available Resources

Available resources	Annual potential (TWh)	Reserves (years)
Oil and gas	15,1 - 20,9	155
Biomass (Bagasse)	1,7 - 6,5	-
Biomass (Marabu)	2,5 - 26,6	-
Hydroelectricity	0,99	-
Wind	2,4 - 28,2	-
Solar	24.433	-

Solar power, if operated over the entire surface of the country, **would provide more than 1,400 times the electricity needs of 2015.**

Energy Ressources used in 2015



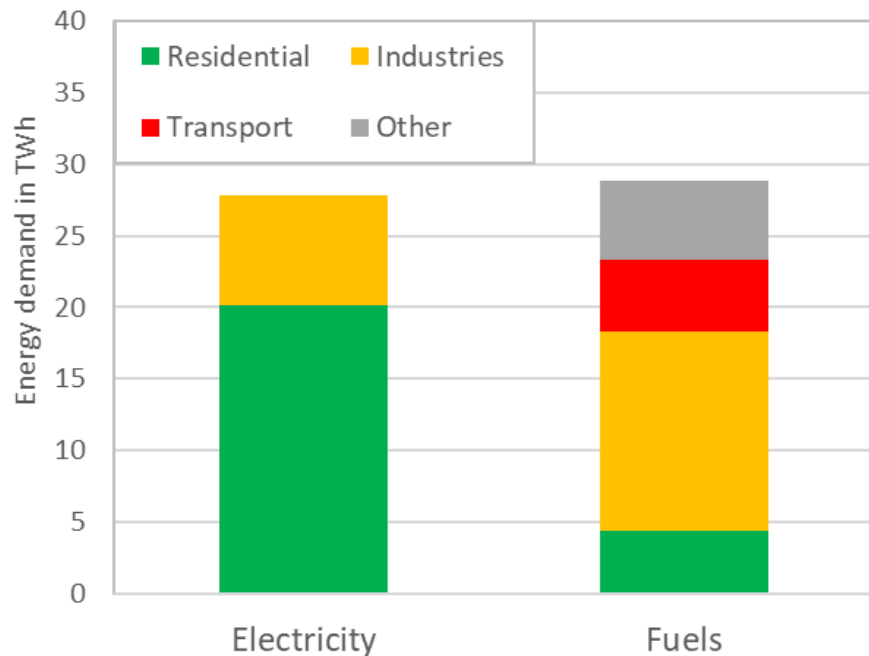
❑ In 2015, energy imports were still important with a share of 42.5% (i.e. 41.9 TWh).

❑ The share of wind and solar energy combined was only 0.06%.

Official Forecast for 2030

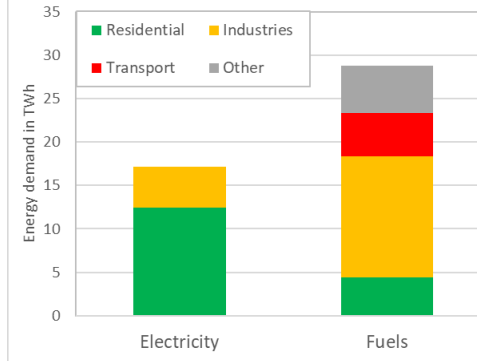
Cuban authorities estimate that the **electricity consumption will increase by 3.28% a year** until 2030. During this period fuel consumption is expected to stagnate. The total energy demand should therefore increase from 46 TWh in 2015 to 56.7 TWh by 2030.

Share of the Cuban energy demand in 2030

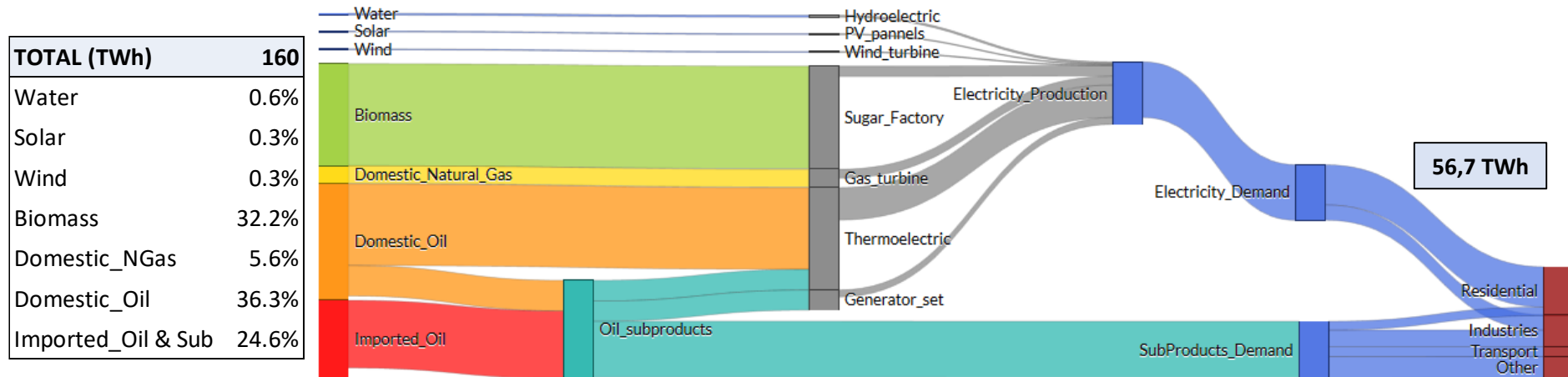


	Electricity	Fuels	Total
Residential	36%	8%	43%
Industries	13%	25%	38%
Transport	0%	9%	9%
Other	0%	10%	10%
Total	49%	51%	56,7 TWh

Share of the Cuban energy demand in 2015



« Official » Strategy for 2030

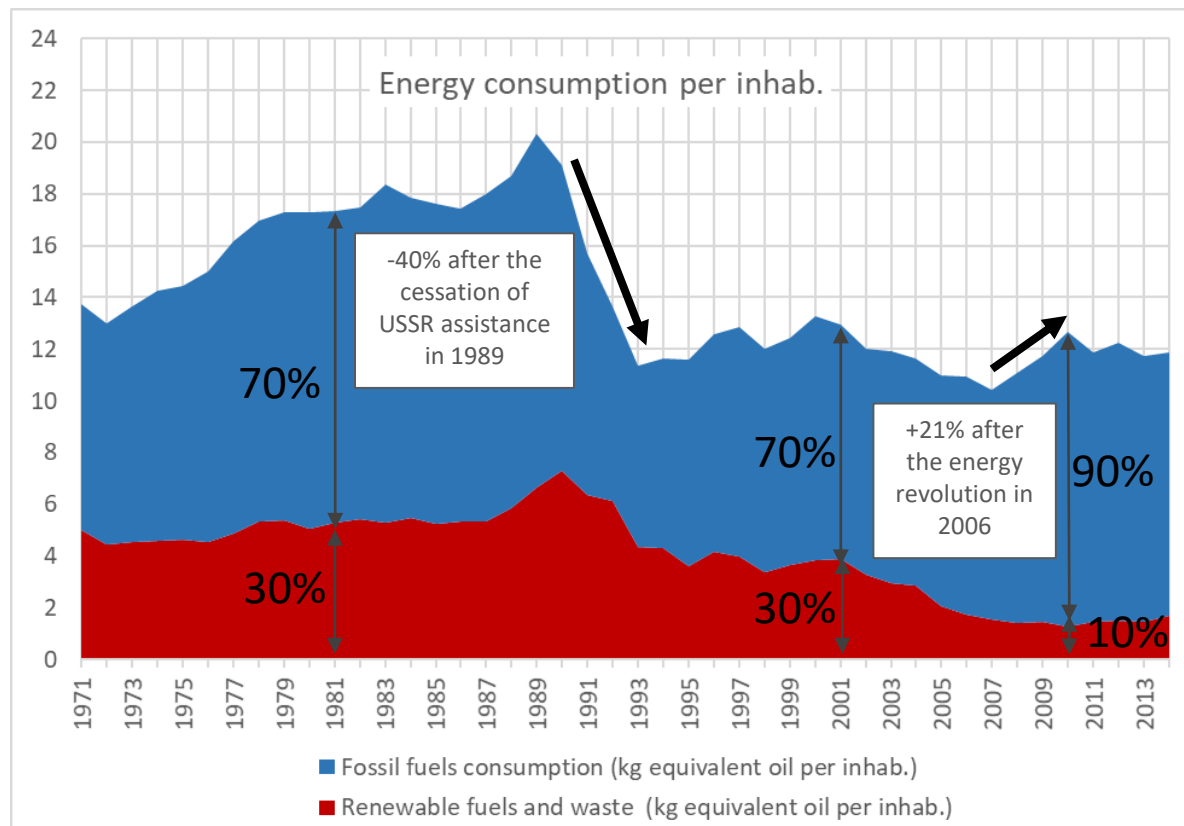


- Decrease energy imports** from 41.9 to 39.4 TWh.
- Increase the exploitation of fossil resources** from 32.8 to 58.1 TWh for oil and from 5.9 to 9 TWh for gas.
- Increase the production of renewable energy** from 18 to 51.5 TWh for biomass and from 0.1 TWh to 2 TWh for solar, wind and hydro

The facts behind political strategies...

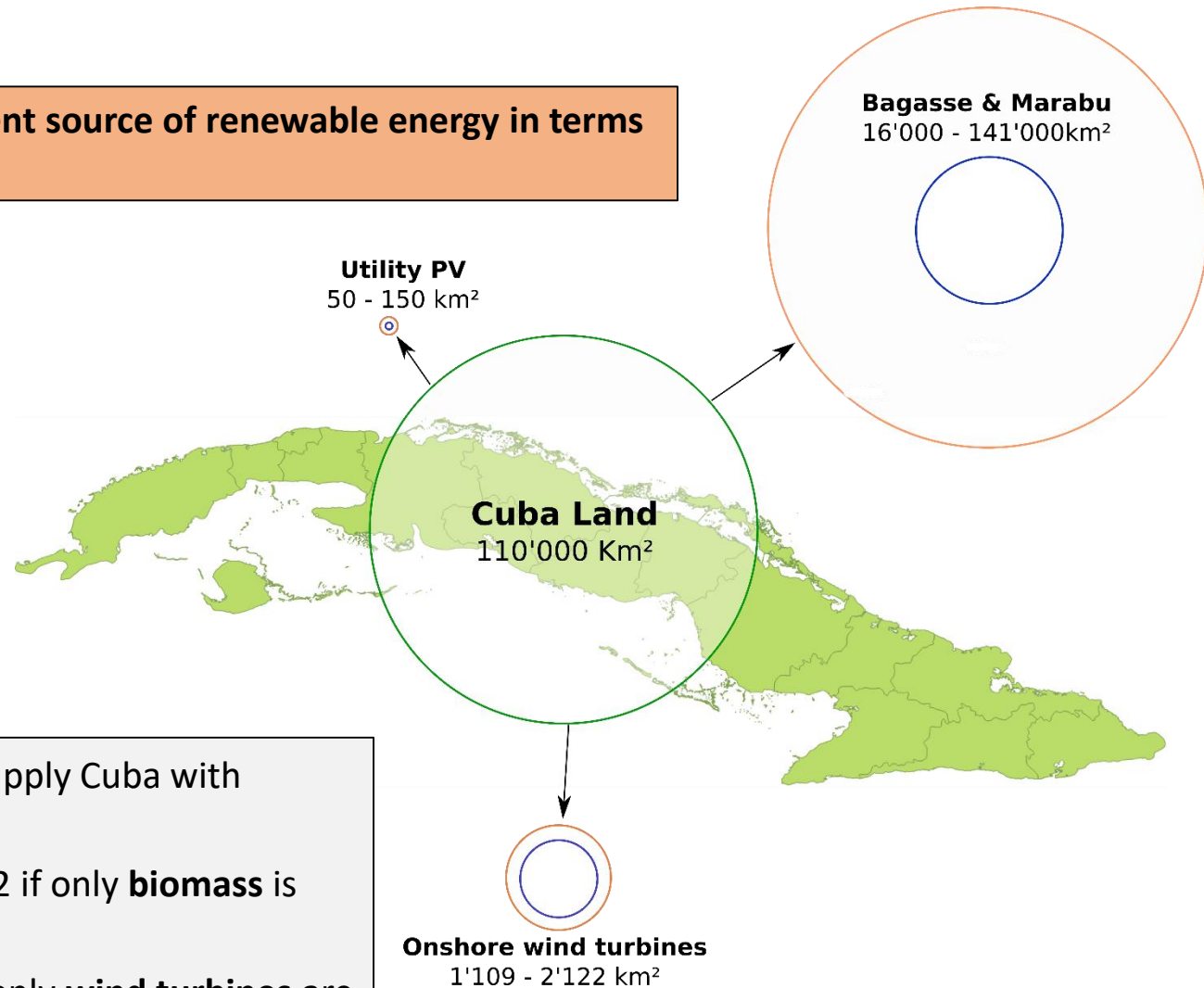
In 2006 Cuba started its “**Energy Revolution**”. The goal was to increase energy efficiency and increase the share of renewable energy but:

- the energy revolution is followed by a 21% **increase in energy consumption** until 2010,
- the **share of renewable decreases** from 30% in 2001 to around 10% in 2010.



The different renewable energies

Biomass is not the most efficient source of renewable energy in terms of land use.

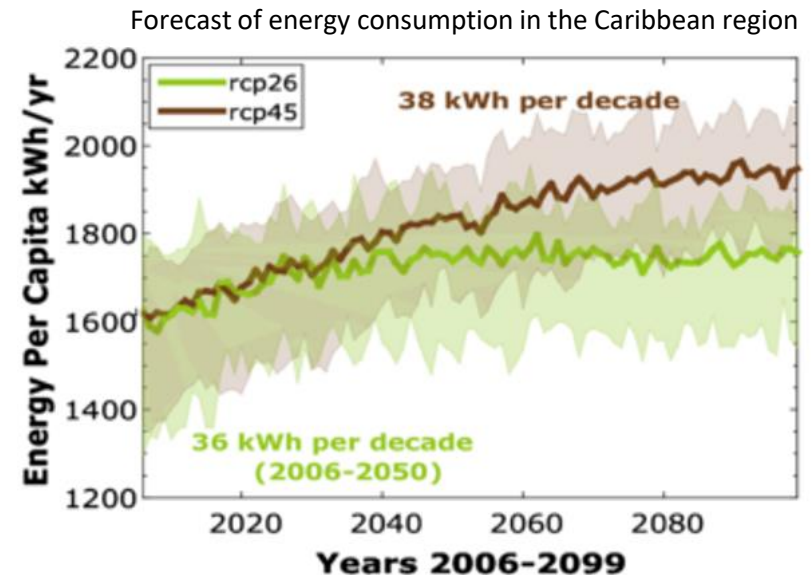
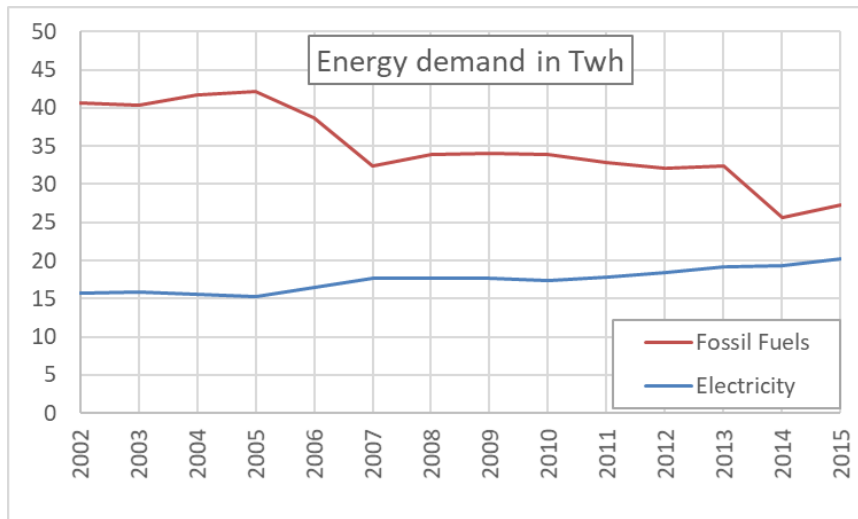


The land surface necessary to supply Cuba with electricity by 2030:

- from 16,000 to 141,000 km² if only **biomass** is used (bagasse and marabu),
- from 1'109 to 2'122 km² if only **wind turbines** are used (on shore only),
- from 50 to 150 km² if only **solar panels** are used.

Rather optimistic forecasts

- ❑ Cuban authorities likely **overestimated** their energy production capacities, for the biomass as well as for the oil extraction.
- ❑ Cuban authorities **underestimated the electric demand**. The increase in 2015 was 4.8% instead of the foreseen 3.28%. The large impact of climate change foreseen over the Caribbean region that will increase the needs for air conditioning (tourism) is not accounted for.

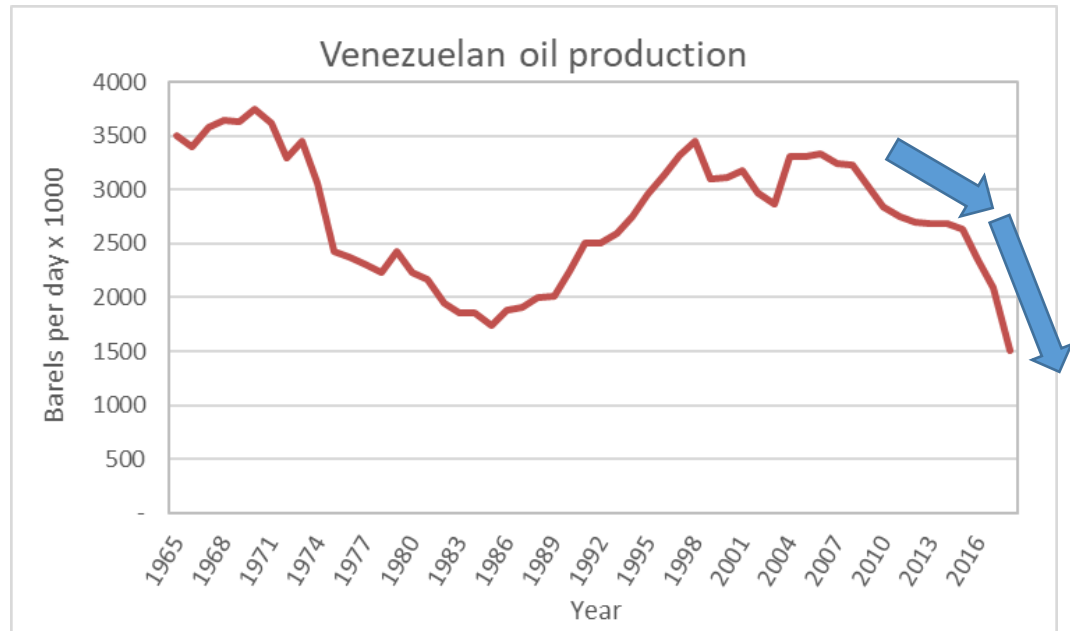


Issues related to the energy supply

In 2005 Cuba concludes a treaty with Venezuela (TSP- Tratado de Comercio de los Pueblos) to **exchange in the field of medical goods, education and oil** between the two nations.



Venezuela faced unprecedented economic difficulties and has seen its oil production decline drastically. It is no longer able to provide Cuba, presumably since 2015.



Alternative scenarios

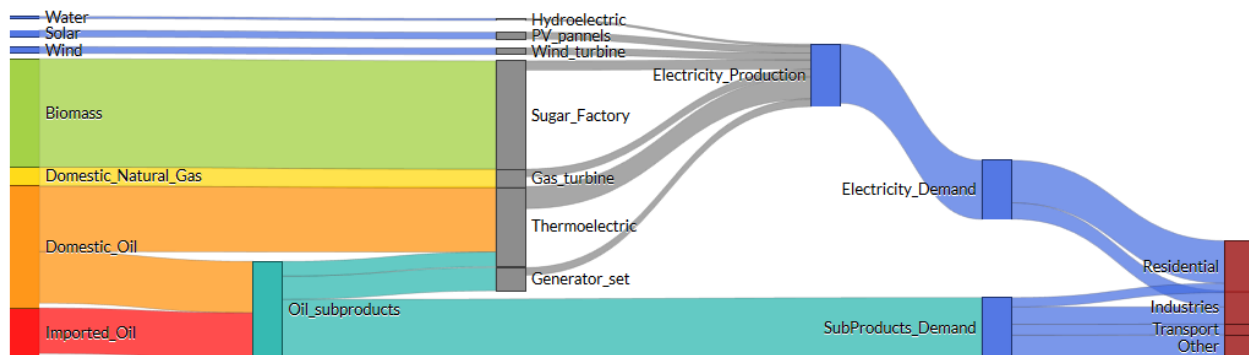
We considered alternative energy scenarios that allow for:

- A potential **increase of the energy offer,**
- A **reduction of the importations** with an **increased share of renewables.**
- A **reduction of the impact on the environment.**

Alternative scenarios

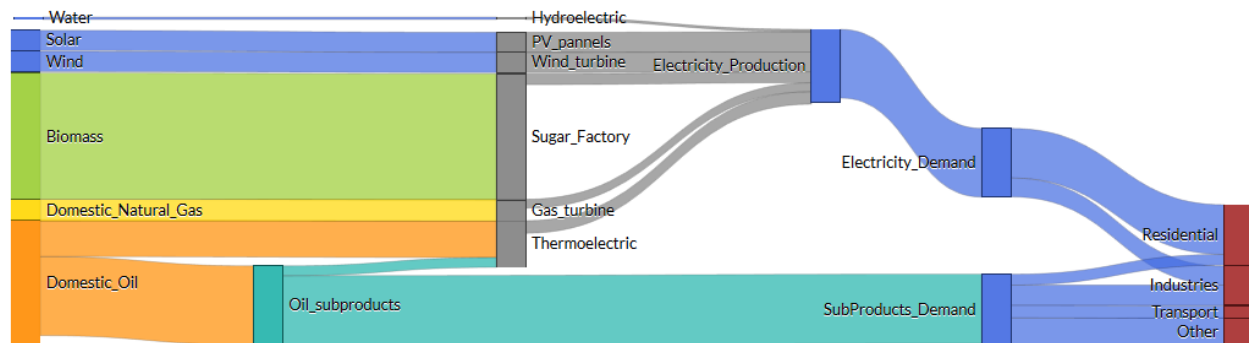
20% of electricity is produced by solar and wind

TOTAL (TWh)	151.5
Water	0.7%
Solar	2.6%
Wind	2.6%
Biomass	34.0%
Domestic_NGas	5.9%
Domestic_Oil	38.4%
Imported_Oil & Sub	15.8%



50% of electricity is produced by solar and wind

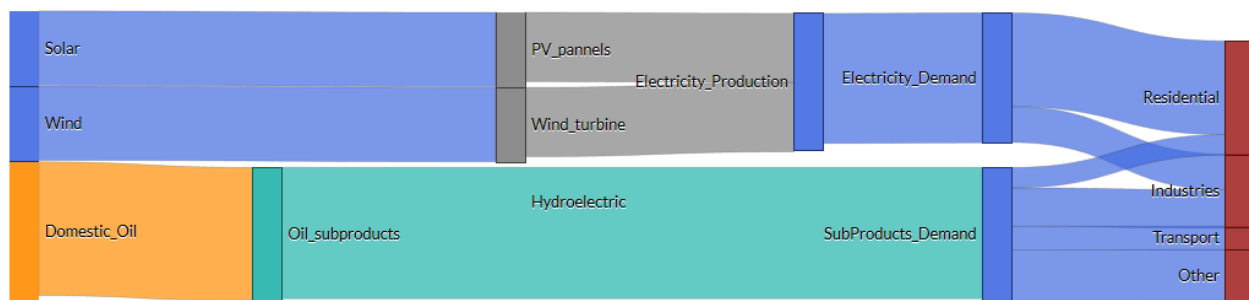
TOTAL (TWh)	128.9
Water	0.8%
Solar	6.4%
Wind	6.4%
Biomass	40.0%
Domestic_NGas	7.0%
Domestic_Oil	39.6%
Imported_Oil & Sub	-



Demand:
56,7 TWh

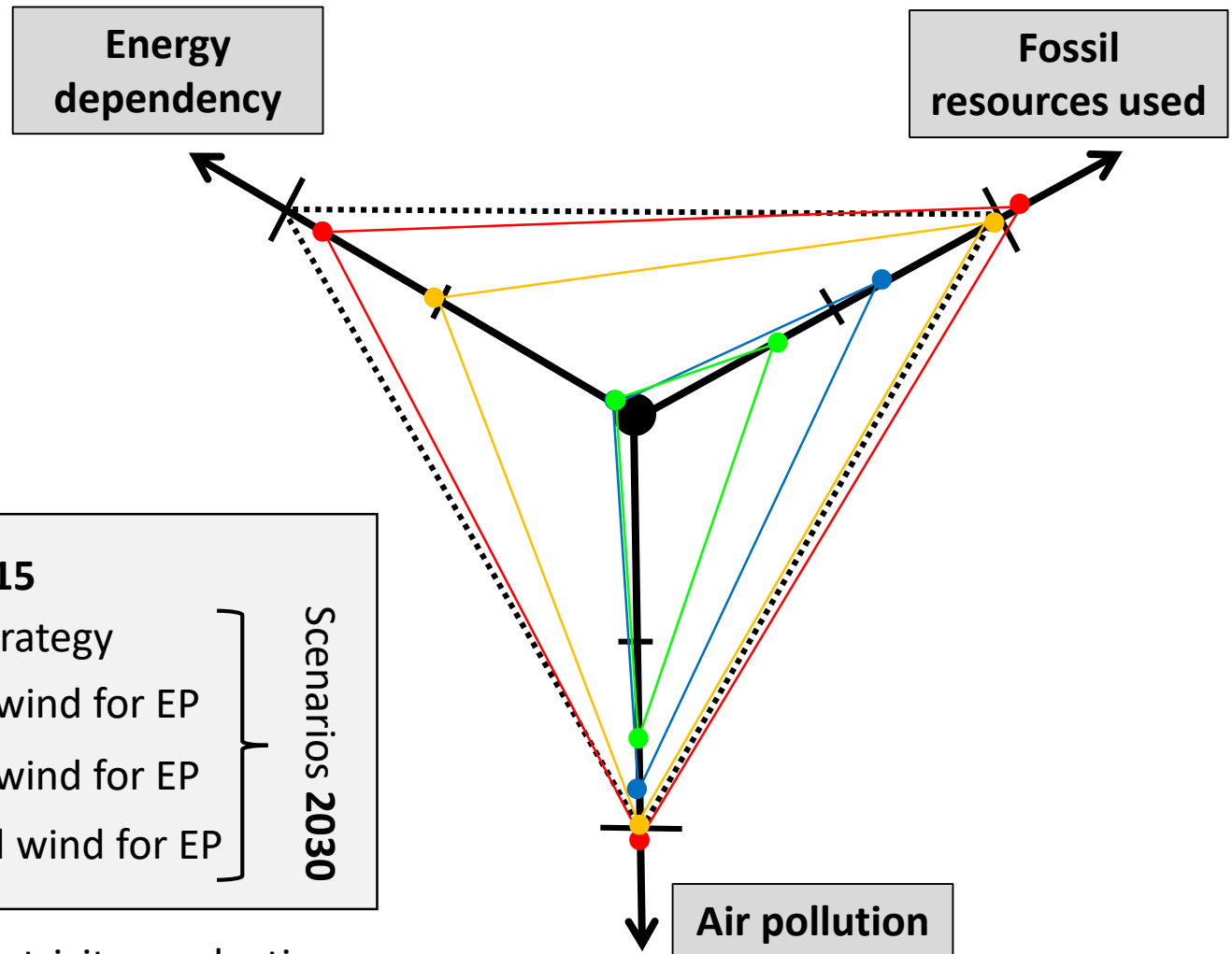
100% of electricity is produced by solar and wind

TOTAL (GWh)	62
Water	-
Solar	25.8%
Wind	25.8%
Biomass	-
Domestic_NGas	-
Domestic_Oil	48.4%
Imported_Oil & Sub	-



Alternative Scenarios

Cuban energy mix



EP = Electricity production

Alternative Scenarios

		2015	Scenarios 2030			
			Official	20%	50%	100%
Resources (TWh)	Total	98,7	160,0	151,5	128,9	62,0
	Water	0,05	1,0	1,0	1,0	0
	Solar	0,03	0,5	4,0	8,2	16,0
	Wind	0,03	0,5	4,0	8,2	16,0
	Biomass	18,0	51,5	51,5	51,5	0
	Cuban natural gas	5,9	9,0	9,0	9,0	0
	Cuban brut oil	32,8	58,1	58,1	51,0	30,0
	Imported fuels	41,9	39,4	23,9	0	0
Criteria	Energy security	1,00	0,83	0,52	0,00	0,00
	Sustainability of the resources	1,00	1,16	1,00	0,68	0,35
	Air quality	1,00	1,07	1,01	0,93	0,84

Indicators:
 0 = best possible situation
 1 = situation in 2015

The increased share of solar and wind energy in the Cuban energy mix would allow to:

- **Improve energy efficiency.** The resources needed to supply 56.7 TWh in 2030 decrease from 160 to 62 TWh.
- **Reduce the country dependency.** Energy imports would decrease and even disappear when at least 50% of the electricity is produced by solar and wind.
- **Increase the sustainability** of the resources with a higher share of renewables.
- **Improve air quality.** Less fuel and biomass are burned leading to reduced levels of pollution.

Conclusions

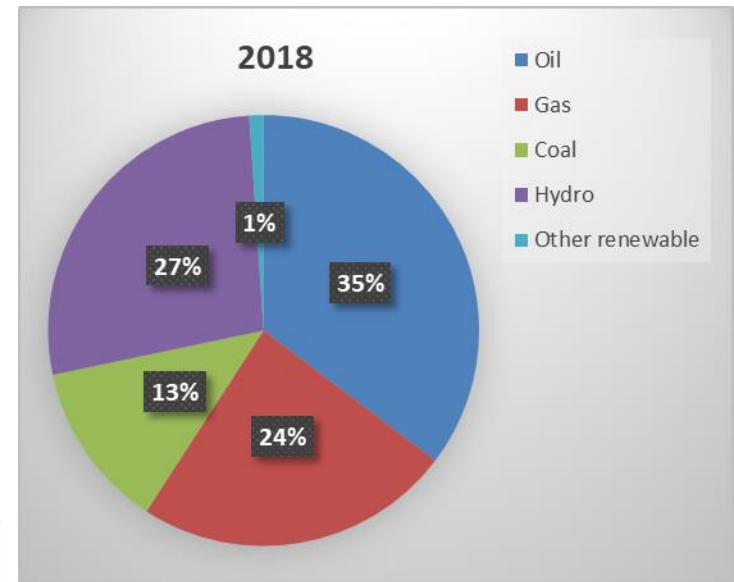
- ❑ Strategies should be integrated and address air quality, climate and energy at the same time.
- ❑ Preference to domestic resources increases economic stability...
- ❑ ...as will do renewable energy in the near (!) future...

What about Colombia?

Colombian Energy Strategies

Characteristics of the Colombian energy mix

- ☐ Full energy independency



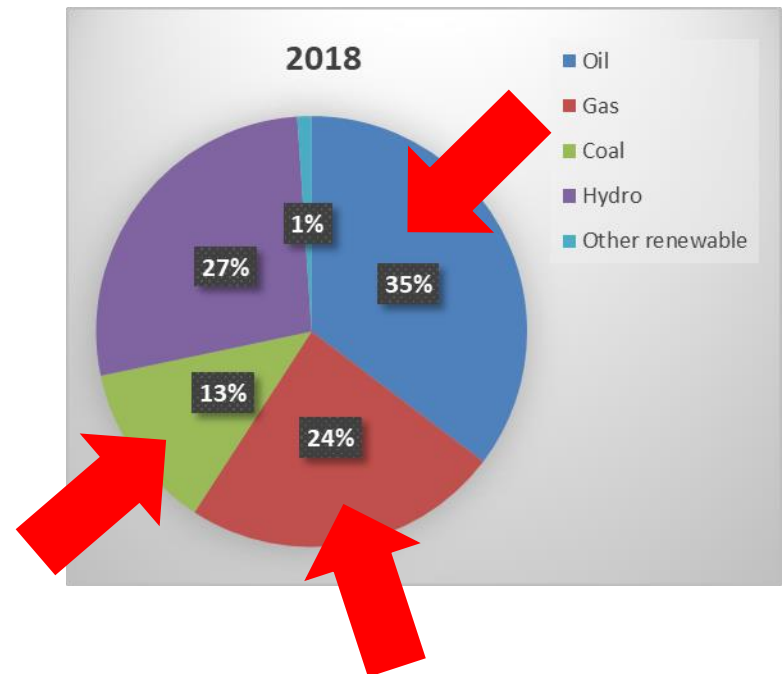
2018	Production	Consumption
Oil [barrels per day x 1000]	866	342
Gas [billion cubic meter]	12.9	13.0
Coal [million tonnes]	84.3	5.9

Colombian Energy Strategies

Characteristics of the Colombian energy mix

- Full energy independency...
- ...but weak sustainability

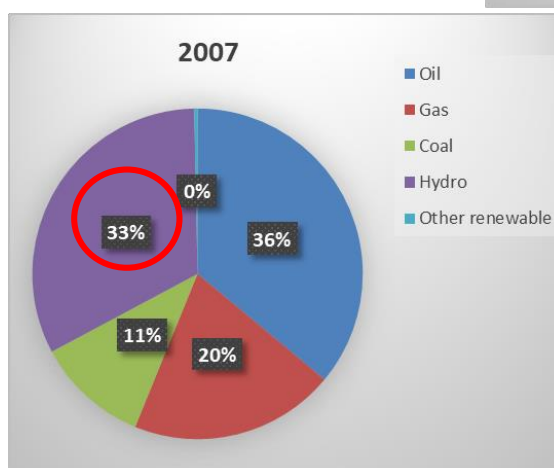
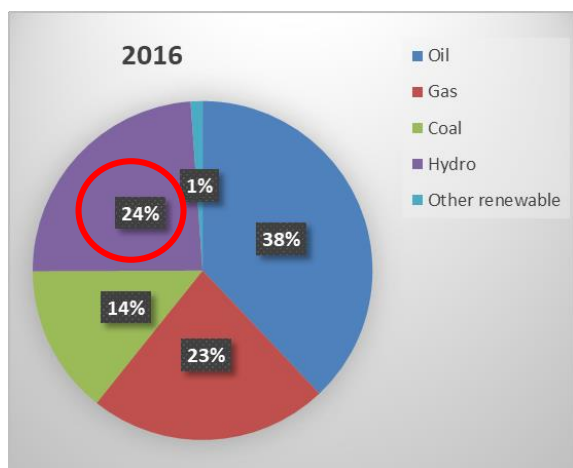
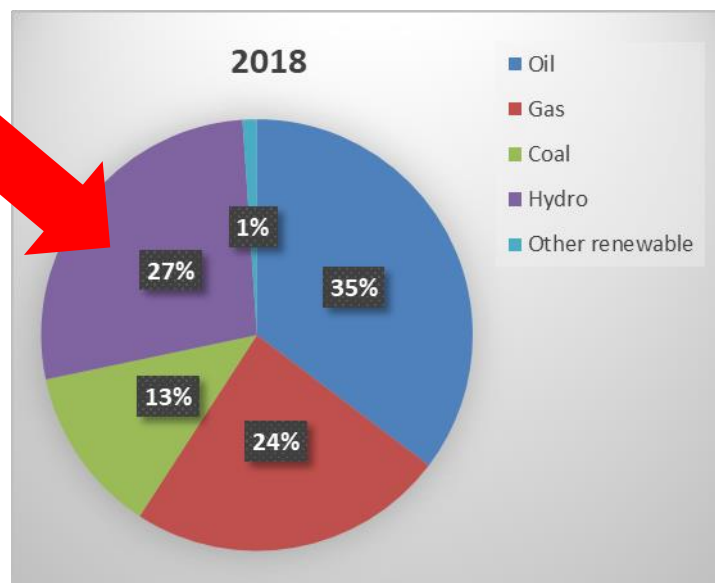
2018	Years
Oil	5.6
Gas	8.3
Coal	58



Colombian Energy Strategies

Characteristics of the Colombian energy mix

- ❑ Full energy independency
- ❑ but weak sustainability



Conclusions

- ❑ Strategies should be integrated and address air quality, climate and energy at the same time.
- ❑ Preference to domestic resources increases economic stability...
- ❑ ...as will do renewable energy in the near (!) future...



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Partnership:

- Climatology and hydrology
- Energy strategies
- Air quality and climate strategies

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