

Cuban's Energy Strategy into 2030:

General Design Features towards a Sustainable Transition

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Partners:



Sponsors:



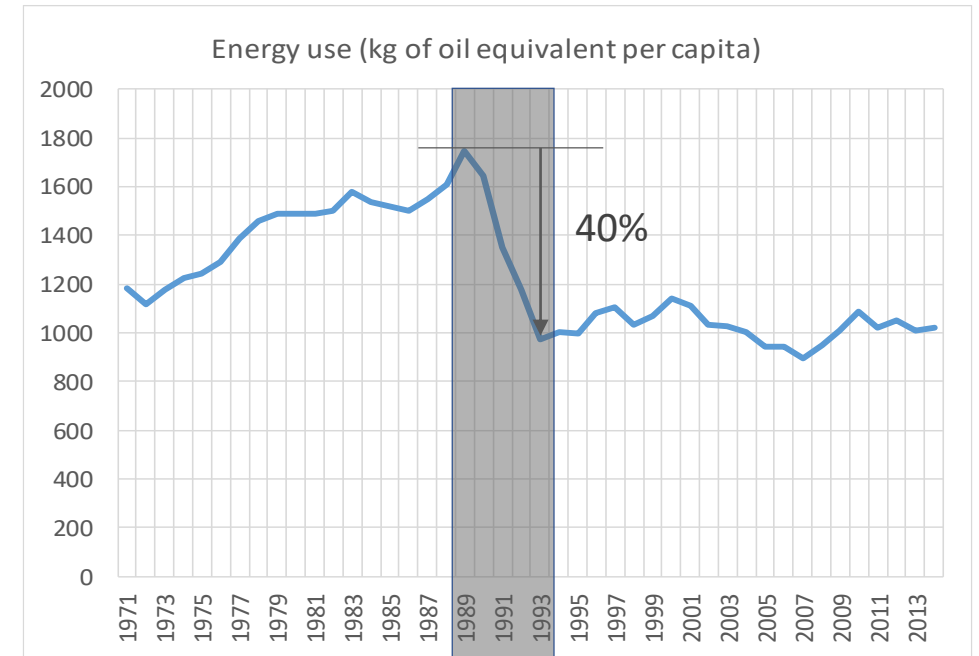
Fonds européen de développement régional (FEDER)
Europäischer Fonds für regionale Entwicklung (EFRE)

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.

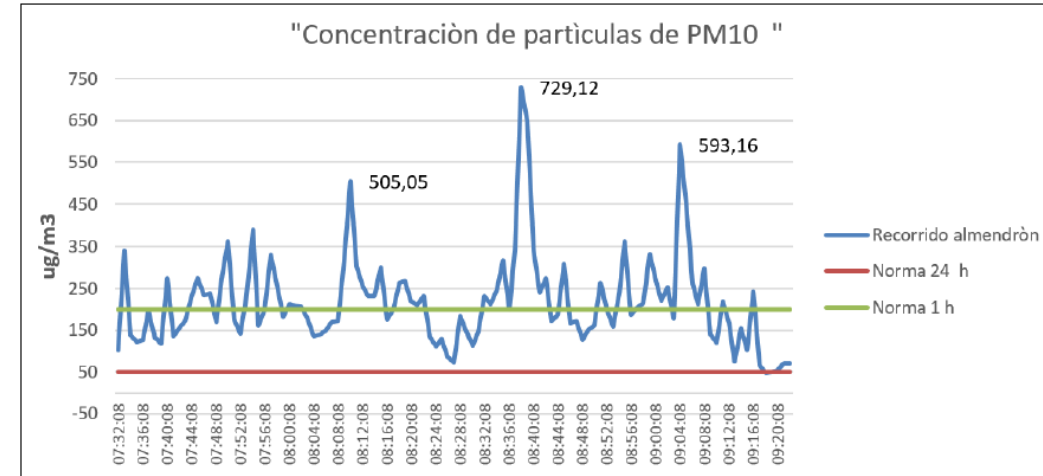


What are the Embargo Implications ?

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

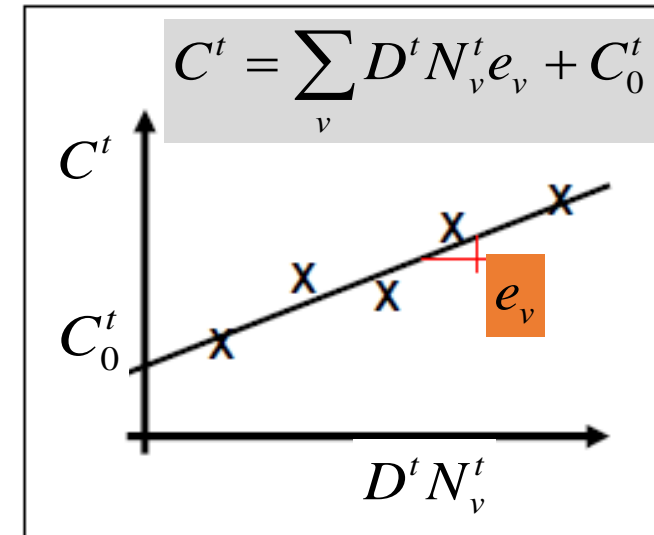
Emission factors for vehicles were not estimated using measurements in a lab. A measurement campaign have been organized in the framework of our project.



Measurements of concentrations

15'000 US\$

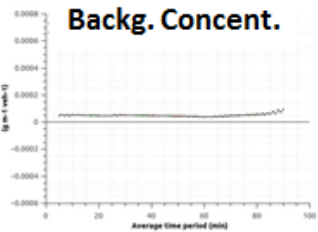
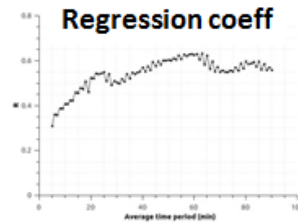
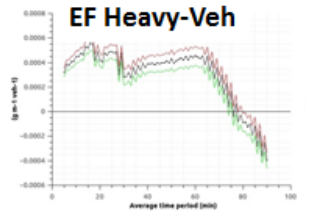
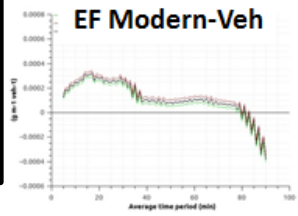
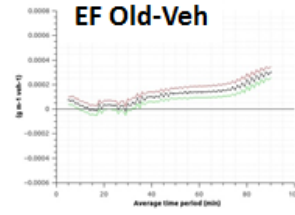
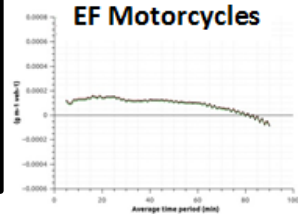
Traffic counting



**Bulk
emission
factors**

Belalcazar, L., C., O. Fuhrer, M. D. Ho, E. Zarate and A. Clappier, 2009: Estimation of road traffic emission factors from a long term tracer study, *Atmos. Environ.*, **43**, 5830-5837.

Air Quality Study: Emissions



	Emissions (mg/km)	Std. Dev 95% Confid	Emis. (mg/km/pers)	Concent. (μm^3)
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

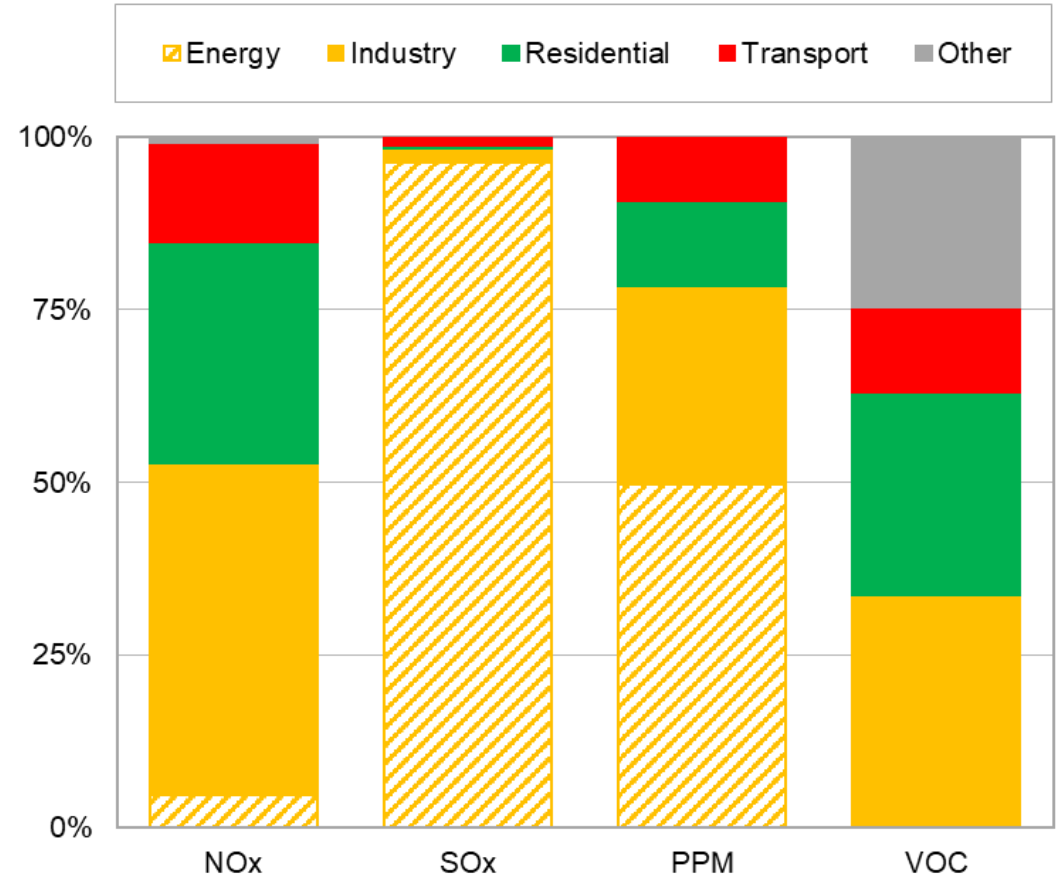
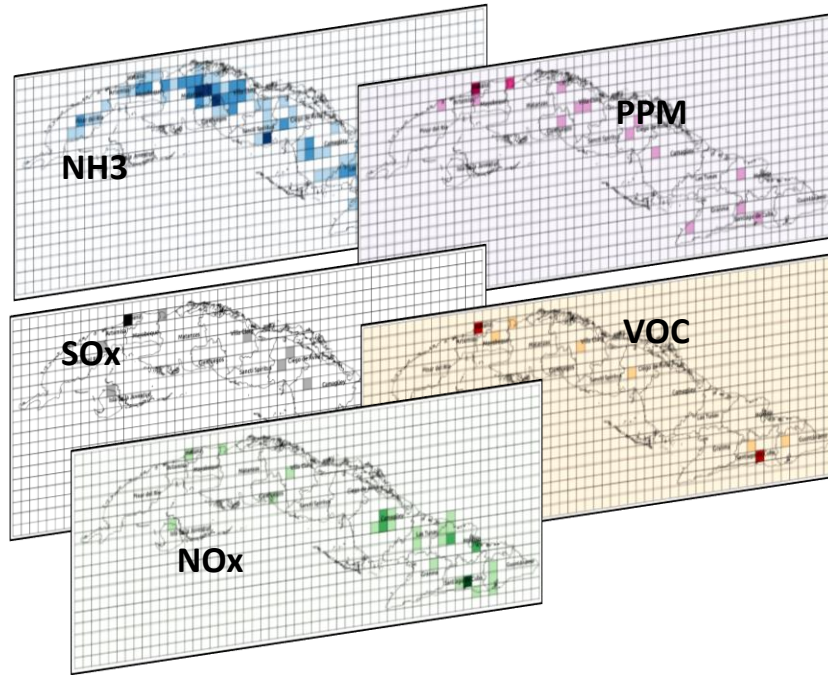
1. Identification of **time-averaging**
2. **Principal Component Regression (PCR)** instead of Multi Linear Regression (MLR)

Madrazo, J., and A. Clappier, 2018: Low-cost methodology to estimate vehicle emission factors, *Atmos. Pollu. Reas.*, **9**, 322-332.

Air Quality Study: Emissions

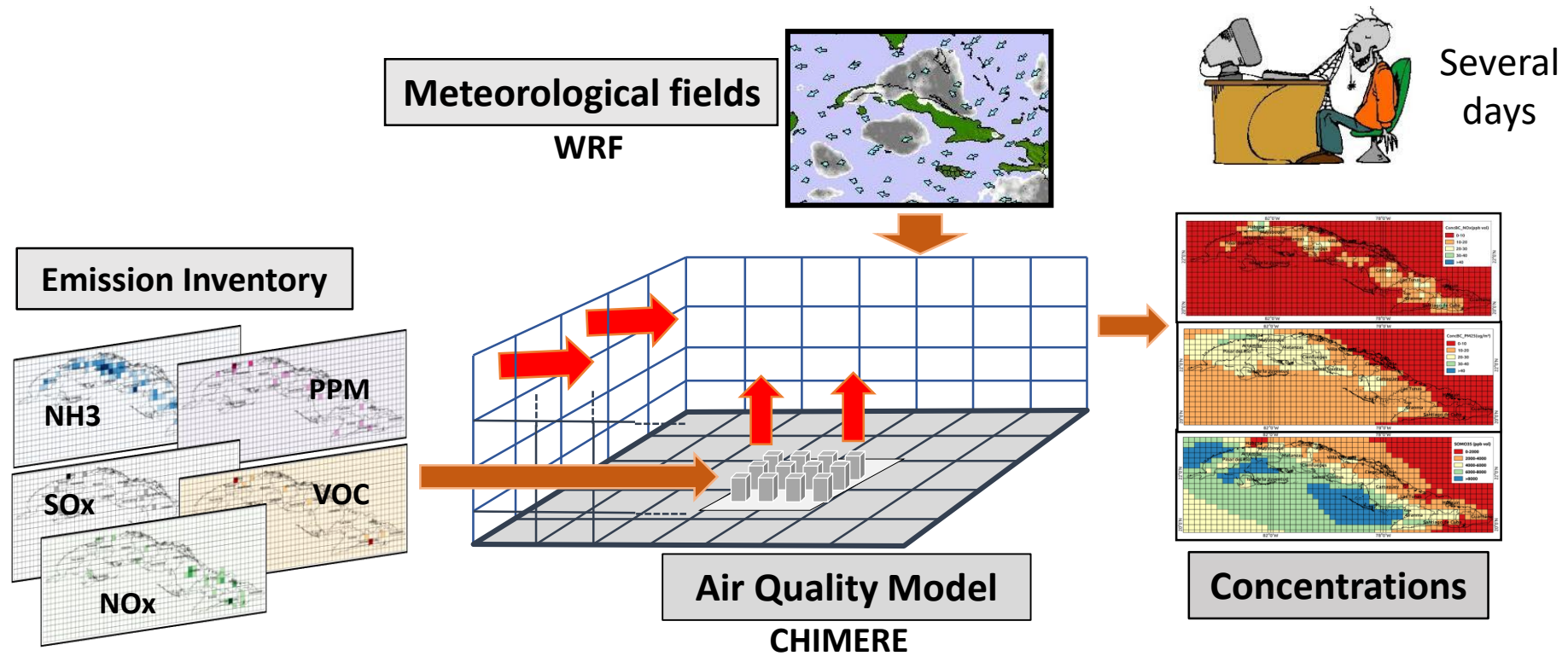
Emissions inventory

24x24 km² and 1 hour resolution



Madrazo, J., A. Clappier, L. Belalcazar, O. Cuesta, H. Contreras, F. Golay, 2018: Screening differences between a local inventory and the Emissions Database for Global Atmospheric Research (EDGAR), *Science of the Total Environ.*, **631-632**, 934-941

Air Quality Study: Numerical Simulations



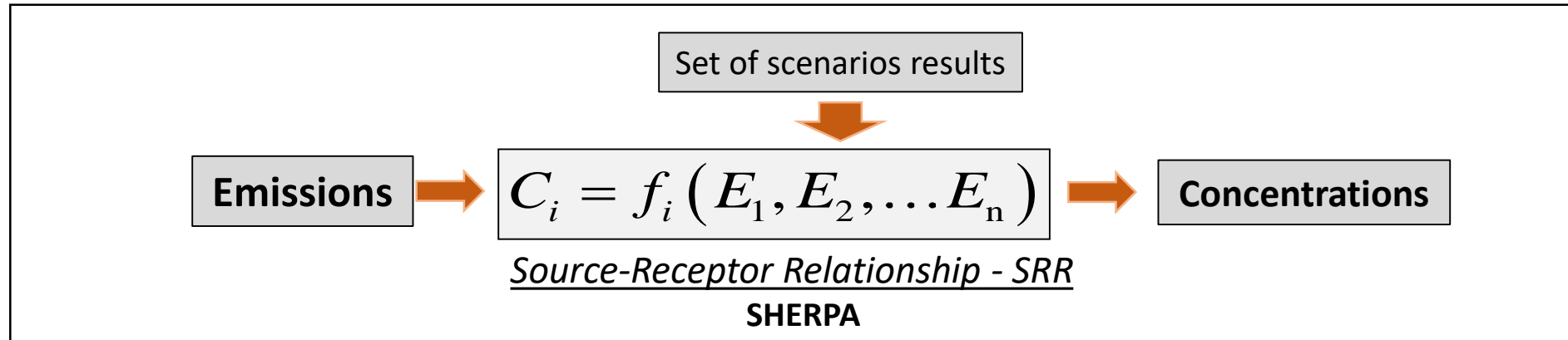
Air Quality Study: Numerical Simulations



Several days

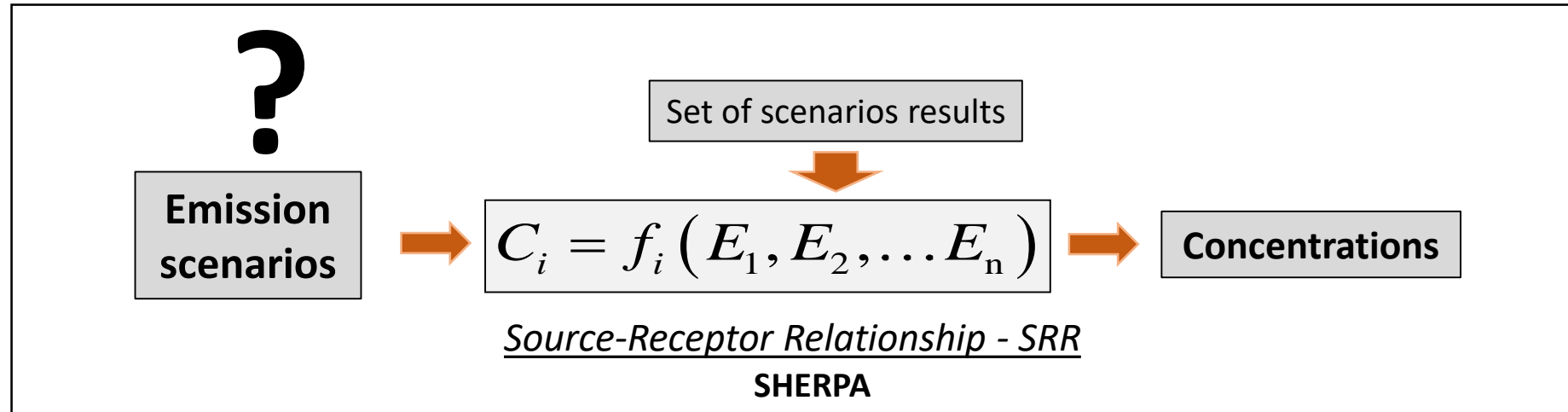


Few minutes



Thunis, P., B. Degraeuwe, E. Pisoni, M. Trombetti, E. Peduzzi, C.A. Belis, J. Wilson, A. Clappier and E. Vignati, 2018: PM2.5 source allocation in European cities: A SHERPA modelling study, *Atmos. Environ.*, **187**, 93-106.

Air Quality Study: Abatement Strategies



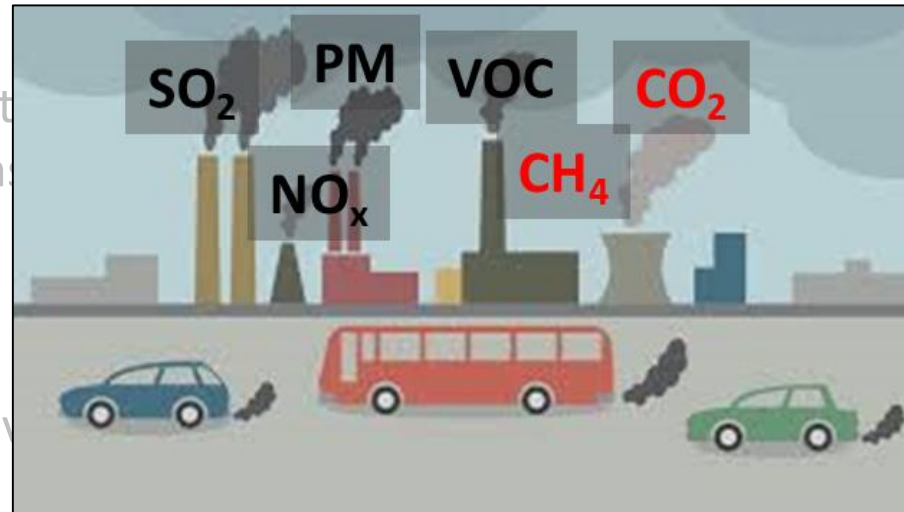
Design of Strategies

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 change are often linked, there are exceptions

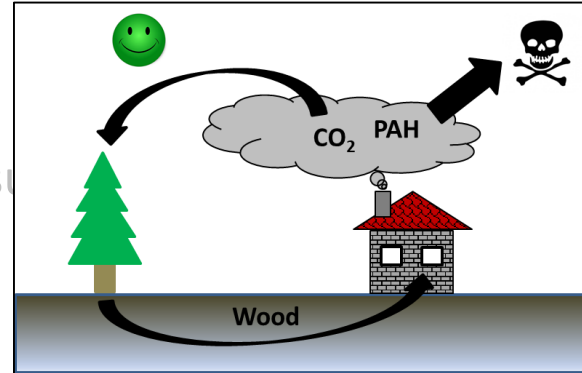
- ❑ Decision makers have



to co-benefits,

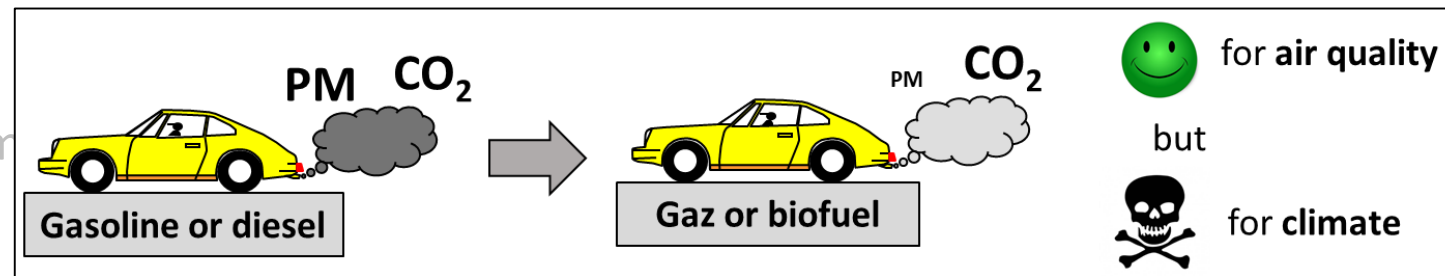
Why should Air Quality, Climate and Energy Strategies be coordinated?

- 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



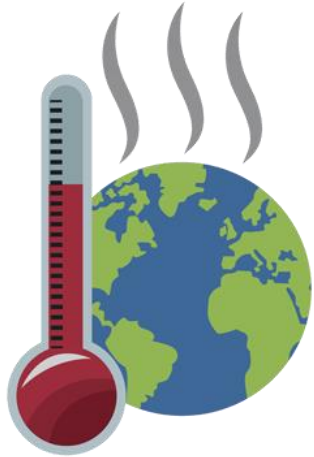
Why should Air Quality, Climate and Energy Strategies be coordinated?

- Air quality and Climate i



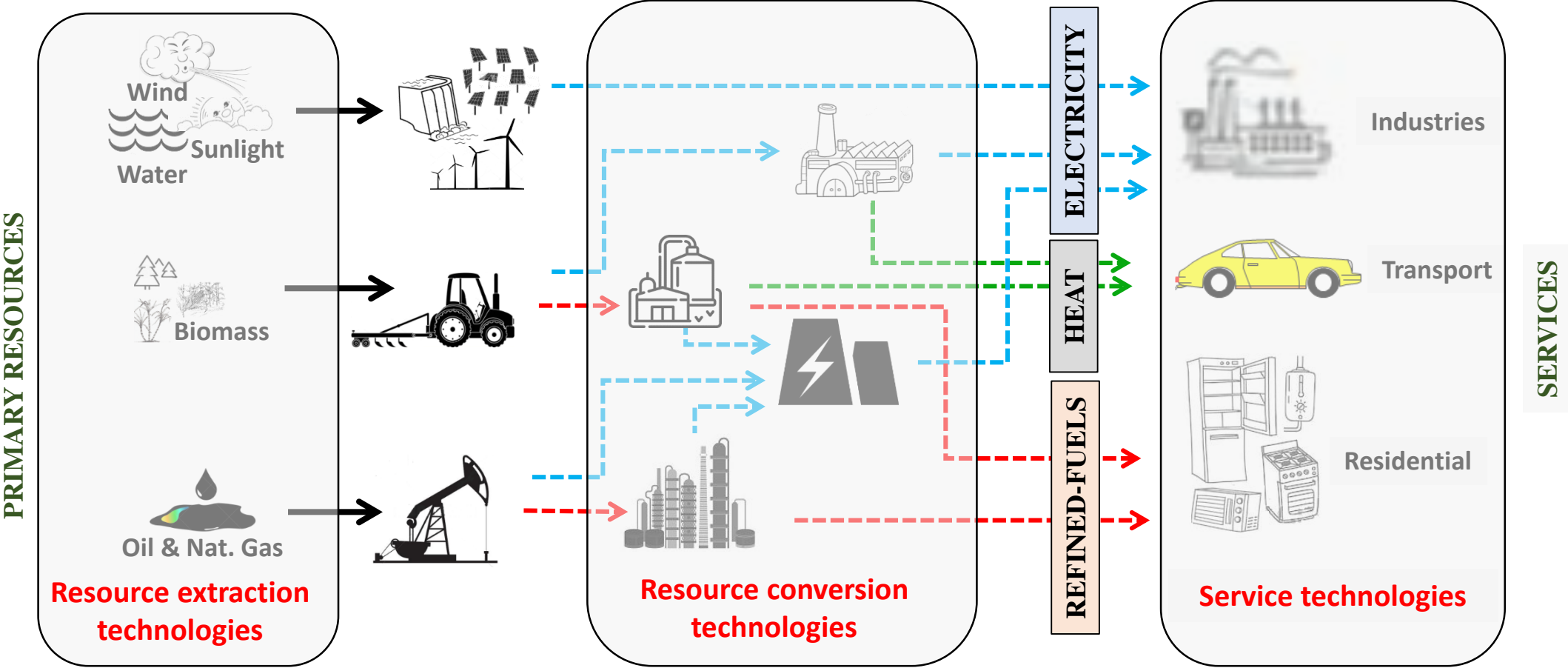
our energy usage (fossil fuels)

- Alt the ... lity ai ... ns.

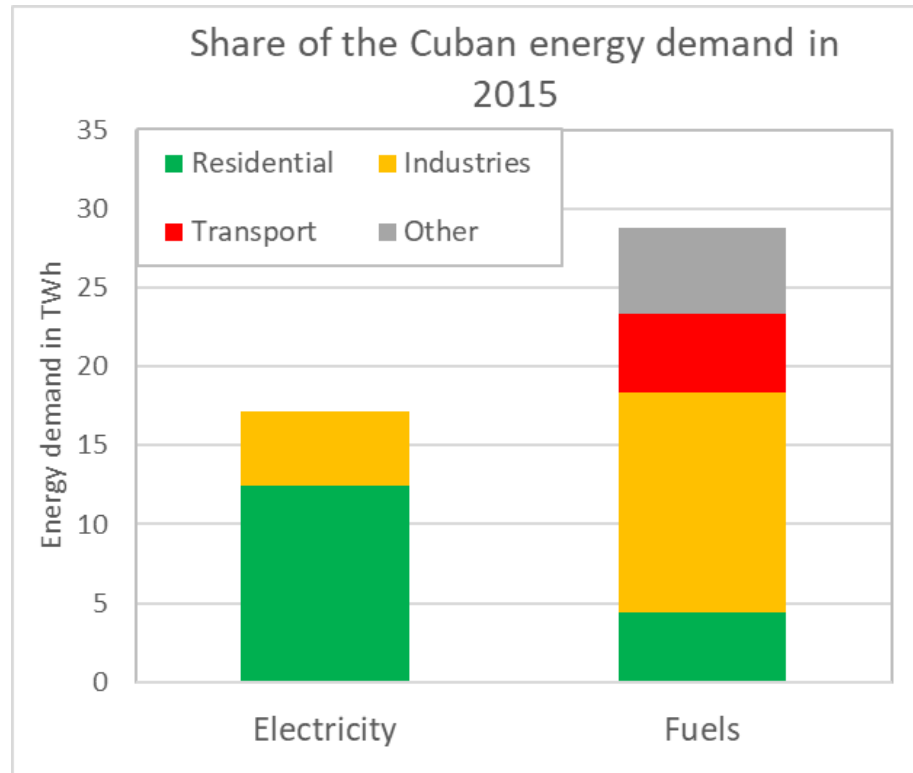


- Decision makers have their own agenda.

Energy and Technologies



Cuban 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%)**.

Cuban Energy Resources Used in 2015

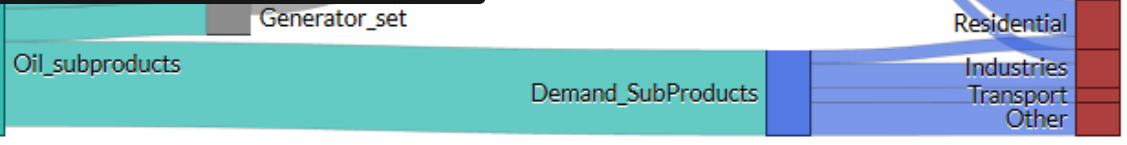


TOTAL (TWh)	98.7
Water	0.05%
Solar	0.03%
Wind	0.03%
Biomass	18.2%
Domestic_NGas	6.0%
Domestic Oil	33.2%
Imported_Oil & Sub	42.5%

- Water
- Solar
- Wind
- Biomass
- Domestic_Natural_Gas
- Domestic_Oil
- Imported_Oil
- Imported_Oil_Subproducts

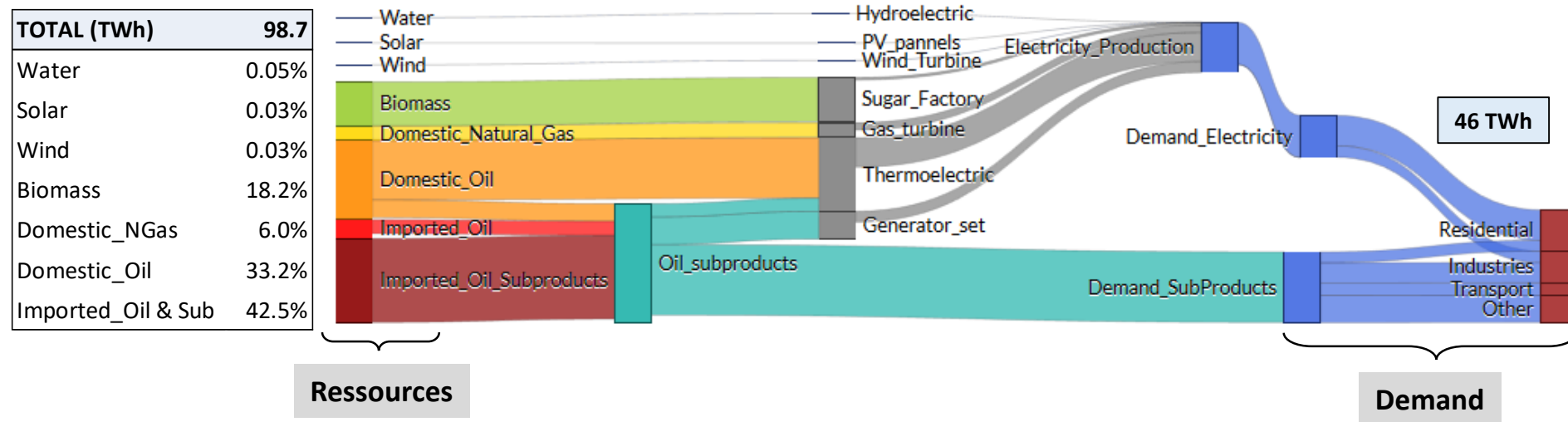


Ressources



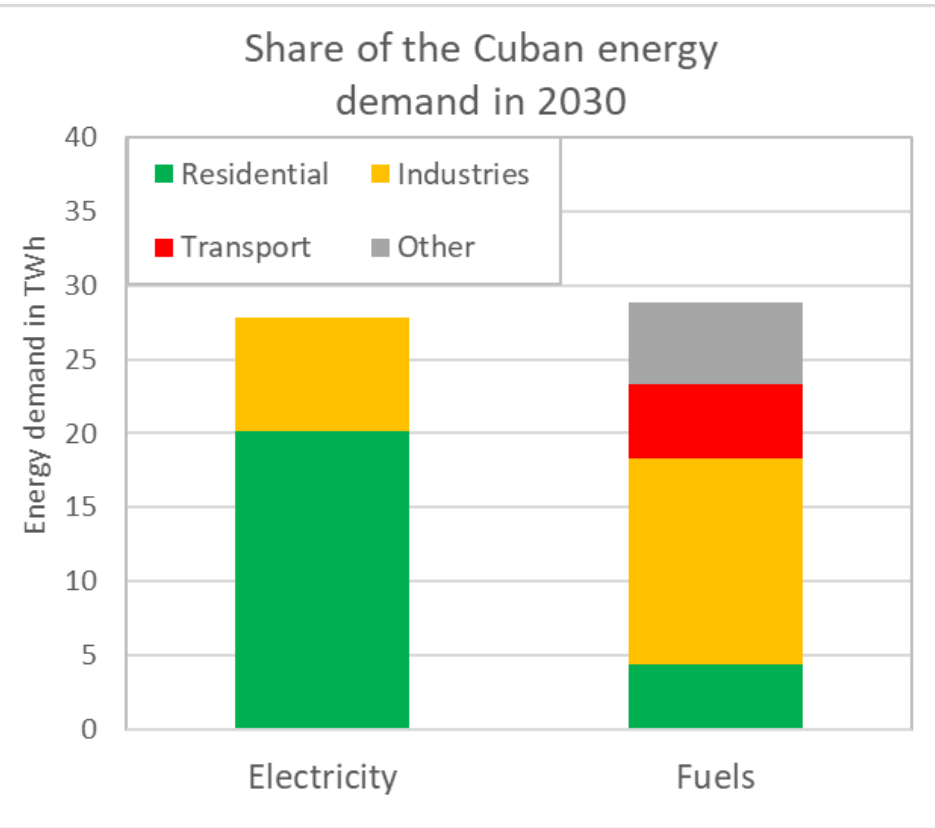
Demand

Cuban Energy Resources Used in 2015

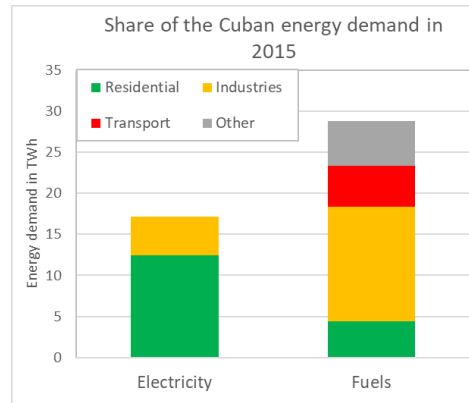


- ❑ In 2015, energy imports were still important with a share of 42.5% (i.e. 41.9 TWh).
- ❑ The share of wind, solar and hydro combined was 0.11%.

« Official » Demand Forecast for 2030

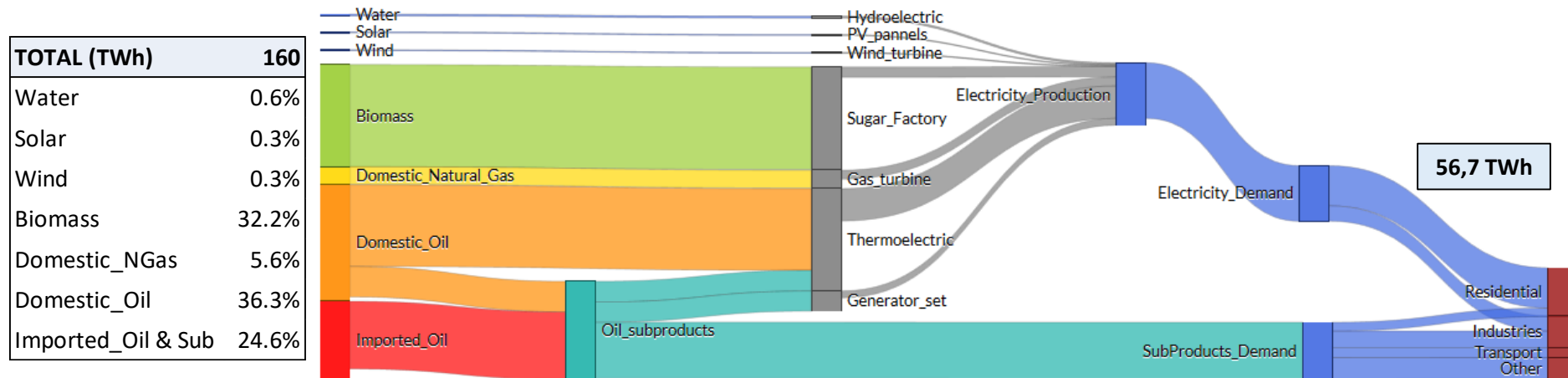


Cuban authorities estimate that the **electricity consumption will increase by 3.28% a year** until 2030. During this period fuel consumption is expected to stagnate. The total energy demand should therefore increase from 46 TWh in 2015 to 56.7 TWh by 2030.



	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

« Official » Strategy for 2030



❑ **Decrease energy imports** from 41.9 to 39.4 TWh.

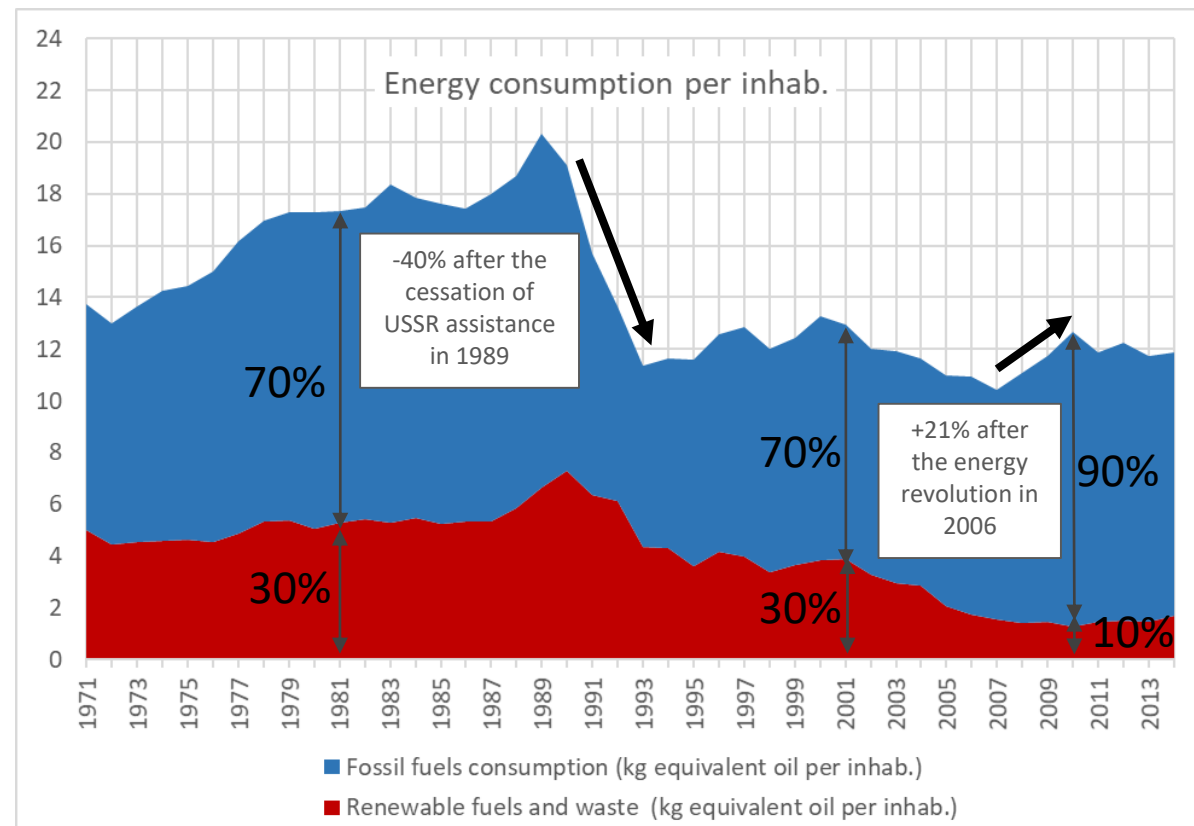
❑ **Increase the exploitation of fossil resources** from 32.8 to 58.1 TWh for oil and from 5.9 to 9 TWh for gas.

❑ **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...

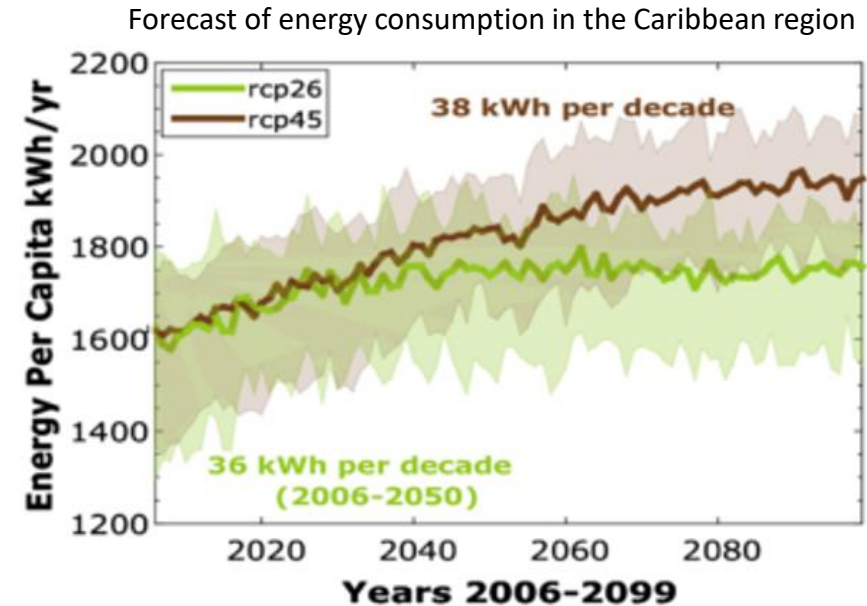
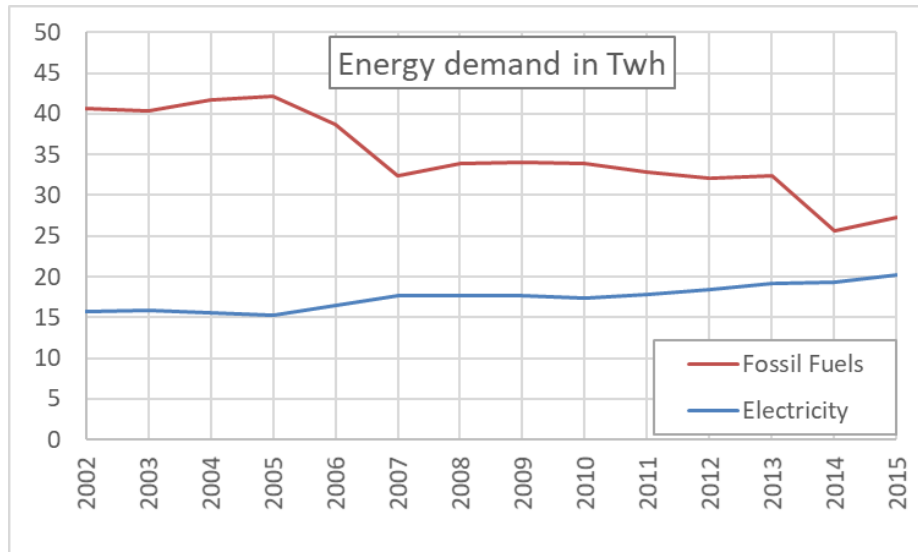
In 2006 Cuba started officially its “**Energy Revolution**”. The goal was to increase the energy efficiency and the share of renewable energy but:

- 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.



Rather Optimistic Forecasts

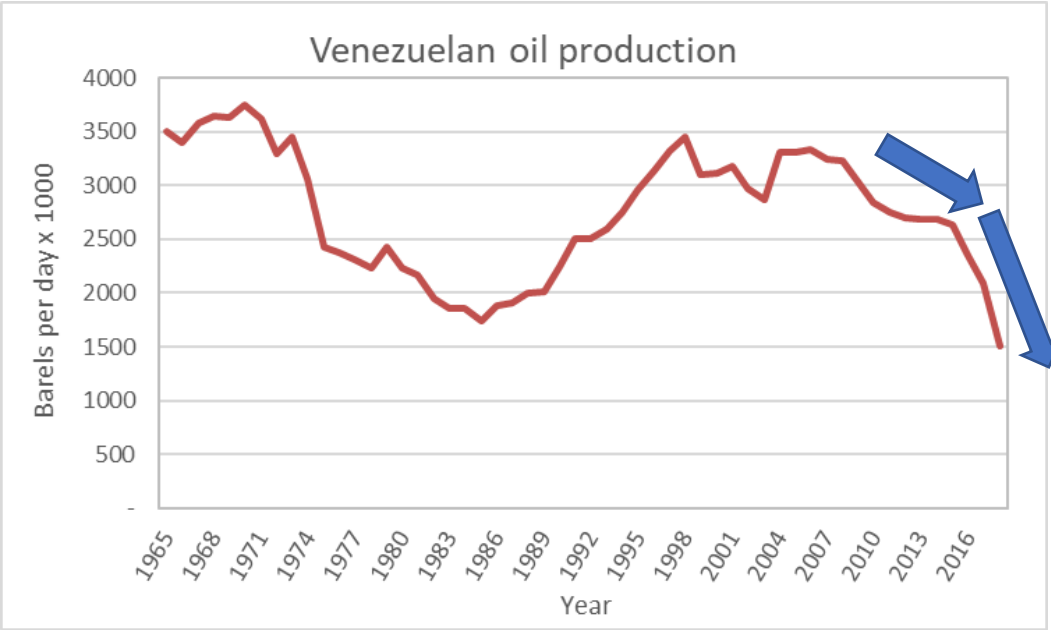
- ❑ Cuban authorities likely **overestimated their energy production capacities**, for the biomass as well as for the oil extraction.
- ❑ Cuban authorities **underestimated the electric demand**. The increase in 2015 was 4.8% instead of the foreseen 3.28%. The large impact of climate change foreseen 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.



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	-

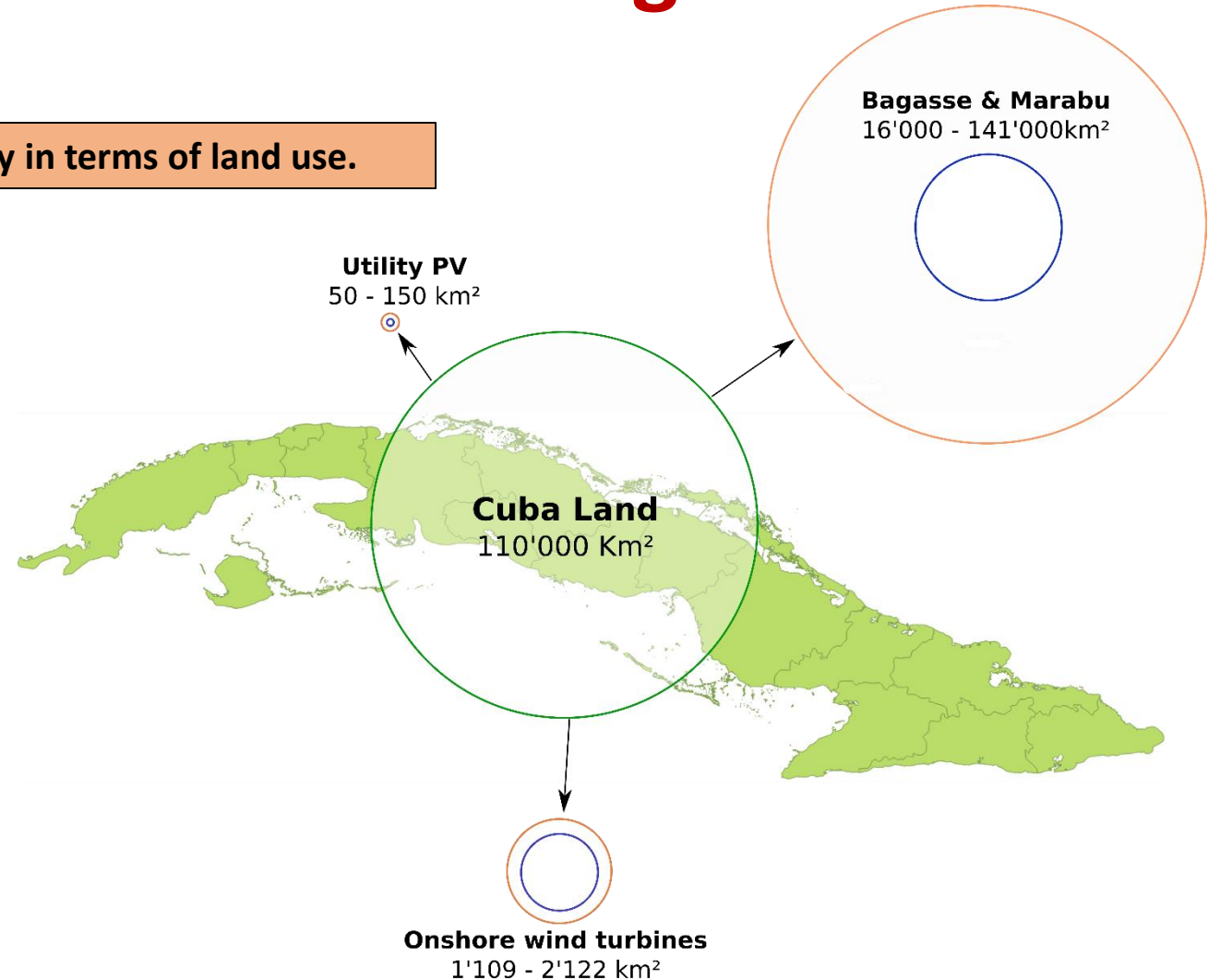
Solar power, if operated over the entire surface of the country, would provide more than 1,400 times the electricity needs of 2015.

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.

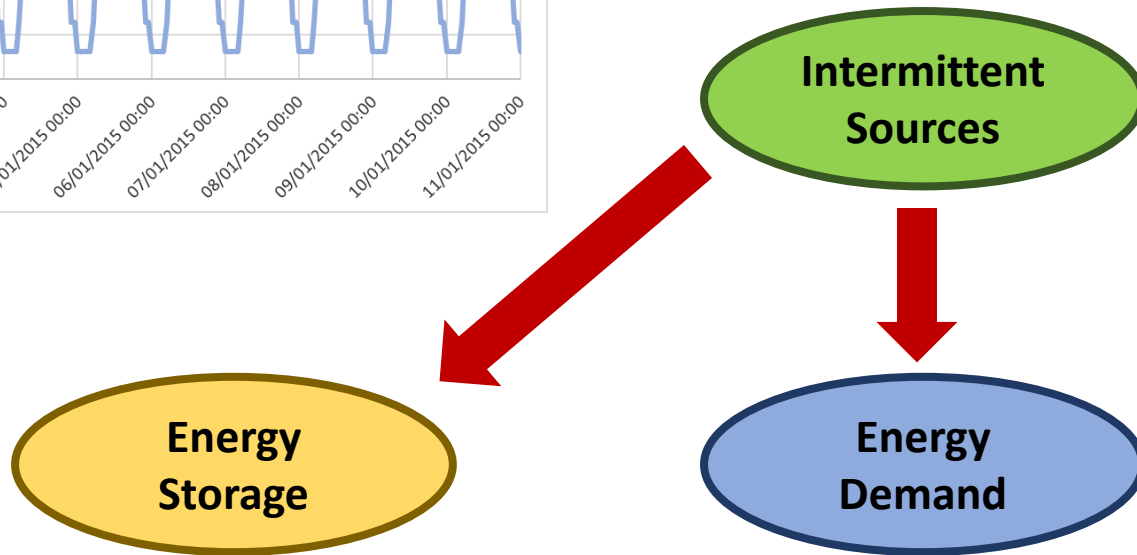
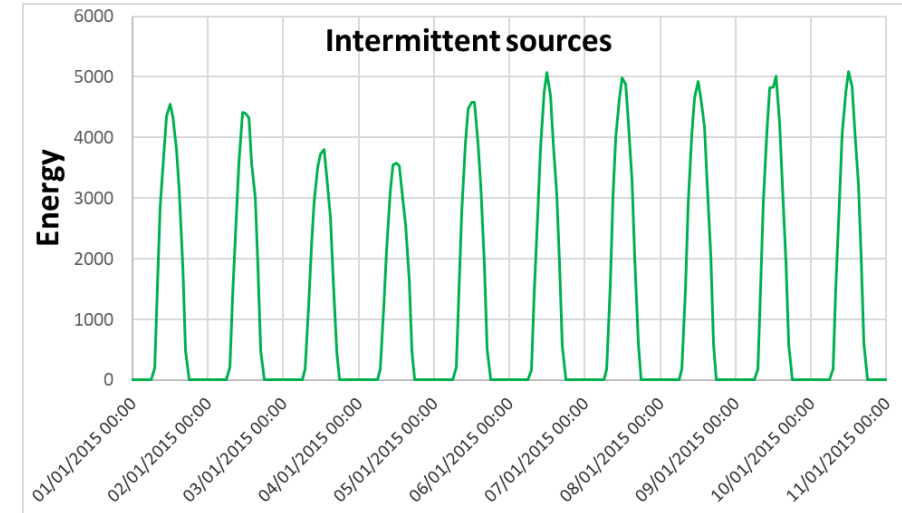
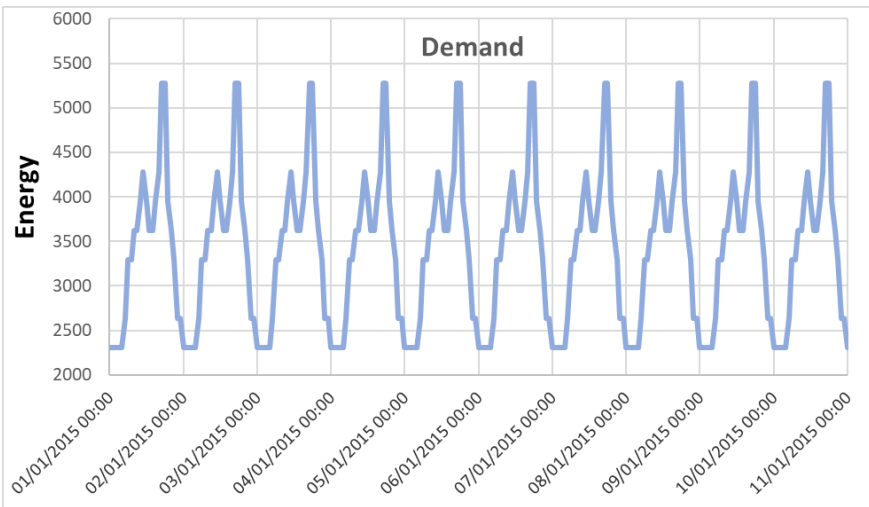


Alternative Scenarios

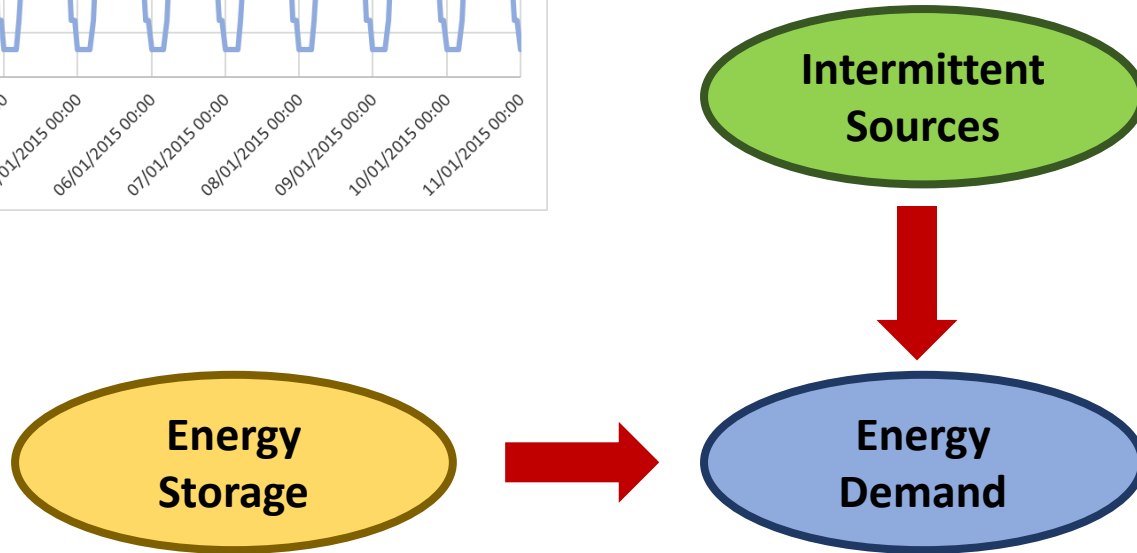
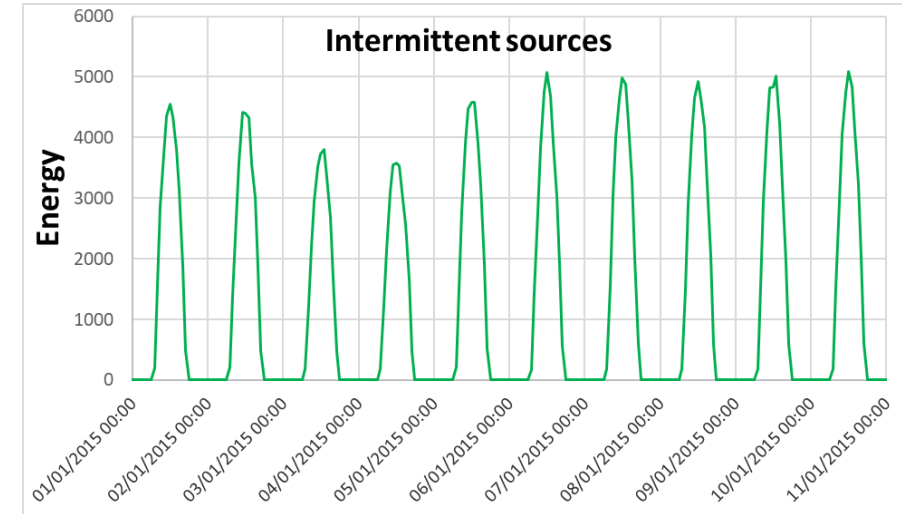
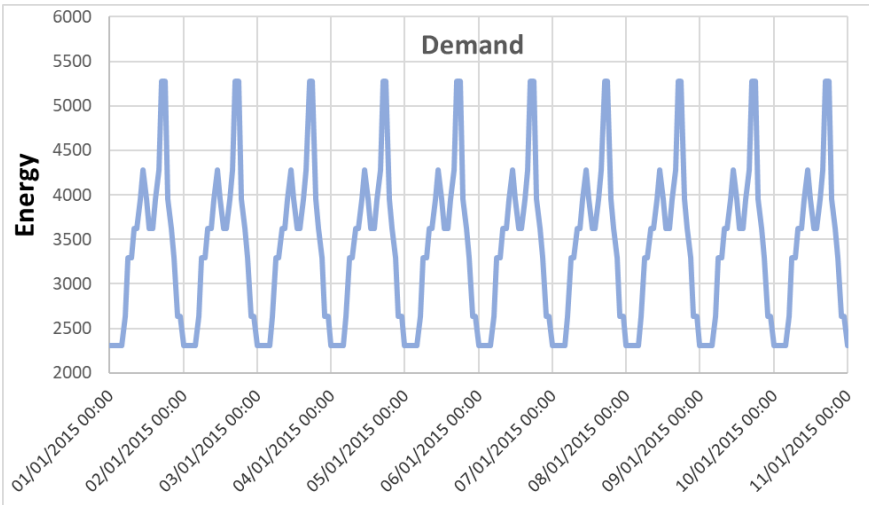
We considered alternative energy scenarios that allow for:

- 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.**

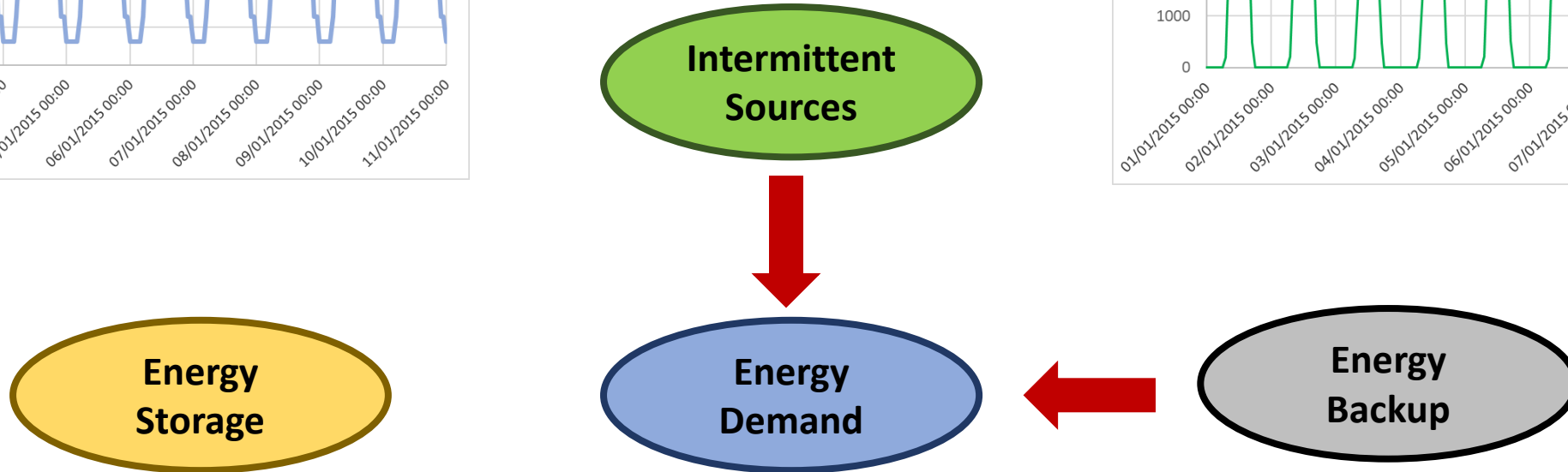
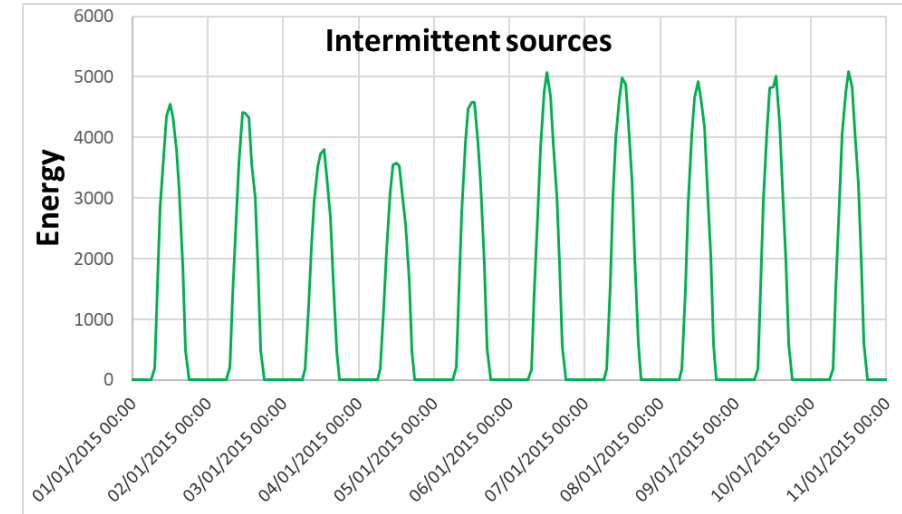
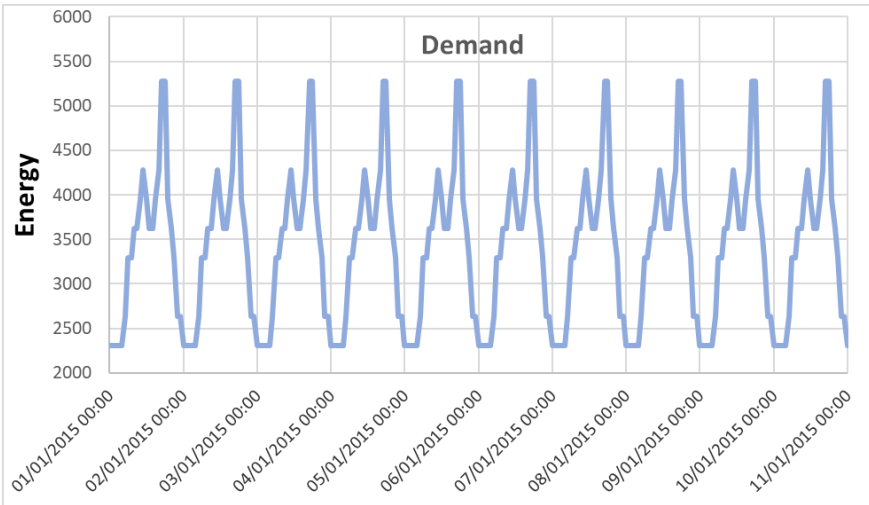
Match Energy Demand with Intermittent Sources



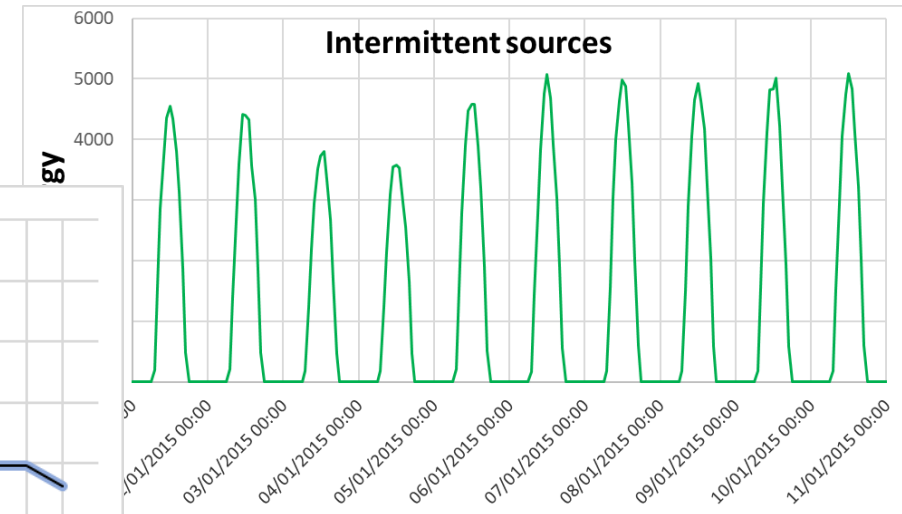
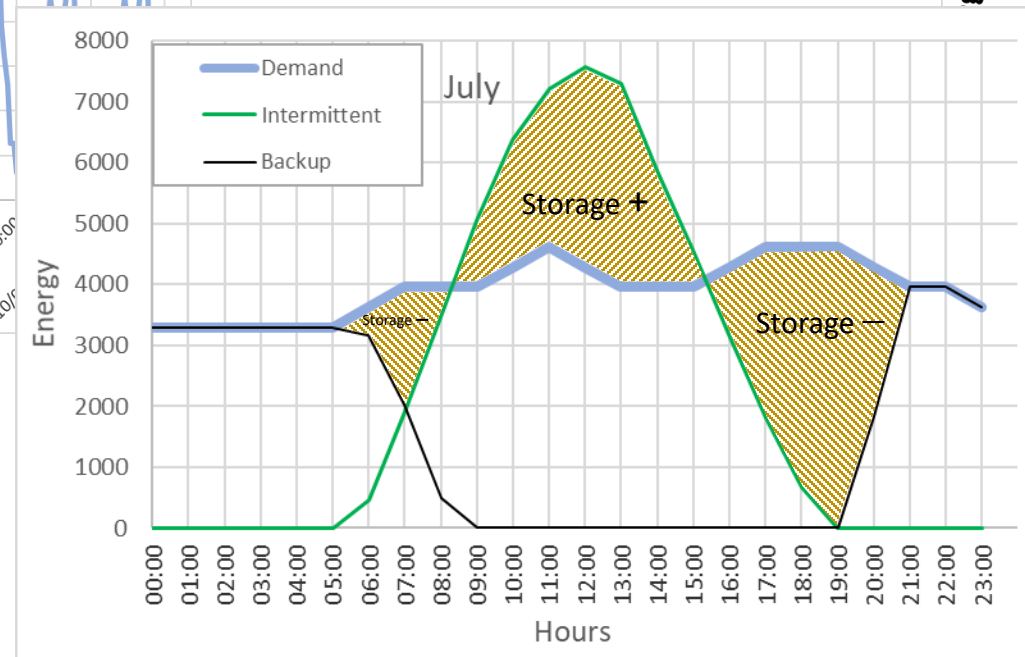
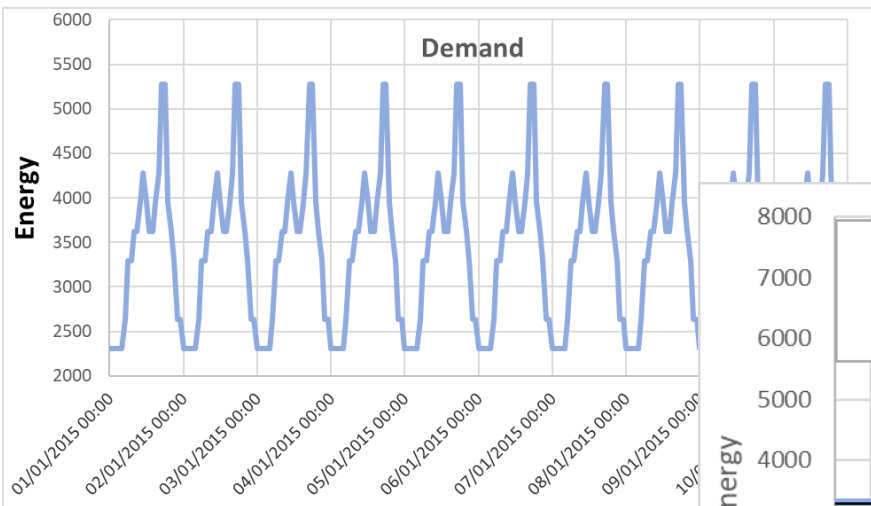
Match Energy Demand with Intermittent Sources



Match Energy Demand with Intermittent Sources



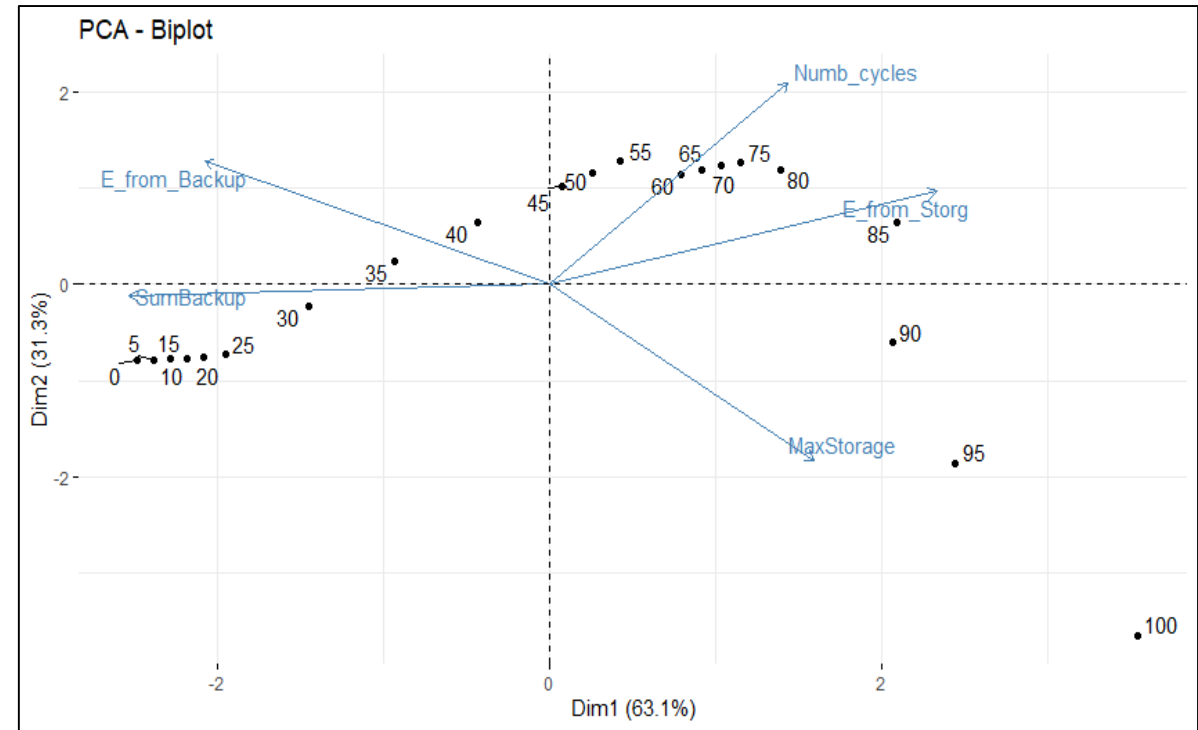
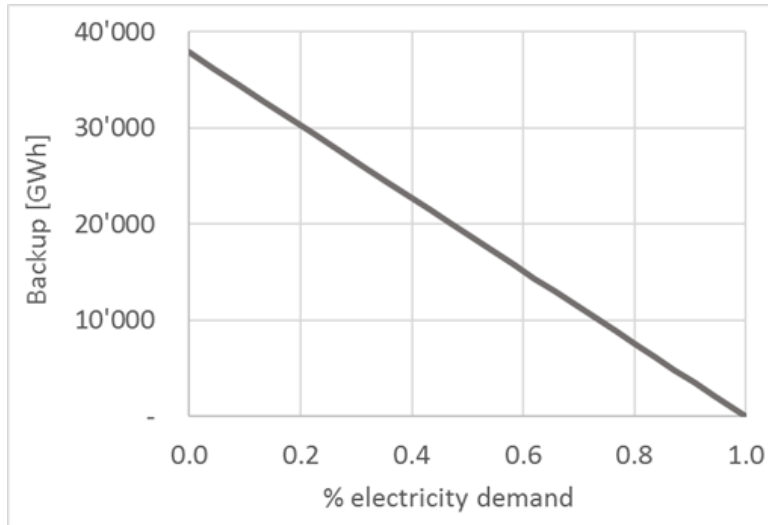
Match Energy Demand with Intermittent Sources



Alternative Scenarios

Increasing part supplied by the intermittent sources:

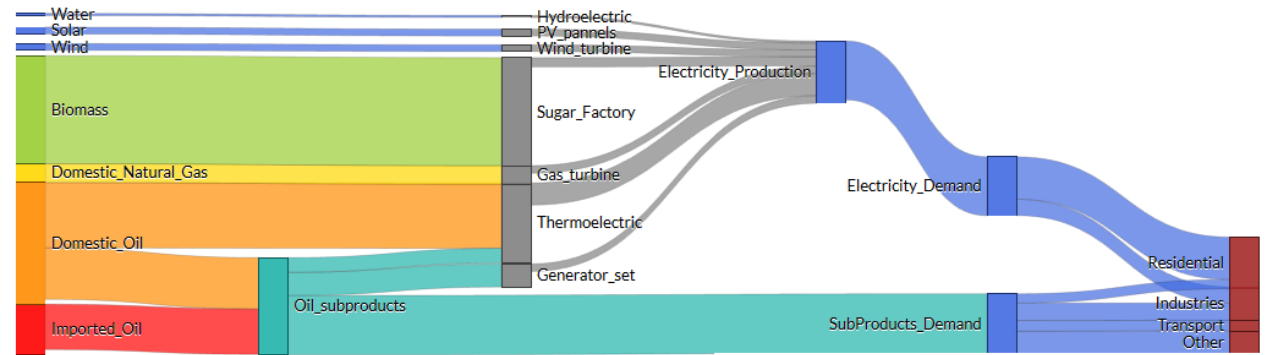
- below 25-35% no Storage but higher Backup
- between 25-35% and 70-80% low storage but same power from Backup
- 100% no Backup but higher Storage



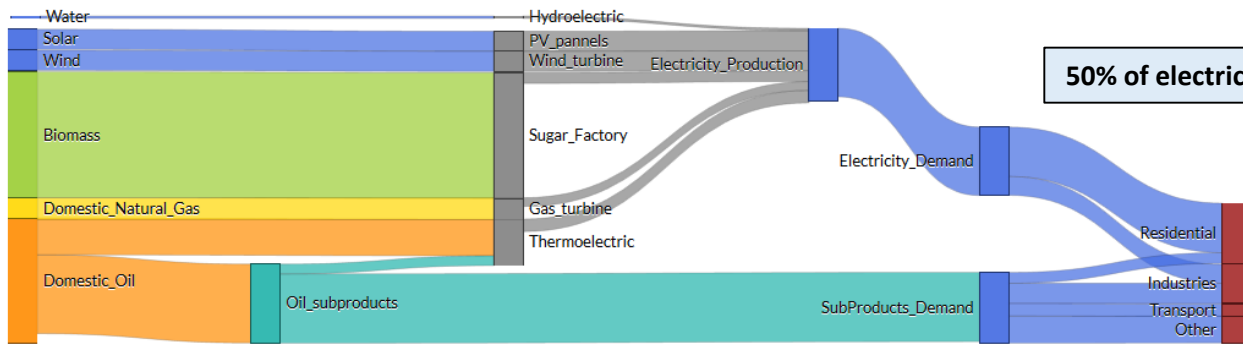
Alternative Scenarios

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%



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	-

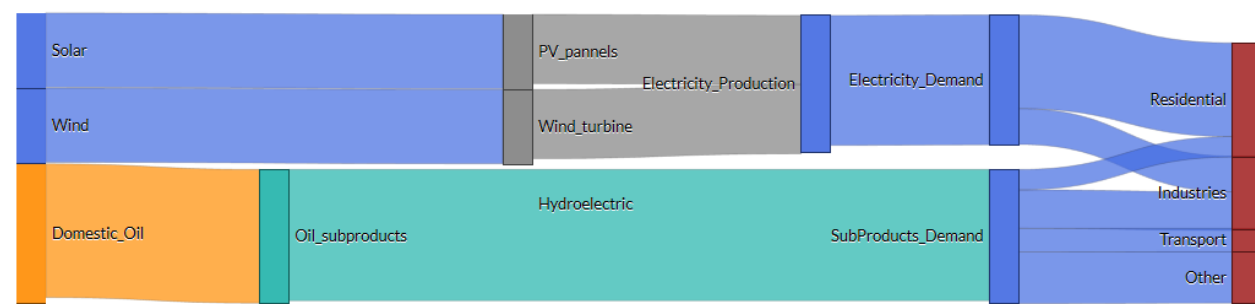


50% of electricity is produced by solar and wind

Demand: 56,7 TWh

100% of electricity is produced by solar and wind

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



Alternative Scenarios

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.

		2015	Scenarios 2030			
			Official	20%	50%	100%
Ressources (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 ressources	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

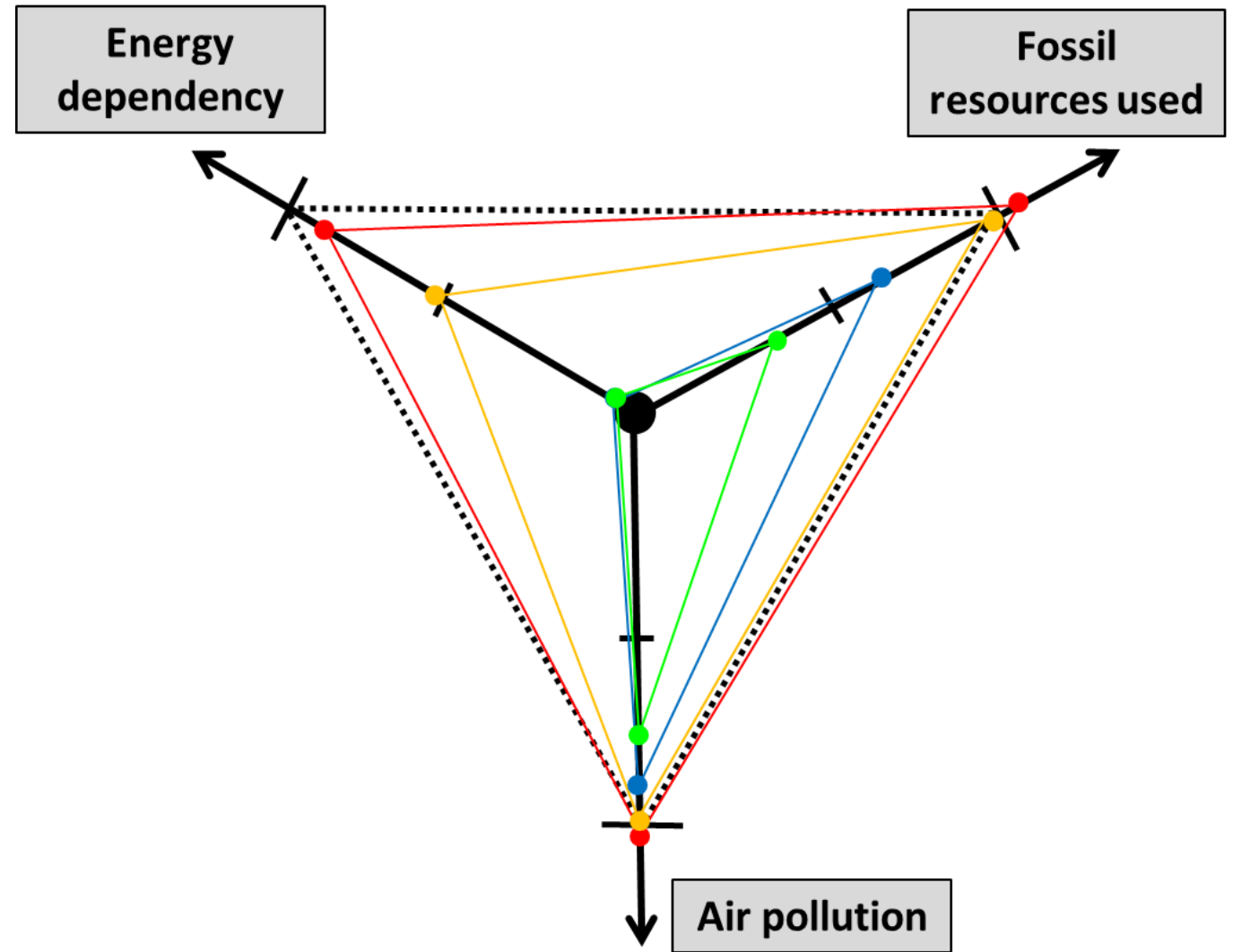
1 = situation in 2015

Alternative Scenarios

Cuban energy mix

- Situation in **2015**
 - Government strategy
 - 20% solar and wind for EP
 - 50% solar and wind for EP
 - 100% solar and wind for EP
- Scenarios **2030**

EP = Electricity production



Conclusions

- ❑ Strategies should be **integrated** (from energy demand to energy resources) and **address several objectives** at the same time (environmental like air quality and climate but also geopolitics like energy supply).
- ❑ Preference to domestic resources increases economic stability...
- ❑ ...as will do renewable energy in the near (!) future...

Thank you

நன்றி

Terima Kasih

谢谢