

Scenario of Energy Transition for Cuba

Preliminary results

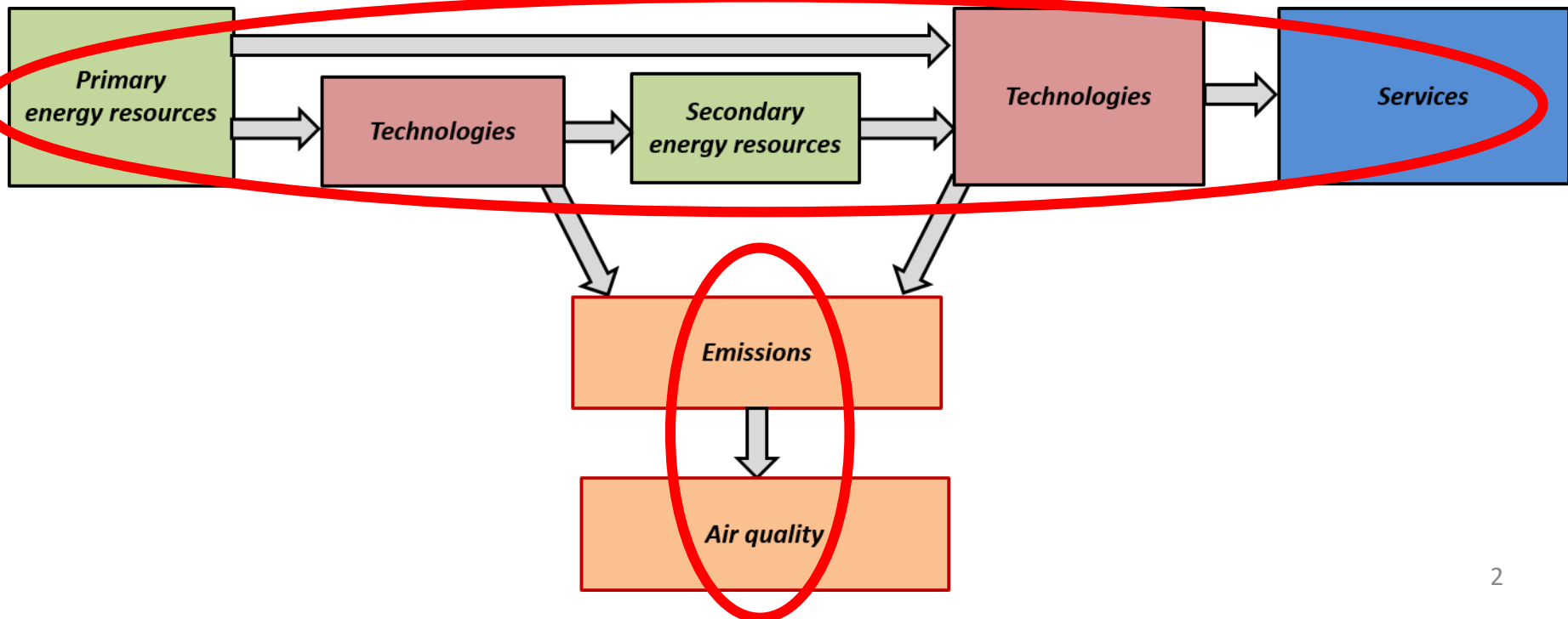
A. Clappier and J. Madrazo

R4D project between Swiss and Cuba

This project is about:

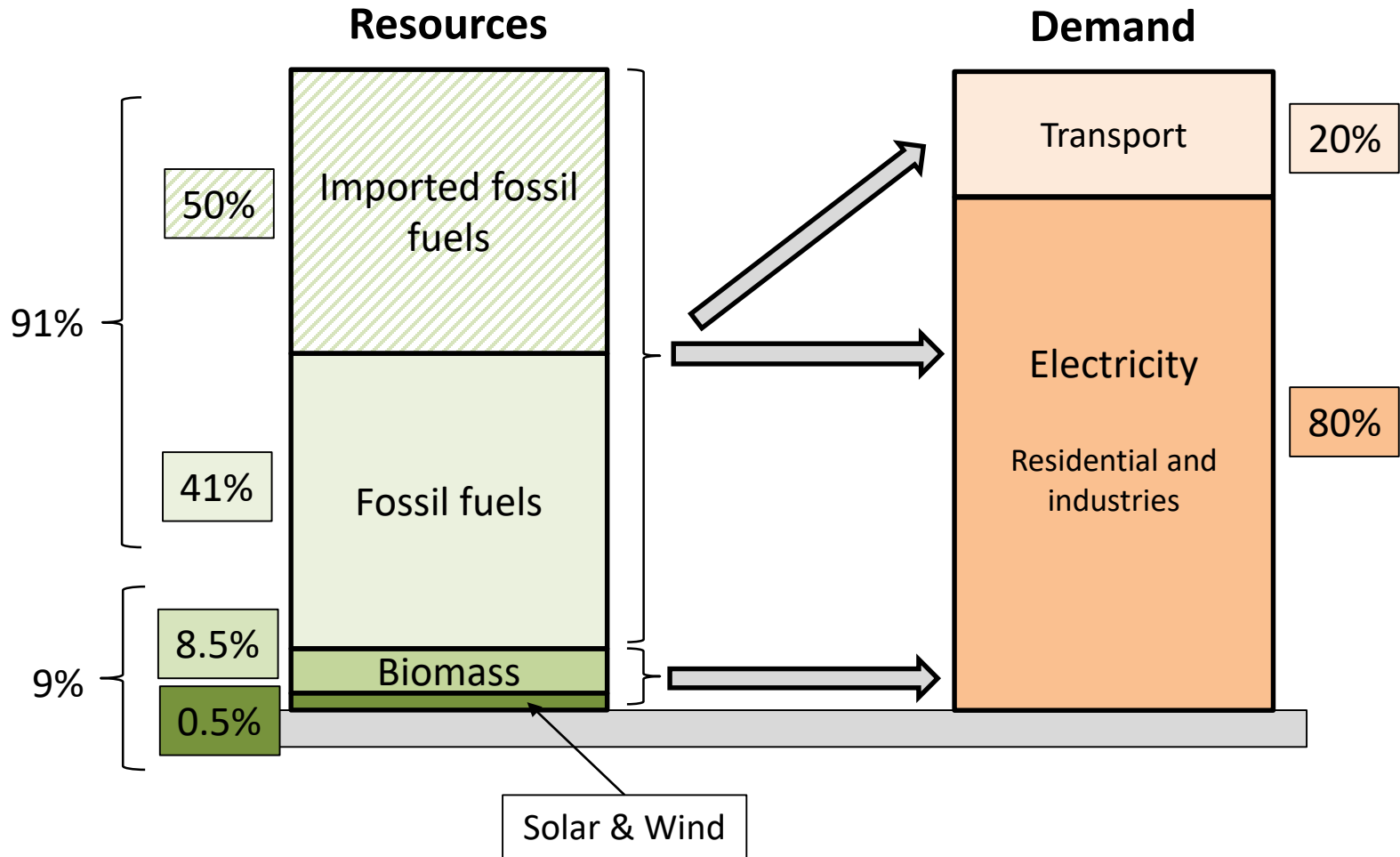
Effective Methodology for the Assessment of Integrated Energy Strategies

It aims at designing a novel integrated assessment methodology for energy strategies, combining process system design methods with emission and air quality models.



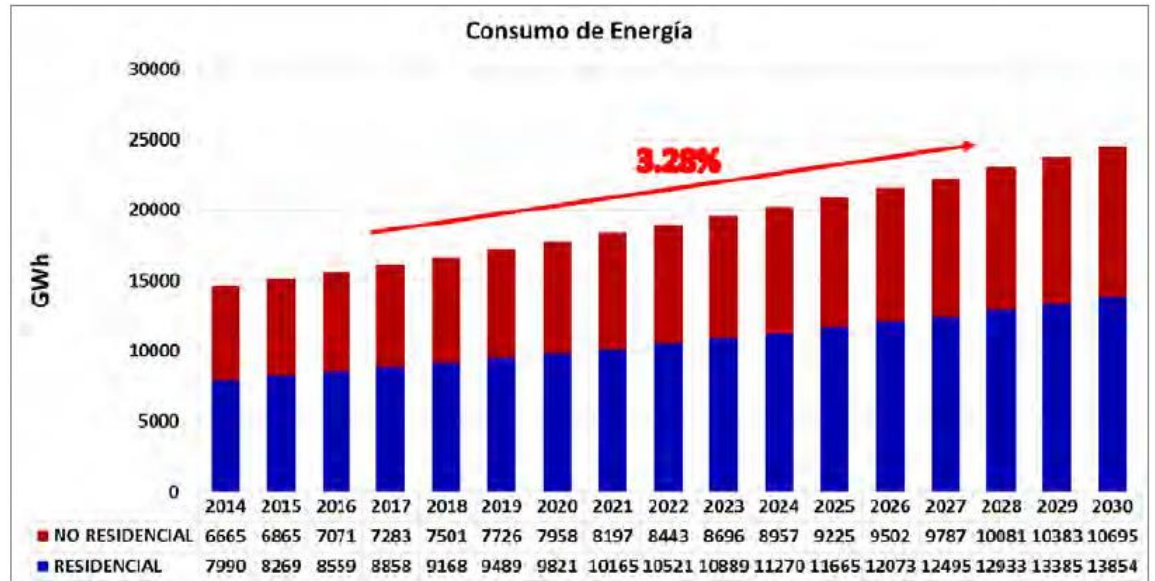
Current Demand and Resources

2015

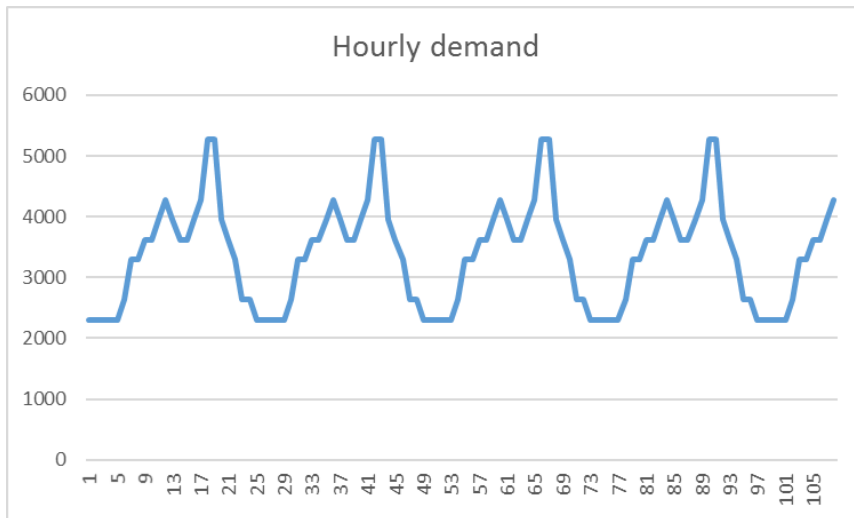


Future Demand (2030)

Increase of the demand



Nota) Residencial: Vivienda particular, No Residencial: Otros propósitos
Fuente: Unión Eléctrica de Cuba

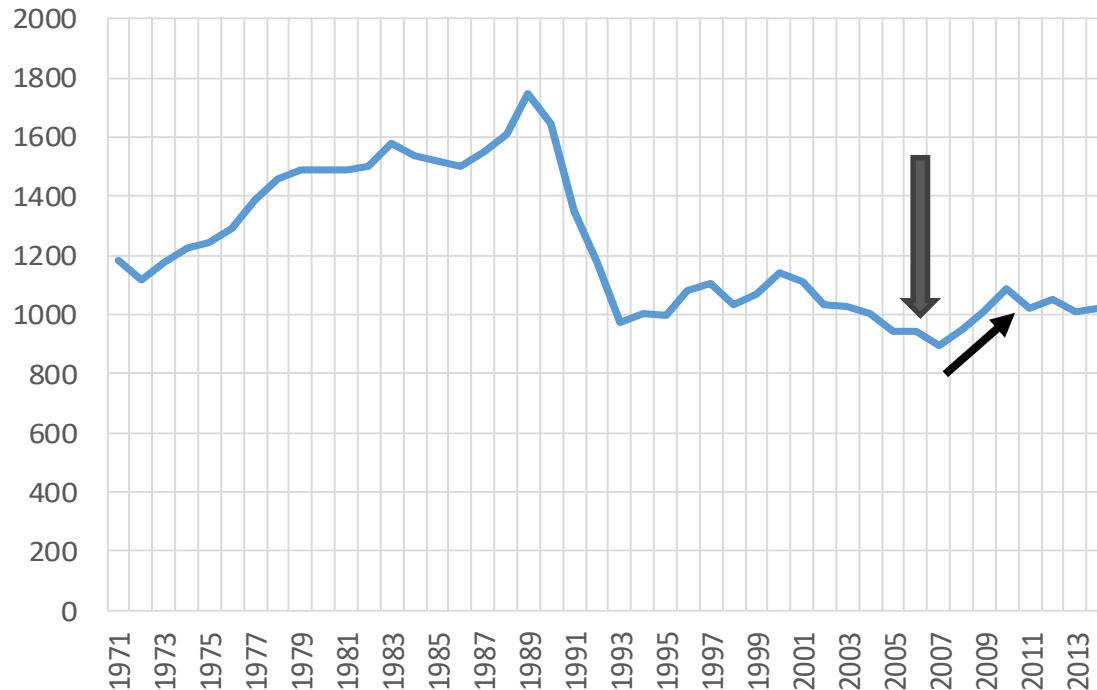


Future Demand

Increase of the energy efficiency

2006: Cuban energy revolution starts

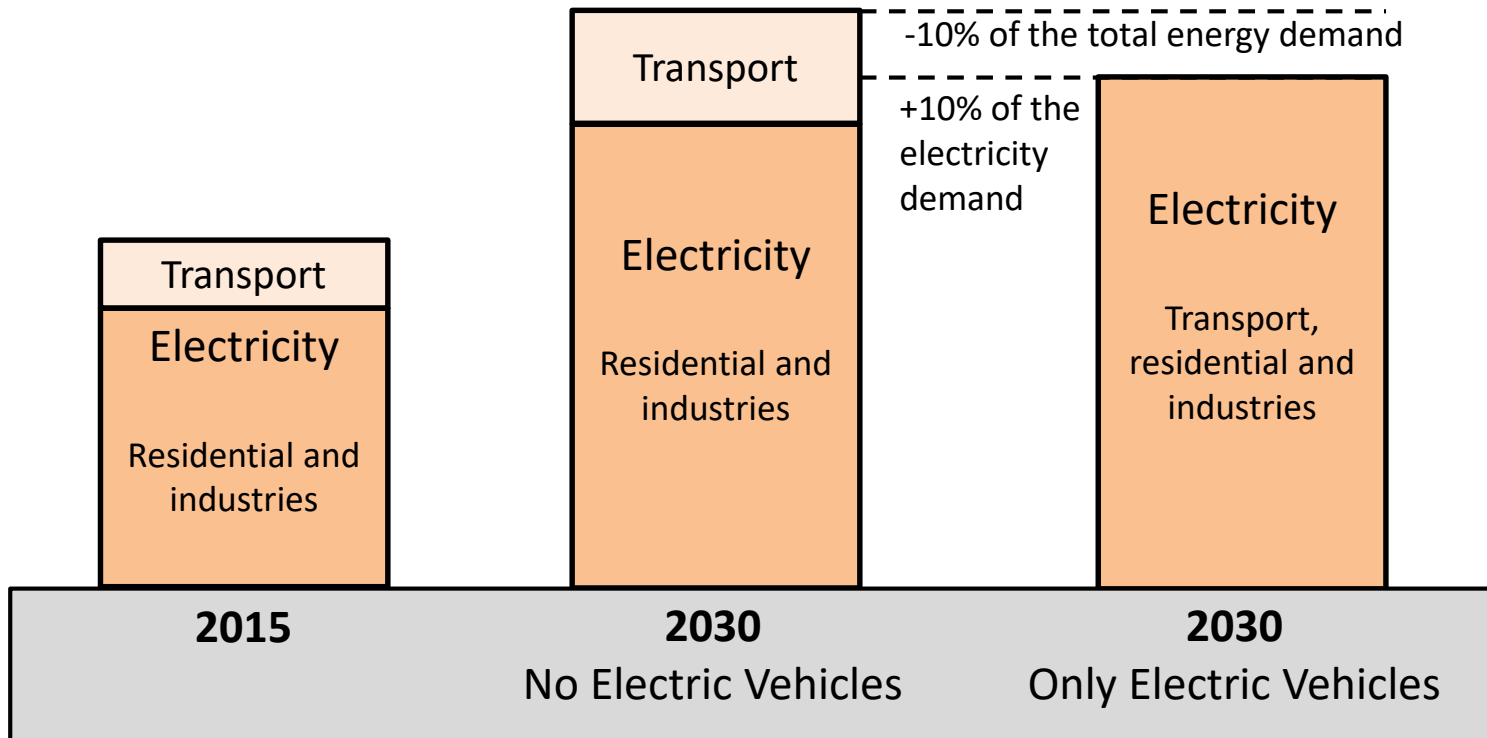
Energy use (kg of oil equivalent per capita)



- Replace the incandescent bulbs by low consumption bulb
- Replace old refrigerators with newer ones
- **Air conditioning systems ?**

Future Demand (2030)

Increase of the energy efficiency



Potentials

Resources	Units	Reserves or potential	Oil equivalent (million toe)
Crude oil and associated gas (onshore)	PJ	4 095	97.8
Crude oil and natural gas (EEZ) (offshore)	PJ	29 308	700
Bagasse and crop residues	Annual GW·h	17 500	1505
Peat	PJ	8 274	200
Hydropower	Annual GW·h	1 300	0.10
Biogas	Annual PJ	7 500	0.18
Wind energy	Annual GW·h	2 418	0.20
Firewood	Annual PJ	21	0.50

+ solar panel: enough to fulfil 100 times the demand in average per year

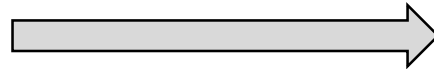


FIG. 3.1. General location of the main renewable energy resources in Cuba.

Criteria to Compare the Different Options

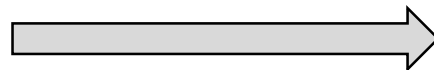
➤ **Cost**

➤ **Energy security**



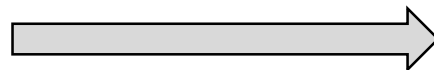
Decrease energy importations

➤ **Sustainability**



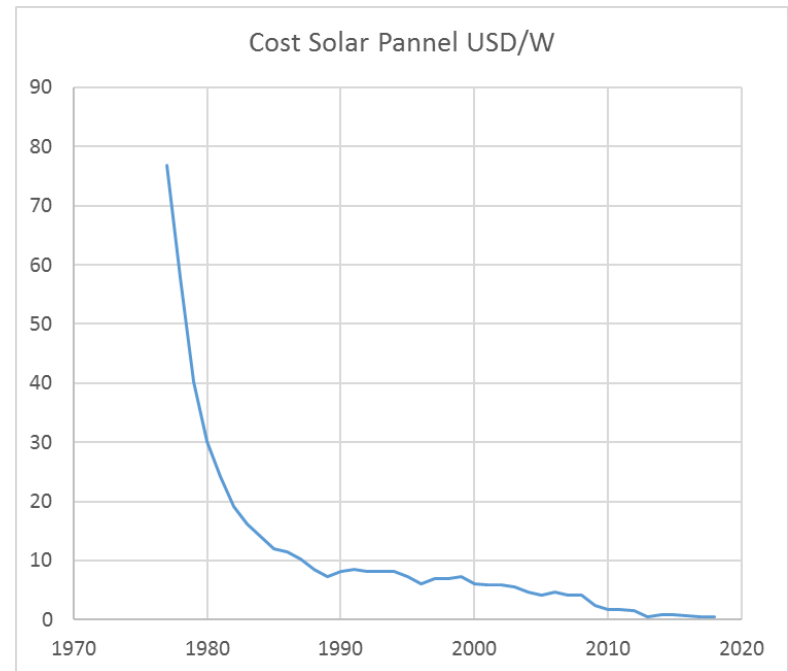
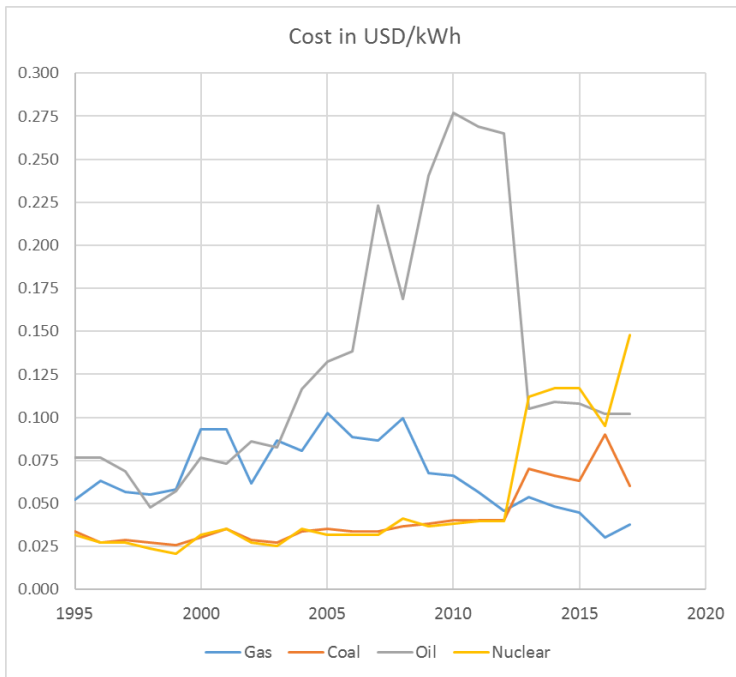
Decrease fossil fuel consumption

➤ **Air quality**

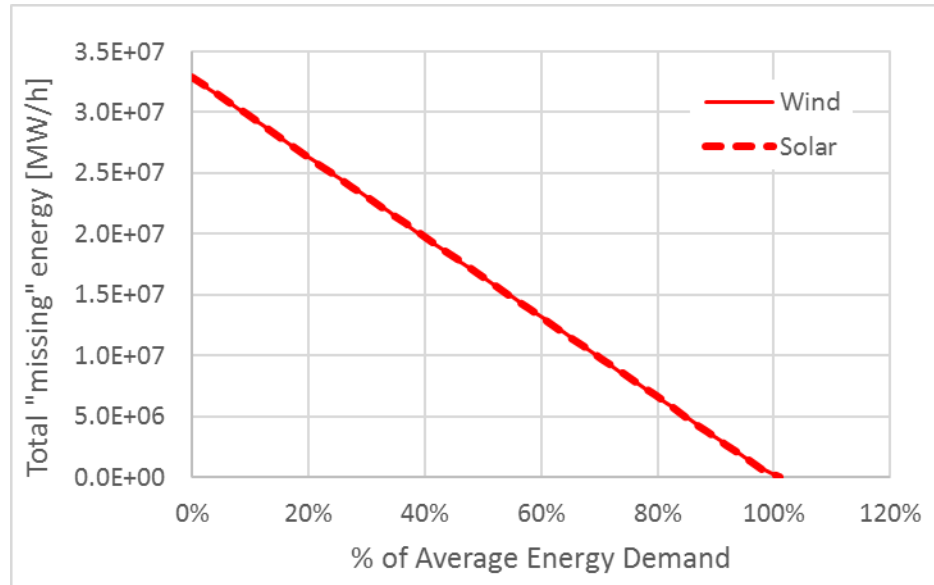


Decrease combustions

Costs

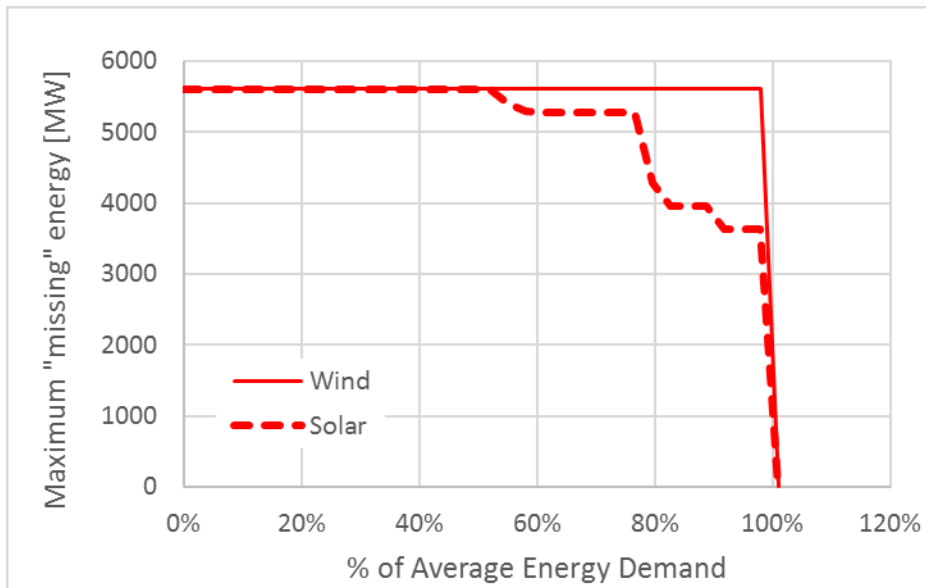


Introduction of Solar & Wind Intermittent Resources into the Energy Mix



In average over the year, more you introduce solar and wind energy less you use other resources

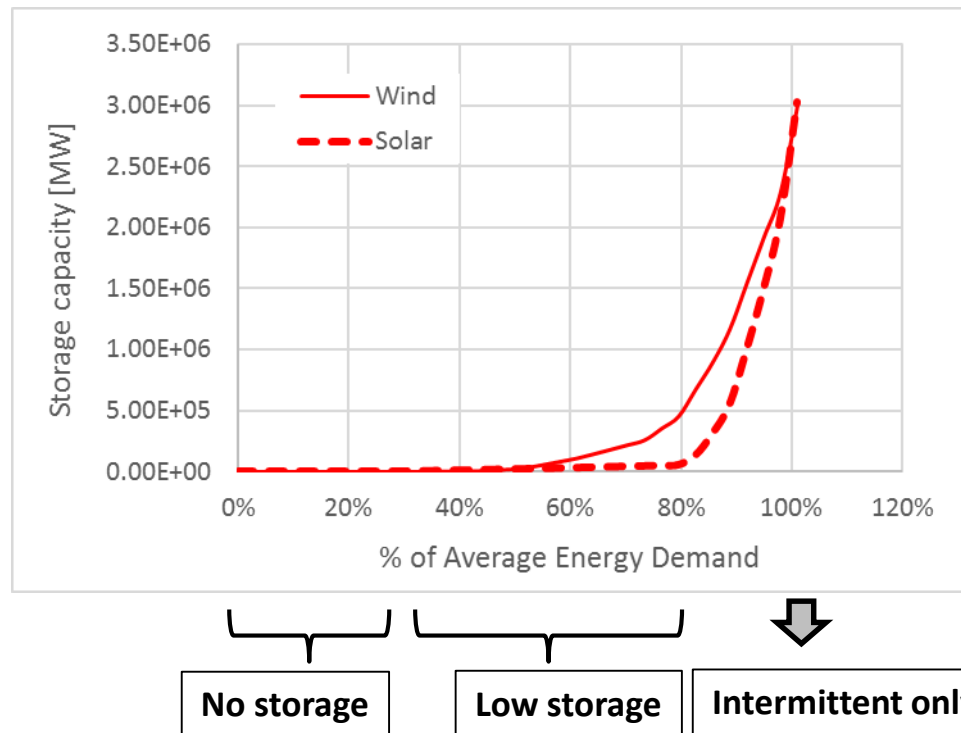
Introduction of Solar & Wind Intermittent Resources into the Energy Mix



The hourly capacity of non-intermittent energy production start to decrease only when an important amount intermittent energy is used

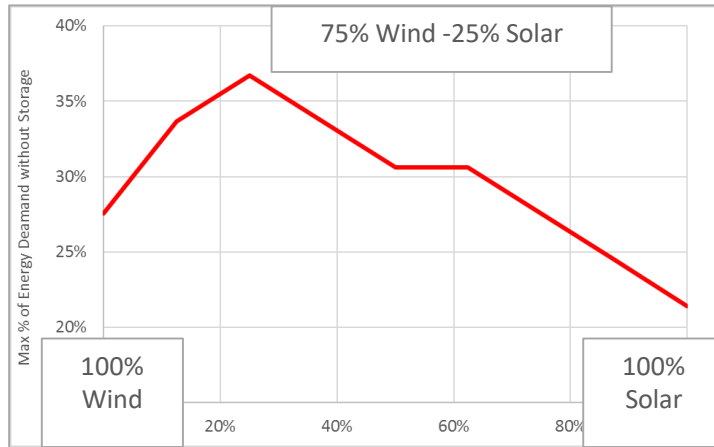
Introduction of Solar & Wind Intermittent Resources into the Energy Mix

Three kind of situations can be considered with regards to the energy storage needed:

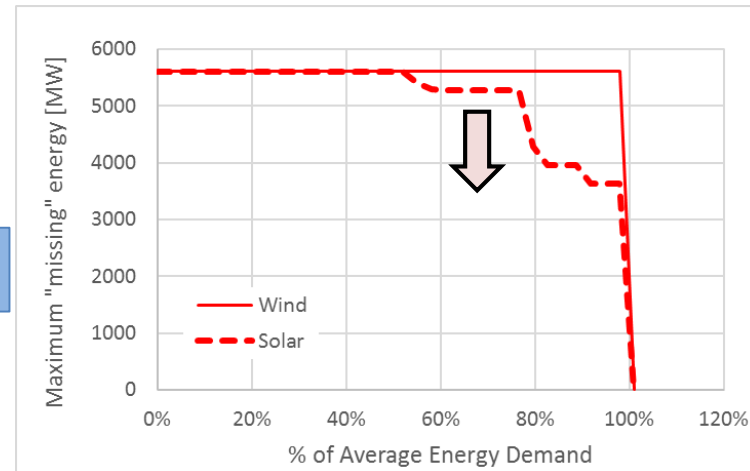


Three Kind of Possible Scenarios

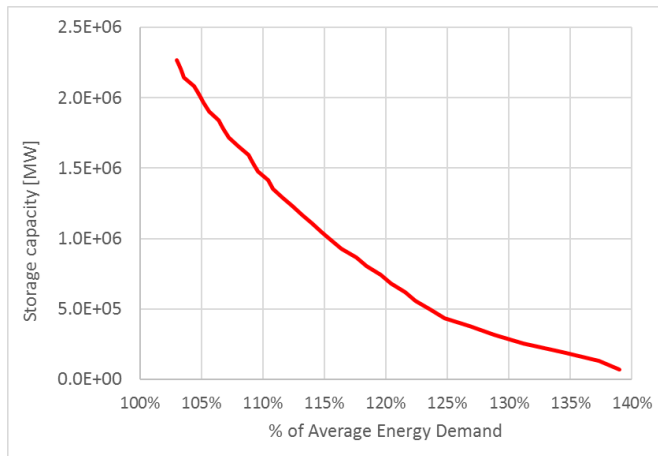
No storage



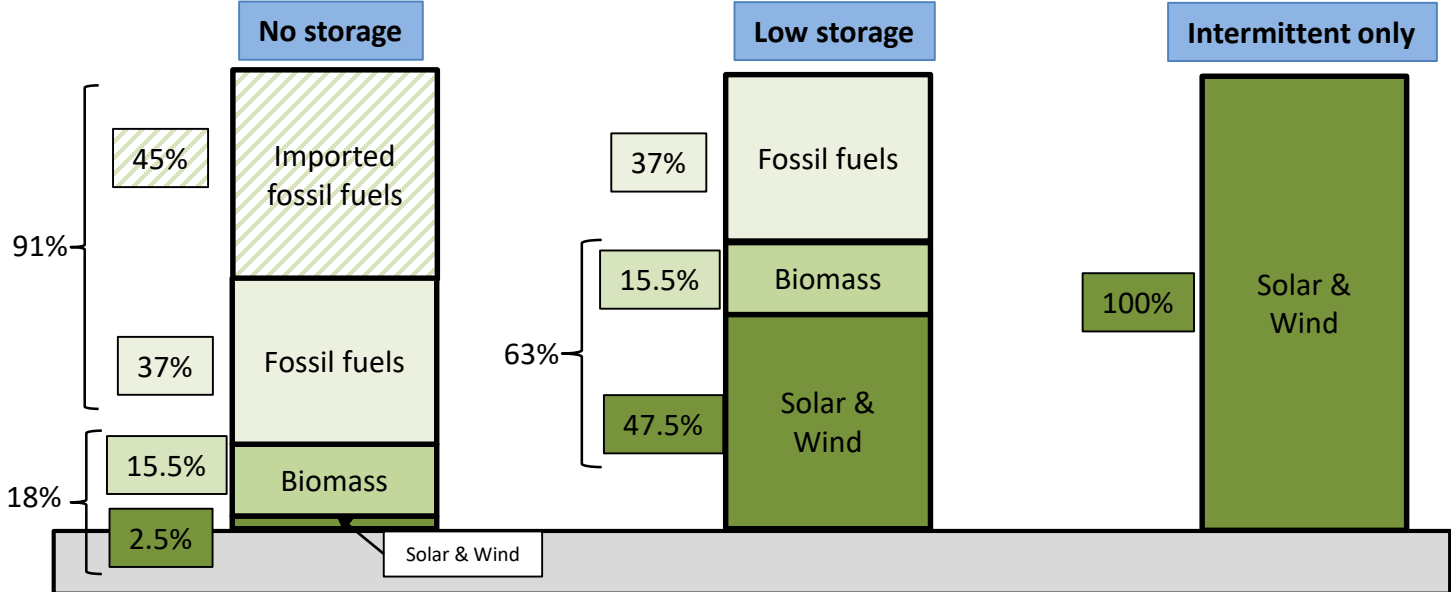
Low storage



Intermittent only



Three Kind of Possible Scenarios



	Energy Security	Sustainability	Air Quality		Storage
			No EV	EV only	
No storage	45%	●	-4%	-	●
Low storage	100%	●	2%	6%	●
Intermittent only	100%	●	13%	16%	●

Conclusions

Demand

- ❑ Residential: Efficiency of air conditioning systems ?
- ❑ Transport: Change to EV increase of 10% the electric demand but reduce of 10% the total energy demand

Resources

- ❑ No storage: worth **energy security**, **sustainability** and **air quality** but no **storage**
- ❑ Low storage: full **energy security**, medium **sustainability**, **air quality** and **storage**
- ❑ Intermittent only: full **energy security**, full **sustainability**, best **air quality** but need **storage**



in terms of energy resources only

A wide-angle photograph of the National Capitol of Cuba in Havana. The large, white, neoclassical building with its prominent dome is the central focus. The sky is blue with scattered white clouds. In the foreground, a paved plaza is active with people walking, a vintage light blue car, a bicycle, and a horse-drawn carriage. To the right, other historic buildings and a church spire are visible in the distance.

Muchias gracias !

Energy Consumption for Transport

World energy use per sector^[92]

Year	2000	2008	2000	2008
Sector	TWh		%*	
Industry	21,733	27,273	26.5	27.8
Transport	22,563	26,742	27.5	27.3
Residential and service	30,555	35,319	37.3	36.0
Non-energy use	7,119	8,688	8.7	8.9
Total*	81,970	98,022	100	100

Source: IEA 2010, Total is calculated from the given sectors
 Numbers are the end use of energy
 Total world energy supply (2008) 143,851 TWh

Energy in the United States^[15]

	Population (million)	Prim. energy (TWh)	Production (TWh)	Import (TWh)	Electricity (TWh)	CO ₂ -emission (Mt)
2004	294.0	27,050	19,085	8,310	3,921	5,800
2007	302.1	27,214	19,366	8,303	4,113	5,769
2008	304.5	26,560	19,841	7,379	4,156	5,596
2009	307.5	25,155	19,613	6,501	3,962	5,195
2010	310.1	25,776	20,056	6,205	4,143	5,369
2012	312.0	25,484	20,757	5,322	4,127	5,287
2012R	314.3	24,895	21,009	4,360	4,069	5,074
2013	316.5	25,451	21,876	3,586	4,110	5,120
Change 2004-2010	5.5%	-4.7%	5.1%	-25.3%	5.7%	-7.4%

Mtoe = 11.63 TWh>, Prim. energy includes energy losses that are 2/3 for nuclear power^[16]
 2012R = CO2 calculation criteria changed, numbers updated

United States primary energy consumption by source and final consumption by sector (2008)^[17]

Supply Sources	Percent of Source	Demand Sectors	Percent of Sector
Petroleum 37.1%	71% Transportation 23% Industrial 5% Residential and Commercial 1% Electric Power	Transportation 27.8%	95% Petroleum 2% Natural Gas 3% Renewable Energy
Natural Gas 23.8%	3% Transportation 34% Industrial 34% Residential and Commercial 29% Electric Power	Industrial 20.6%	42% Petroleum 40% Natural Gas 9% Coal 10% Renewable Energy
Coal 22.5%	8% Industrial <1% Residential and Commercial 91% Electric Power	Residential and Commercial 10.8%	16% Petroleum 76% Natural Gas 1% Coal 1% Renewable Energy
Renewable Energy 7.3%	11% Transportation 28% Industrial 10% Residential and Commercial 51% Electric Power	Electric Power 40.1%	1% Petroleum 17% Natural Gas 51% Coal 9% Renewable Energy 21% Nuclear Electric Power
Nuclear Electric Power 8.5%	100% Electric Power		