Socioeconomic Impacts of Green Energy Growth Policy in Morocco - a General Equilibrium Analysis

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The energy sector is critical to the Moroccan green growth strategy. In 2011 Morocco imported 96% of its commercial energy spending Dh91 billion, as compared with 19 billion in 2002. This dependence weighs heavily on economic and financial stability of the Kingdom and on its development opportunities. The energy constraint is likely to increase in the future. Indeed, the success of the recently launched sectoral strategies in key sectors (agriculture, fishing, tourism, industry) is based partly on the ability to improve access to energy which remains relatively low.

The current energy profile also has important environmental consequences as oil and coal together constitute 84% of total commercial energy. Energy access is critical for the Moroccan poor, and their use of wood for fuel contributes to deforestation. If Morocco could move towards a more renewable energy profile, it could reduce the foreign exchange burden of energy imports and reduce greenhouse gas (GHG) emissions at the same time.

The Government of Morocco (GOM) energy plan has three major goals:

- To guarantee adequate energy supply while at the same time reducing dependence on foreign energy supplies
- To limit the environmental impacts of the Moroccan growth model
- To guarantee energy access to the population, especially the poor

The GOM asked the World Bank to work with an inter-ministerial group consisting of Ministry of Energy, Mines, Water and Environment, and the High Planning Commission. The group chose to adapt a computable general equilibrium (CGE) model named MANAGE (Mitigation, Adaptation, and New Technologies Applied General Equilibrium Model). MANAGE is a hybrid model in that it is a prototypical CGE model but with a greater richness in technologies employed in the energy sector. Thus, the energy component has “bottom-up” features that are well integrated with the top-down CGE structure.

This paper presents in a first section the main characteristics of the energy sector in Morocco, its strengths and weaknesses and trends. The second section sets out the objectives of the government and the foundations and strategic priorities of energy policy. The third section presents the methodological approach used for the evaluation of energy choices in Morocco and finally the last section presents the simulation results and conclusions.

Energy in Morocco

Commercial energy consumption per person in Morocco is 0.52 tons of oil equivalent (TOE) per person compared with a world average of 1.86 TOE per person

(Table 1). Energy consumption usually reflects economic activity, so the lower level of energy per person is to a large degree a function of the income per person. Per capita energy consumption is Spain is five times that of Morocco, reflecting the higher level of income and development of energy infrastructure.

In terms of energy intensity (TOE/GDP), Morocco is 0.22 compared with a world average of 0.25. Thus, Moroccan energy intensity is roughly equal to the world average, and far higher than the 0.14 of OECD countries. As countries move up the income scale, at some point they generally begin to become more efficient users of energy. The low level of energy consumption per person and the high level energy consumption per unit of income also adversely impacts Morocco's competitive position in the global economy.

Table 1: Energy consumption per capita and energy intensity in 2010

2010	Energy consumption per capita		Energy intensity
	(TOE / capita)	Electricity consumption (KWh / capita)	(TOE/000 2005 USD)
World	1.86	2892	0.25
OECD	4.39	8315	0.14
Algeria	1.14	1026	0.35
Egypt	0.90	1608	0.61
Spain	2.77	6155	0.11
France	4.04	7756	0.12
Greece	2.44	5245	0.11
Israel	3.01	6858	0.14
Jordan	1.19	226	0.43
Libya	3.01	4270	0.35
Morocco	0.54	781	0.22
Tunisia	0.91	1350	0.24
Turkey	1.44	2474	0.19

Source: International Energy Agency, 2012

Electricity consumption per capita in Morocco is 781 KWH per person compared with a global average of 2,892 KWH/capita. Electricity consumption per person in Morocco is just over half that of Tunisia. Expanding the electricity infrastructure in Morocco could be a significant enabler for future economic development.

Examining the Moroccan input-output table reveals that there are three sectors which are very intensive in use of petroleum products – transport, fishing, and manufacturing. These three sectors use about 43% of petroleum products but represent only about 9% of GDP.

Many energy products, especially petroleum products, are highly subsidized in Morocco, and the subsidy system not only distorts product prices but also places a heavy burden on the public treasury. In fact petroleum product subsidies in 2011 amounted to Dh 44.5 trillion, which represented 5.4% of GDP and 89% of the public investment budget.

In many cases, the subsidy amounts to a high fraction of the product price, e.g., 68% for butane, around 45% for fuel oil, and 35% for diesel. The butane subsidy benefits all income categories with 13% going to the poorest quintile and 30% to the richest (Table 2). However, the petroleum product subsidies are not well targeted with 7% going to the poorest quintile and 42% to the richest.

Table 2: Distribution of subsidies among groups of households

	Quintile of the population according to the level of expenditure per person							
	Q1	Q2	Q3	Q4	Q5	Q5/Q1	Poor	Non-Poor
Share of the category in the overall consumption of petroleum products (%)	7.0	10.9	16.2	23.9	42.0	6	1.9	98.1
Share of the category in consumption of Butane (%)	13.1	16.0	19.5	21.7	29.8	2.27	5.2	94.8
Butane subsitdy (DH/person in 2011)	257	314	383	426	585	2.27	229	408

Source: Moroccan Planning Commission

Aims and objectives of Moroccan energy policy

Morocco aims to create a better balance between imported and domestic energy and to progressively align domestic consumer prices to world prices. Energy subsidies would be gradually reduced over time, but with targeted subsidies for butane and diesel. The GOM also aims for natural gas to play a somewhat more important role in the future energy economy.

The GOM also aims to move to an energy portfolio with more renewable energy coming from hydroelectricity, solar, and wind energy. In 2011 only about 4% of total energy came from renewables with about 3% being hydropower and 1% wind. Morocco intends to increase investment in solar energy in the future.

Another key pillar of Moroccan energy strategy is increased energy efficiency. Policies and investments will be made to increase energy efficiency across the whole economy. These include increased fuel efficiency in the transportation fleet, usage of more high efficiency electric lighting, programs for improved building energy efficiency, increase in the efficiency of electric motors, and modernization of industrial production to increase energy efficiency and reduce pollution.

Morocco also aims to reduce environmental and GHG emissions through the energy strategy. Lead and sulfur emissions will be reduced through new low sulfur diesel, and unleaded gasoline. The goal is to reduce GHG emissions by 2,874 kT of CO_2 per year by 2030 through improved efficiency and 20,825 kT CO_2 per year via increased use of renewable energy.

Methodology

As indicated above a hybrid CGE model named MANAGE was used for the analysis. It is a recursive dynamic model conceived for energy and climate change research. The model has many standard characteristics of a dynamic CGE model of neoclassical economic growth with labor growth being exogenous and capital growth derived from savings and investment decisions. It uses constant elasticity of substitution (CES) functions among different inputs. Energy is assumed to be a compliment of capital in the short term but a substitute in the long term. There are two vintages of capital equipment with the new capital being of higher energy efficiency than old capital. There is specific capital for solar and wind energy that cannot be used in other sectors. The model incorporates a consumer preference shift towards the newer renewable technologies. The model has the capacity for multi-input and multi-output. For example, electricity can be produced by different technologies (solar, wind, hydro, and thermal). Also, more than one product can be produced from an input, e.g., oilseeds going to vegetable oil and lamp oil and oilseed meal. The model also tracks GHG emissions throughout the economy basically with emission being a function of different kinds of fossil fuel use.

Production is modeled using a series of nested constant elasticity of substitution (CES) functions to capture substitution and complementarity between different inputs, notably capital and labor. Higher energy prices tend to lead to higher costs in the short term, when substitution is low. In the long-term, introduction of more efficient technologies would attenuate the short-term cost effect.

The capital factor in the physical model is divided into two components, new and old physical equipment. This dualistic structure enables new equipment to be more sensitive to changes in energy prices. This is the case for the electricity sector in which electricity can be produced by fossil-intensive fuels: such as coal and oil, and technology without fossil fuels: such as hydropower and solar energy. Thus, part of the electricity sector response to climate policy measures is to change the composition of the different technologies used for energy production. To capture substitution possibilities realistically, capital is represented by new and old capital. In fact, this distinction between the two kinds of capital determines to the extent to which conventional electricity suppliers can respond to changes in relative prices. The Social Accounting Matrix (SAM) does not distinguish between the specific capital and mobile capital, so additional assumptions were necessary. We introduced a specific capital for solar and wind energy, which cannot be used in other sectors.

The level of disaggregation of the energy sphere is crucial for understanding the diversification of the energy mix. The model takes into account the disaggregated targets in the government's renewable energy strategy.

Another important feature of the model is that the household is disaggregated into five households representing each quintile from poor to rich. This disaggregated household permits analysis of the impacts of the different policies on the poor as well as the entire economy. The date for this disaggregation comes from household surveys conducted in 2007.

The model uses constant difference of elasticity (CDE) structure for household demand. It is calibrated from different price and income elasticities. The CDE structure works somewhat better than the linear expenditure system often used.

The model includes the current policy intervention such as the energy subsidies described above. That permits it to be used to evaluate the impact of removal of those subsidies. The model uses the Armington structure of imperfect substitution between imported and domestic goods. For the base case, it assumes Morocco is a small country, and its imports and exports do not affect the world prices of goods. However, the capacity exists to introduce import and export demand functions.

The model makes use of the social accounting matrix (SAM) for 2007. The energy disaggregation is derived from the energy balance taken from the Ministry of Energy. The energy data is well integrated into the SAM.

Scenario Analysis

The analysis is done for a reference case (business as usual - BAU) and two green scenarios. The assumed evolution of prices is provided in Table 3. Crude oil is assumed to increase 75% and natural gas 50%. The price of coal remains constant.

Table 3: Import Price Assumptions for energy products (DH/TOE)

	2007	2010	2015	2020	2025	2030
Coal	1021	1021	1021	1021	1021	1021
Crude oil	4145	6218	7254	7254	7254	7254
Natural gas	2105	3157	3157	3157	3157	3157
Gasoline	6241	9362	10922	10922	10922	10922
Diesel	5041	7561	8822	8822	8822	8822
Butane and propane	7411	11117	11117	11117	11117	11117
Electricity	10068	10068	10068	10068	10068	10068

Source: Authors' assumptions

The current account is assumed to be fixed, and it is the real exchange rate that adjusts to restore external account balance. Investment adjusts endogenously to accommodate any change in savings. In terms of energy efficiency, it is assumed to Increase in the baseline autonomously by 0.5% per year overall and by 1% per year in households. In the second scenario, it is assumed to grow by 1.4% in the two cases.

The first green scenario (variant 1) retains the energy subsidies and the second eliminates the subsidies and reduces taxes to compensate for the subsidy elimination. For all three scenarios, population in 2030 is 38 million, and economic growth is 5%.

Results

For each scenario, the following results will be presented:

- Structure of energy supply and demand
- Energy sector production, role in the national economy, composition of imports and exports, commercial balance, and public finance
- Social impacts reflected in the evolution of the living standard of the poor
- Environmental impacts measured by changes in GHG emissions

Reference case (BAU)

The scenario BAU represents a trend of intensive use of primary energy to meet the needs of economic and demographic growth. The reference or business as usual (BAU) case exhibits the following basic results:

- Morocco continues to rely primarily on imported fossil fuels to supply its growing energy demands.
- Economic growth averages 5% over all the planning horizon. However, energy intensive sectors that benefit from the energy subsidies generally grow faster, and other sectors slower.
- Total energy consumption roughly triples moving from 15 to 45 TOE between 2007 and 2030. CO_2 emissions also roughly triple moving from 43 to 130 million tons.
- With rising global oil and natural gas prices and increased consumption, the burden of the energy subsidies goes from 4% of GDP in 2011 to 10% in 2030.
- Household income grows at around 4% through 2025, but drops to 3% in 2030.

Some of the more detailed results are contained in Tables 4 and 5. GDP grows (by assumption about 5% per year and population about 1%. Imports grow faster than exports throughout the period, due in part to the energy import bill. Most of the GDP growth is from capital, while the growth in labor productivity reaches nearly 50% by 2030.

Income shares by quintile remain roughly constant over the time period, but real income growth falls for all quintiles, as shown in Table 6. This is partly due to the increased burden of taxes to pay the energy subsidies, which increase over time with increasing energy consumption.

Table 4: Macroeconomic Evolution in the BAU Scenario (%)

	2015	2020	2025	2030
GDP	5.1	4.9	5	5.1
Population	1	0.9	0.9	0.7
GDP per capita	4	4	4.1	4.4
Consumption	4.1	4.2	4.3	4.5
Government	5.1	4.9	5	5.1
Investment	4	4.2	4.3	4.5
Exports	4.5	4.4	4.4	3.6
Imports	6.3	5.8	5.6	5

Source: MANAGE model results

Table 5: Breakdown of Growth and Productivity

	2015	2020	2025	2030
	Growth rate, in % per year			
GDP	5.1	4.9	5	5.1
Labor	1.5	1	0.8	0.6
Capital	3.9	4	4.1	4.2
	Decomposition of the sources of growth (%)			
Labor	11	8	7	5
Capital	41	42	44	44
Productivity of Labor	39	42	45	49
Residual	8	7	5	2

Source: MANAGE model results

Table 6: Evolution of Household real Income (%)

Groups of Households	2015	2020	2025	2030
Q1 (Poorest 20%)	3.8	4.0	4.2	3.1
Q2	3.8	4.0	4.1	3.0
Q3	3.8	4.0	4.1	3.0
Q4	3.7	3.9	4.0	2.9
Q5 (Richest 20%)	3.9	4.0	4.2	3.1
Total household	3.8	4.0	4, 2	3.0

Source: MANAGE model results

Green Scenario – Alternative 1

The first green scenario differs from the reference case in two important ways:

- There are substantial investments is wind, solar, and hydro renewable energy such that renewable energy attains 15% of total energy and 42% of electric power by 2030; and
- There are major improvements in energy efficiency. However, the energy import bill remains high despite the growth in domestic renewable energy, and reaches 10% of GDP compared with 12% in the BAU case.

Both the growth in renewable energy and energy efficiency require very large increases in capital investment. In fact, national savings are insufficient to finance the required increase in capital investment, so direct foreign investment is required.

The main results of scenario 1 are as follows:

- Energy consumption grows to 39 million TOE by 2030 compared with 45 TOE in the reference case. CO_2 emissions increased to 110 tons compared with 130 tons in the reference case.
- The reduced energy growth is due to two primary causes: 1)increased energy efficiency, and 2)reduction in income growth in the last two periods. The combination of the burden of financing the renewable energy investments plus maintaining the energy subsidies caused the slower growth in GDP.
- As in the BAU case, the shares by quintile of total income remain relatively stable over time. However, the average shares of energy consumption as a percent of total consumption by quintiles show large differences among income groups (Table 7).

Table 7: Average Share of Energy in Total Consumption (%)

	Q1 (Poorest 20%)	Q2	Q3	Q4	Q5 (Richest 20%)
Firewood	0.15	0.12	0.10	0.08	0.05
Charcoal	0.11	0.11	0.13	0.16	0.50
Gasoline	0.84	0.81	0.83	0.93	1.00
Diesel	1.56	1.49	1.53	1.72	1.85
Butane and propane	2.97	2.24	1.88	1.59	1.34
Electricity	3.24	3.10	2.92	2.49	1.72
Total	8.87	7.87	7.39	6.97	6.46

Source: MANAGE model results

Green Scenario – Alternative 2

The second green scenario differs from the first mainly due to the gradual elimination of energy subsidies. Domestic energy prices become aligned with international prices by 2030. The main results of this case are as follows:

- Economic growth follows a very different pattern with very slow growth initially followed by more rapid growth than the reference case. The shock of higher energy prices causes the near term slower growth. In the longer term, because taxes are reduced with the reduction in energy subsidies, economic activity is stimulated. Also, the alignment of national energy prices with international prices causes the Moroccan economy to become more efficient.
- Total energy consumption falls between the two previous cases. Energy consumption is higher than in scenario 1 because of higher economic growth in scenario 2 and increased energy efficiency. It is lower than the reference case because of assumed growth in energy efficiency.
- CO_2 emissions in 2030 are in between the scenario 1 and reference cases.
- A base assumption in all cases is that the nominal exchange rate is fixed. In this case, the shock of subsidy reduction in the near term causes appreciation in the real exchange rate and a loss of economic competitiveness. Over the longer term, as the economy is stimulated by the lower taxes and alignment of national energy prices with world prices, the economy rebounds.
- The energy subsidy elimination adversely impacts the poorer households more than the richer households. This difference appears to be due largely to the loss of the butane subsidy.

In this scenario, the gradual alignment of Moroccan energy prices with world prices and the accompanying reduction in energy subsidies reduces the fiscal burden of the energy subsidies substantially as shown in Table 8. Energy subsidies go from 48 billion Dirhams in 2012 to 1.7 billion in 2030.

Table 8: Evolution of Energy Subsidies (billions of DH)

	2012	2015	2020	2025	2030
Gasoline	2.7	1.3	0.4	0.12	0.04
Diesel	22.1	12.2	4.5	1.66	0.62
Butane and propane	13.8	9.8	5.4	3	1.67
Other refined products	9.3	3.5	0.7	0.14	0.03
Total	48	27	11	4.4	1.7

Source: MANAGE model results

Tables 9 and 10 provide the evolution of sectoral and total output and the change over time in household income by quintile. The increasing energy prices causes a decline in total output in the initial period and a slower growth in the subsequent period. With time, however, the rate of economic growth increases to 6.5%, which is higher than the BAU case. Essentially what is happening is that the increased overall efficiency in the economy due to the alignment of energy prices with world prices leads to higher economic growth. Also, the reduction of the fiscal burden of the energy subsidies stimulates economic growth.

Table 9: Evolution of sectoral output in the case of rising energy prices (%)

	2015	2020	2025	2030
Agriculture	-0.4	2.0	4.6	5.0
Firewood	1.5	3.2	5.7	6.2
Other forest products	1.4	3.4	5.9	6.4
Fishing	0.8	3.8	6.5	7.5
Crude oil	-2.4	3.4	5.9	6.4
Natural gas	-2.6	3.2	5.7	6.2
Other products of the mining industry	2.3	5.0	7.8	8.3
Food and tobacco	-0.5	1.9	4.5	4.9
Textile and leather	3.5	4.9	6.8	7.3
Wood charcoal	1.5	3.1	5.6	6.0
Other products of the chemical industry	3.2	5.5	8.0	8.4
Mechanical, electrical and metallurgical industry	1.6	3.9	6.3	6.7
Other manufacturing industries	0.9	3.7	6.2	6.7
Gasoline	-2.4	3.2	5.6	6.1
Diesel	-2.4	3.1	5.6	6.1
Butane and propane	-1.5	3.1	5.6	6.1
Other petroleum products	-2.6	3.3	5.7	6.3
Electricity	1.6	3.8	6.5	7.0
Water	0.9	3.5	6.0	6.5
Building and public works	0.3	2.8	5.4	6.0
Commercial sector	0.7	3.3	5.8	6.3
Hotels and restaurants	1.1	3.7	6.3	6.7
Transport	-2.5	3.7	6.5	7.0
Other services	1 , 1	3.5	6.0	6.5
Total	-1.6	3.5	6.0	6.5

Source: MANAGE model results

Table 10 provides the difference in household income between this case and variant 1 of the green scenario. Elimination of the energy subsidies is clearly regressive Poorer households income falls more than richer households. This is due in part to their dependence on butane and the high rate of subsidy for butane fuel. The poorer households are also adversely affected for a longer period than richer households. However, by the end of the period, even the poorest household group is better off in this case than in variant 1. The improvement in efficiency in the overall economy results in a relative improvement by the end for all income classes.

Table 10: Difference between variants 1 and 2 in real household income (%)

	2015	2020	2025	2030
Q1 (Poorest 20%)	-2.11	-1.98	-0.02	0.09
Q2	-1.81	-1.69	0.35	0.93
Q3	-1.75	-1.65	1.64	2.55
Q4	-1.85	-1.77	2.51	3.36
Q5 (Richest 20%)	-1.86	-1.77	2.31	2.60
Total	-1,84	-1.75	2.28	2.46

Source: MANAGE model results

Discussion and conclusions

This section contains some of the key conclusions of the analysis. The reference case involves huge increases in energy consumption, increasing dependence on imported energy, large increases in GHG emissions, and a substantial increase in the government budget and economic burdens of the energy subsidies.

Figures 1, 2, 3, and 4 provide the time paths of energy consumption, total emissions, GDP, and emissions per capita for the three cases. Energy consumption is highest in the BAU case. For most of the time horizon it is lowest in the Green alternative 2 scenario. However, by the end of the time horizon, energy consumption is actually higher in green alternative 2 than alternative 1. This is basically because by the end of the time period, the economic stimulus from subsidy removal has overtaken the drag in the earlier periods.

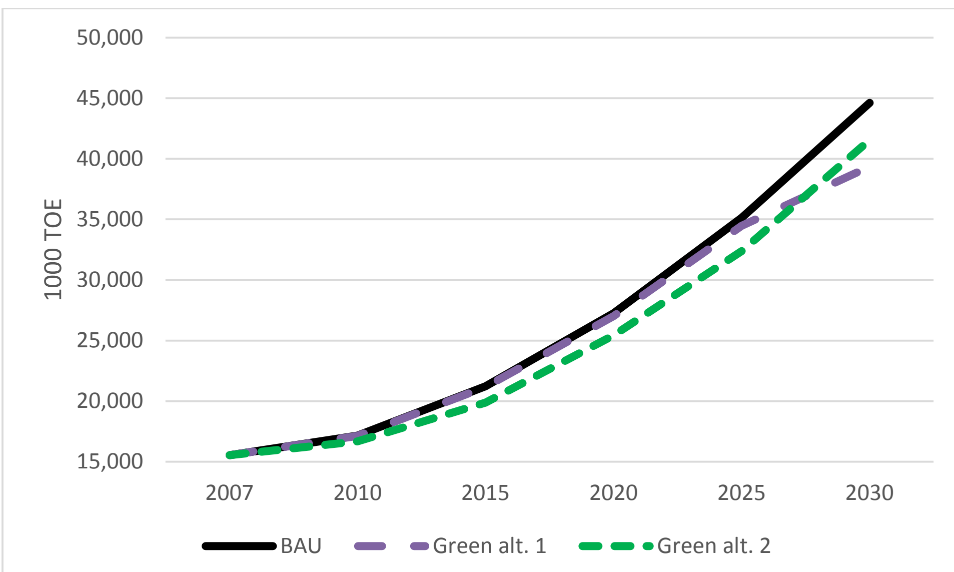

Figure 1, Total Energy Consumption in the Three Cases

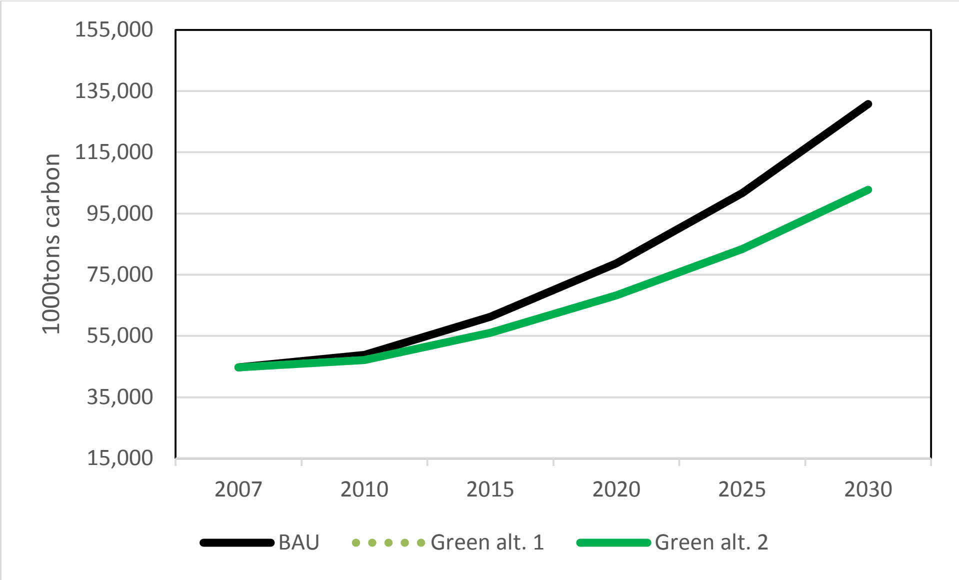

Figure 2. Carbon Emissions over the Time Period

Emissions are the same in the two green scenarios basically driven by the efficiency and renewable energy investments programmed into both cases. Both case have 21% lower emissions by the end of the period than in the base case.

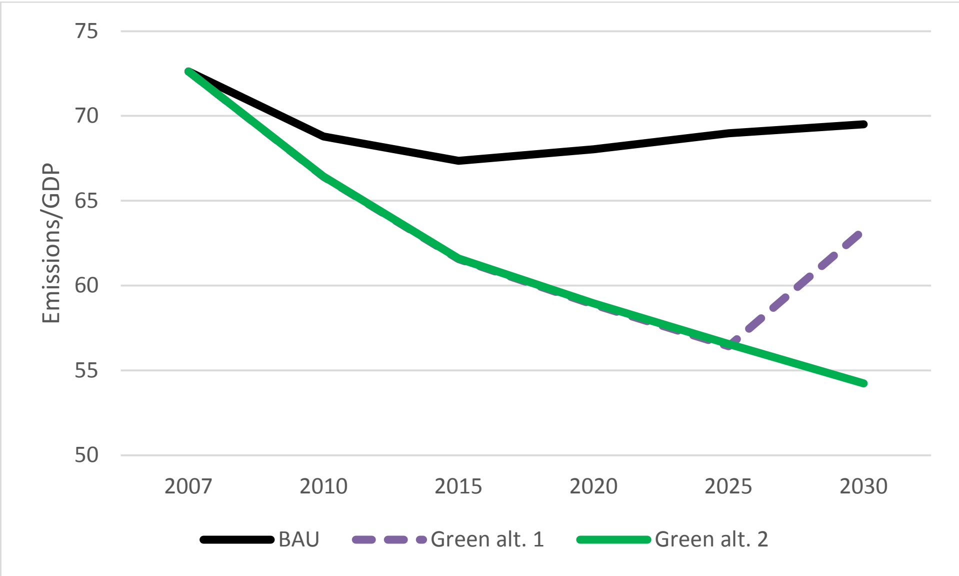

Figure 3. Emissions per Unit of GDP

Emissions per unit of GDP are much higher in the base case than in either of the green cases. Interestingly emissions per unit of GDP are lower at the end for the second green scenario. This is largely because by the end the economy is growing faster due to the reduced subsidy burden while the burden continues in green alternative 1.

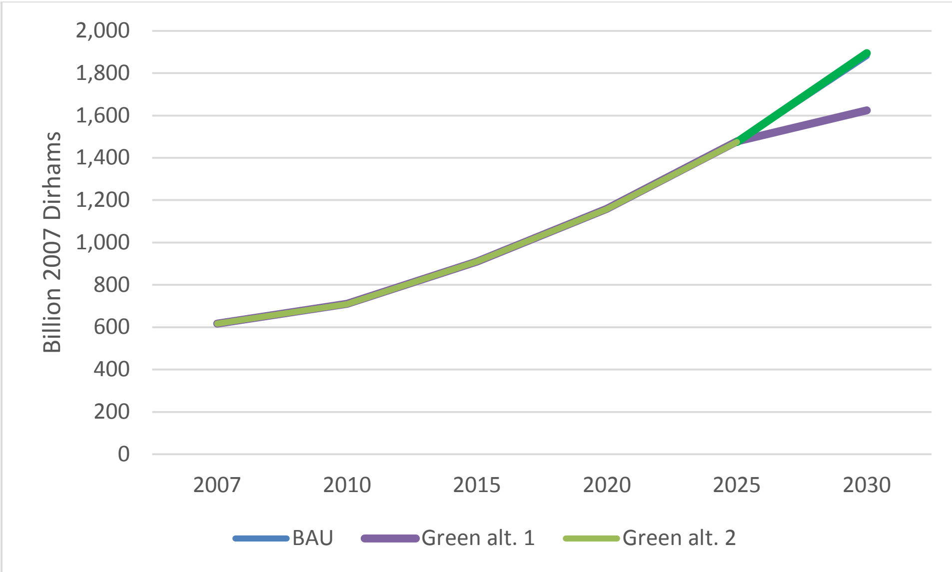

Figure 4. GDP Growth over Time

The path of GDP growth over time is essentially the same for the second green scenario and the BAU case. However, GDP growth falters at the end for the first green case again due to the subsidy burden. Domestic production also falls 14% in the final period for the same reason.

The large investments in renewable energy without addressing the energy subsidy issue (scenario 1) involves a reduction in economic growth due to the high cost of the renewable investments coupled with the energy subsidies. The magnitude of investments required surpasses the national savings capacity and requires foreign capital investment.

Scenario 2 combining subsidy removal with renewable investments has several valuable lessons:

- Subsidy removal impacts are quite different in the short and long term. In the short term, economic growth is reduced, but it accelerates substantially in the long term due to the stimulus of reduced taxes and increased energy efficiency.
- Elimination of energy subsidies causes adverse impacts on the poor households such that considerations of an improved social safety net would be needed to accompany the subsidy reductions.
- A fixed (nominal) exchange rate policy exacerbates the economic impacts of the subsidy removal. Subsidy removal induced inflation causes appreciation of the real exchange rate.
- Subsidy reduction combined with renewable energy and efficiency investments can increase economic growth and reduce GHG emissions.

If Morocco were to embark on the path towards more renewable energy along with aligning its energy prices with world prices and reducing energy subsidies, the changes would be quite large and would need to be handled carefully. The magnitude of investment required for the green energy path is huge and would need to be planned over a period of time. Subsidy removal also would need to be developed to help minimize the adverse impacts on the poor. For example, the butane subsidy might be reduced more slowly than the other energy subsidies. However, over the longer term, the Moroccan economy and society would be better off and more efficient if these steps were taken.