MODELING RENEWABLE ENERGY READINESS

WETICE: JUNE 28, 2011
MIT & MIST

NAZLI CHOUCRI
DANIEL GOLDSMITH
TOUFIC MEZHER

TECHNOLOGY POLICY

Modeling technology policy is becoming an increasingly important capability to steer states and societies toward sustainability.

MODELING RE-READINESS

Simulation-modeling to evaluate renewable energy readiness: the ability to develop renewable energy, taking into account critical ecological, economic, governance, and institutional factors.

OIL-EXPORTING COUNTRIES

While the dynamics underlying shifts towards renewable energy are generic, we focus on the United Arab Emirates (UAE) as a counter-intuitive case. An oil exporting country that has made a policy decision to develop sources of renewable energy.

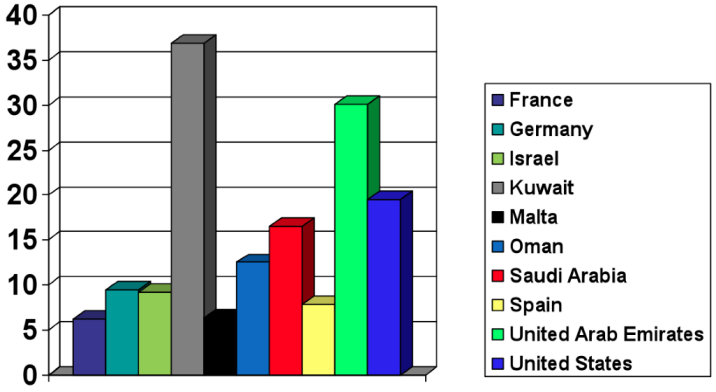
➔ **Broadly stated, our goal is to identify, describe, and design methods to support technology policy in the energy domain, with special attention to the factors that shape the readiness for renewable energy (RE-readiness).**

➔ **We define RE-readiness as the ability to pursue renewable energy creation opportunities taking into account critical ecological, economic, governance, and institutional dimensions.**

➔ **Our approach recognizes the complex realities created by different perspectives of the renewable energy issue and potential consequences, when:**

(a) viewed from a policy context;
(b) represented in analytical form;
(c) signaled by empirical indicators; and
(d) based on alternative contingencies.

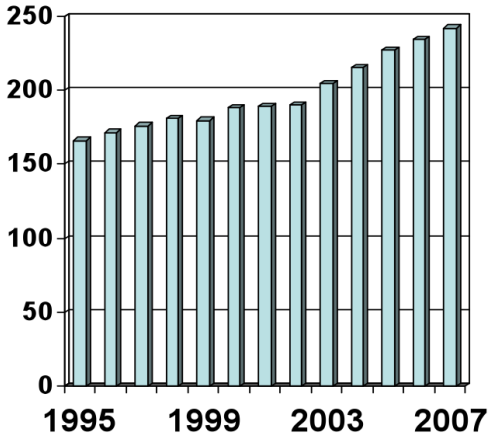
Co2 Emissions per Capita



ECOLOGICAL PRESSURES

The UAE's "carbon footprint" per capita is among the highest in the world.

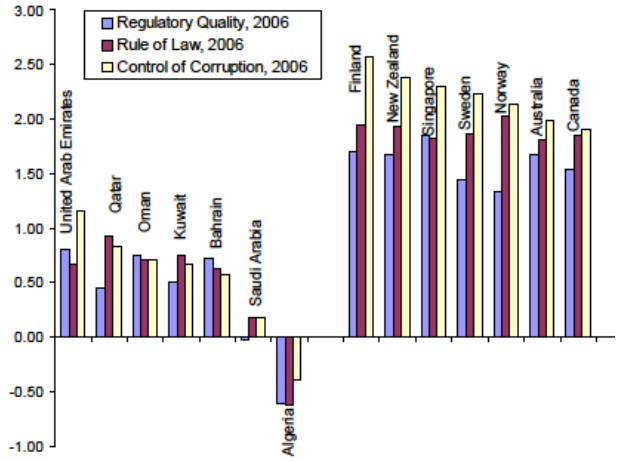
GDP, Billions
(Constant 2000 US$)



ECONOMIC PROSPERITY

UAE has experienced significant economic progress and increasing prosperity, particularly in Abu Dhabi.

Governance Indicators



INCOMPLETE GOVERNANCE

The UAE is in that distinctive category of a country that is very rich but with relatively limited managerial and institutional foundations and performance.

Source: World Bank (2009)

UAE FUNDAMENTALS

The United Arab shares with Kuwait and Saudi Arabia some fundamental features, like a small population relative to its resource base, and a rapidly growing modern sector of the economy, due to its oil wealth.

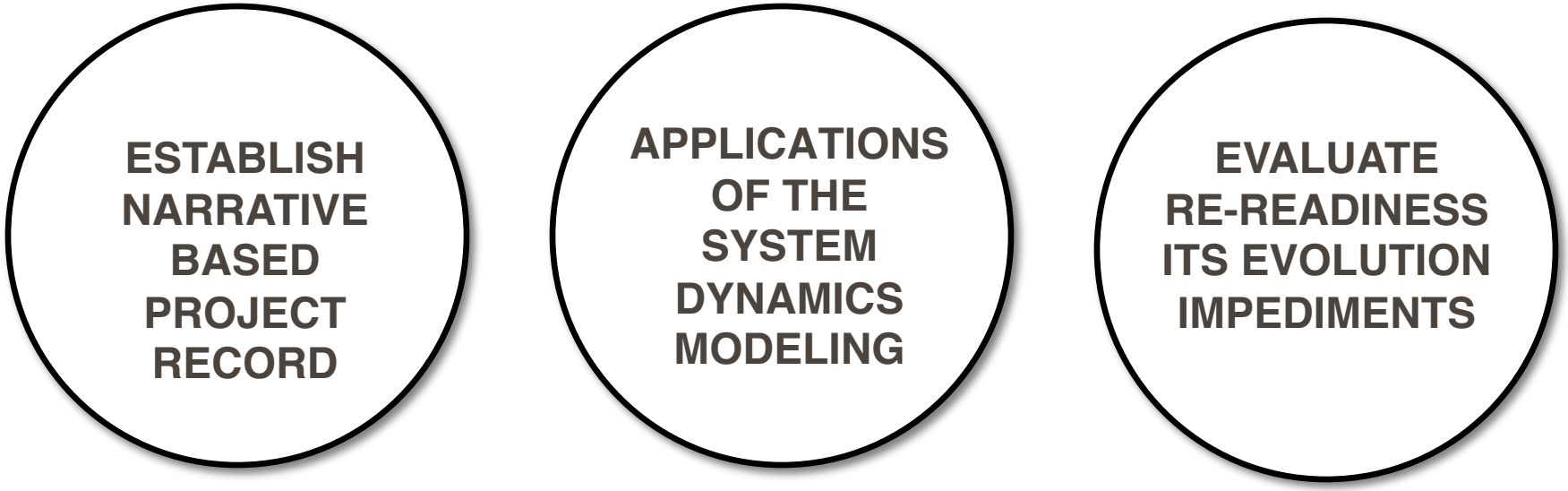
But unlike the other two countries, the leadership of its capital and largest Emirate, Abu Dhabi, has begun to coordinate and define its energy policy for the 21st century, including a systematic approach to establish a renewable energy sector.

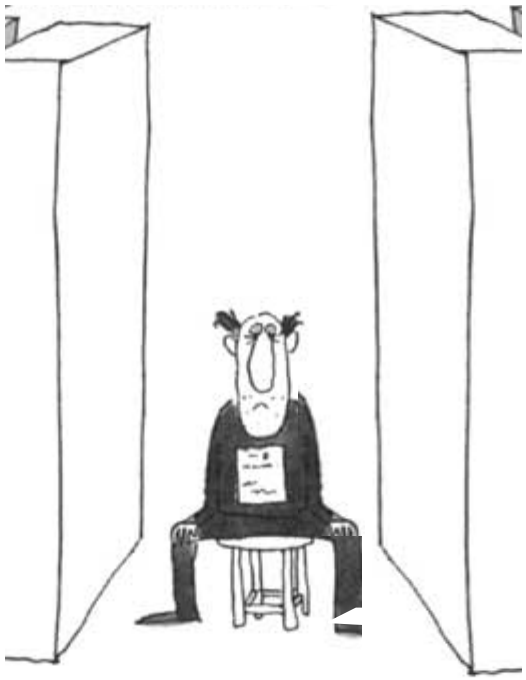
MASDAR INITIATIVIE

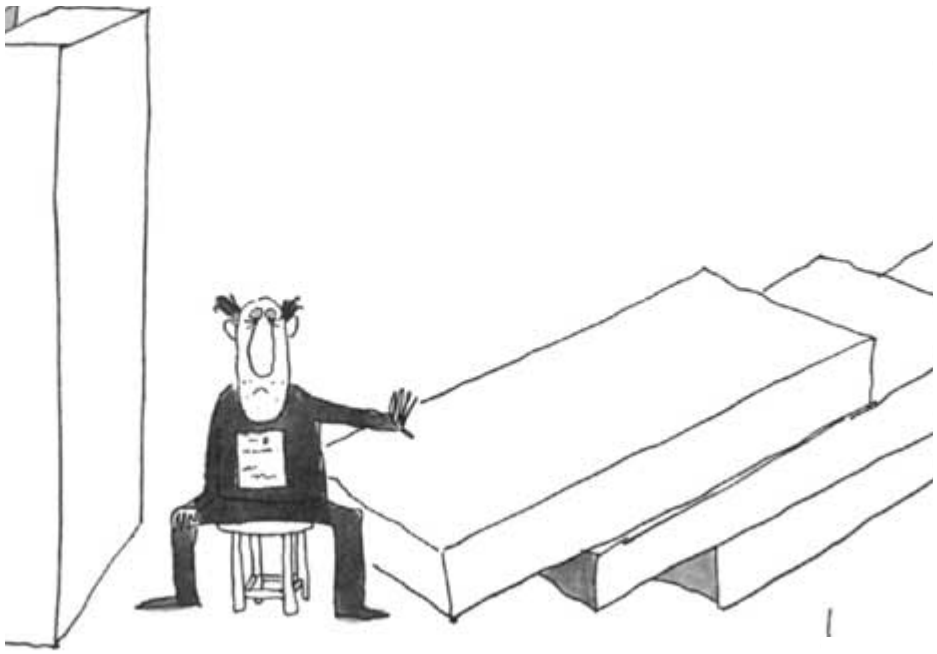
“The emirate of Abu Dhabi, the capital of the United Arab Emirates, has been a leader in the field of hydrocarbons for nearly half a century.

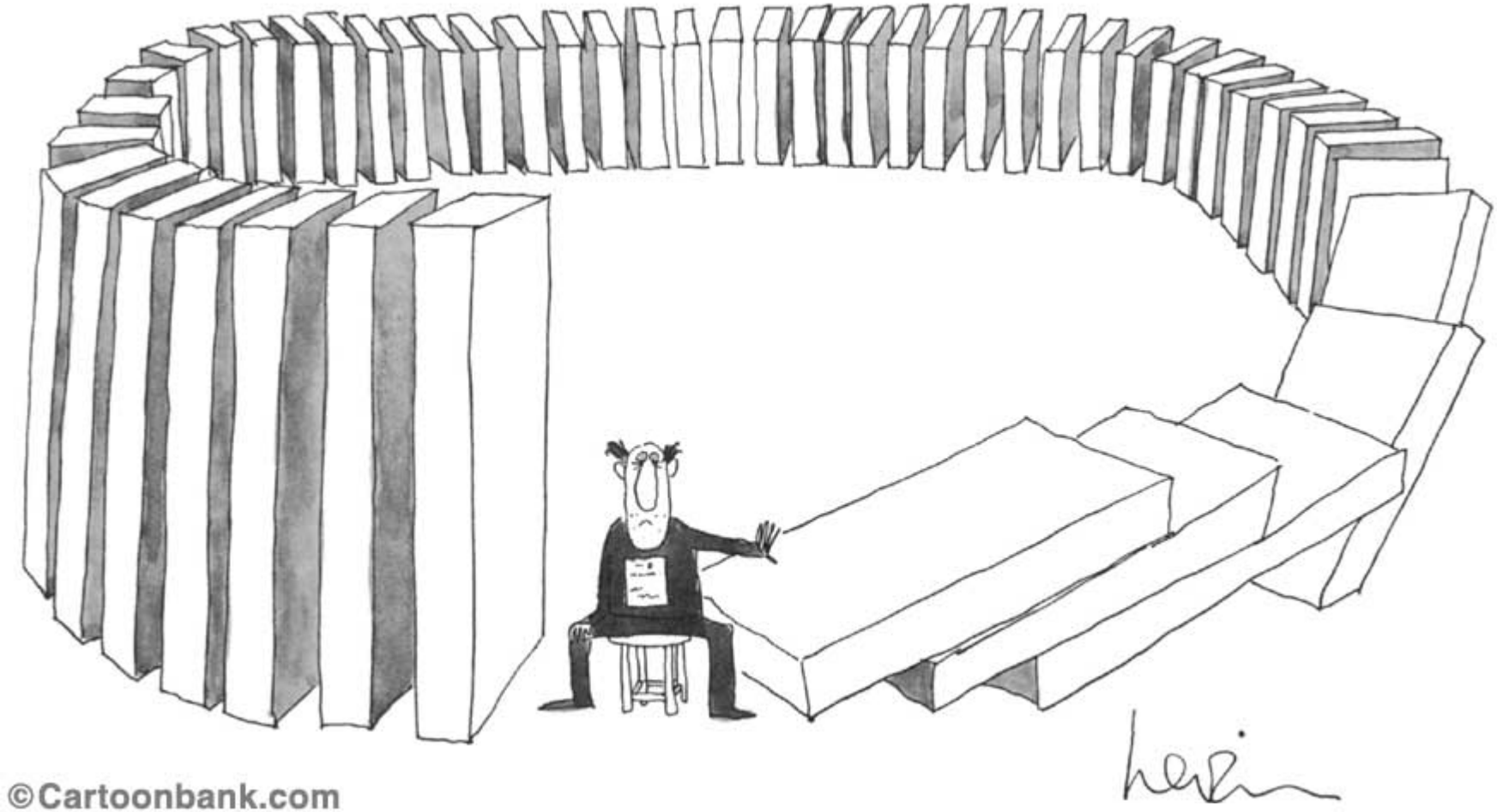
One of Masdar's primary objectives is to build upon Abu Dhabi's energy leadership and develop an entirely new domestic economic sector built on energy innovation and intellectual property, thereby establishing the Emirate as the regional and global center of future energy solutions.”
-- Masdar Press Release, 2008

RESEARCH CHALLENGES









BACKGROUND

System Dynamics Modeling was developed at MIT in the 1950s.

Its been applied to numerous domains such as strategy, management, & process improvement; its even been applied to insurgency & nation failure.

APPROACH

It is designed to help addresses limitations of linear logic and over simplification caused by typical human assumptions and behaviors.

In other words, its hard to manage complexity in our heads alone.

KEY FEATURES

We can design simulations to experiment in complex systems.

For example, we can’t shut down hospitals to evaluate different IT packages.

1. August 2008

Large 100-200 megawatt concentrated solar power (CSP) facilities driving CO2 Emissions reductions.

2. May 2009

Introduced three major changes: new CSP deployment schedule, kilowatt-hour cost estimate changes, and recognition of subsidy issue.

3. January 2010

A core shift in technology choice – the inclusion of photovoltaic (PV) capacity, as well as expanded subsidy plans.

1. August 2008

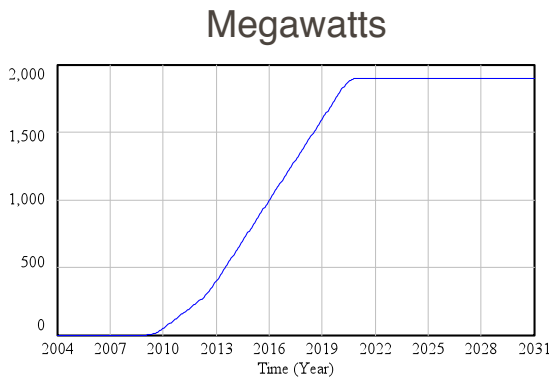
Build a 100-megawatt concentrated solar power (CSP) facility each year for three years, beginning in 2010, and then later construct a 200-megawatt facility each year for the subsequent eight years. Also included:

- the peak demand forecast, taken from the ADWEC Winter 2007/2008 Demand Forecast
- the implied reduction in CO2 Emissions from CSP, which are calculated as 7.78 x 10-4 metric tons CO2 / kWh using USEPA data.

2. May 2009

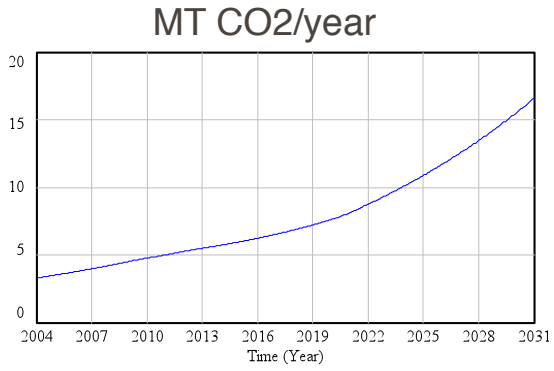
3. January 2010

AUGUST 2008 SIMULATION OUTPUT



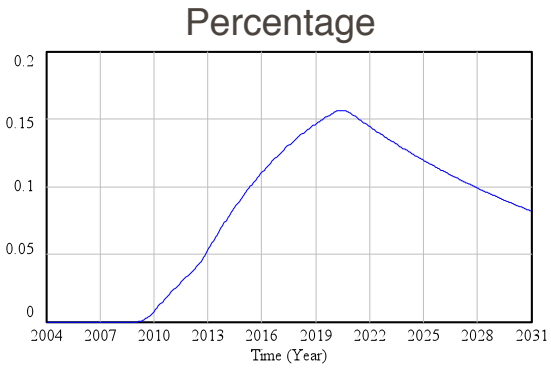
CUMULATIVE CSP CAPACITY

Assumed that at least 7% of the Emirate's power generation capacity will come from renewable energy sources by 2020. The target provided a critical anchor for policymaking and drove the original CSP assumptions.



TOTAL EMISSIONS

The plan shows an exponential increase in energy demand.



PERCENTAGE FROM CSP

Shows a rise but subsequent decline in percentage of CSP. This figure highlights the mismatch between demand and supply embedded in the August 2008 plan

1. August 2008

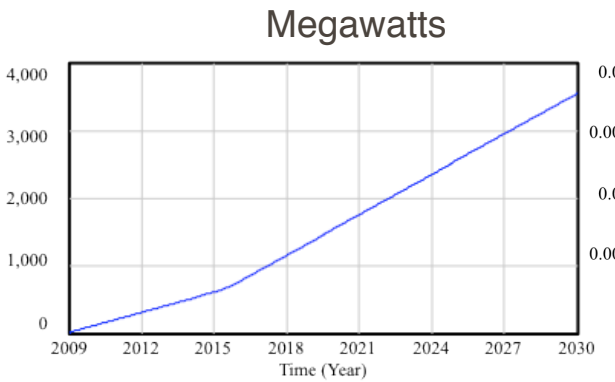
2. May 2009

Original estimate for kilowatt-hour cost was relatively low, but with the completion of subsequent work, the figure went up substantially. As of May 2009, the first CSP plant had not yet begun construction. This confirmed the limited degree of RE-readiness displayed in the August 2008 plan.

In response the May 2009 plan was adjusted so that it would begin CSP deployment in 2011, with 100-megawatt facilities being built each year for five years, and 200-megawatt facilities being built for the subsequent five years, adopting a longer time horizon. Other additions: subsidies, new calculation inputs for solar generation, natural gas reduction, solar thermal, and new inputs to energy demand growth from desalination.

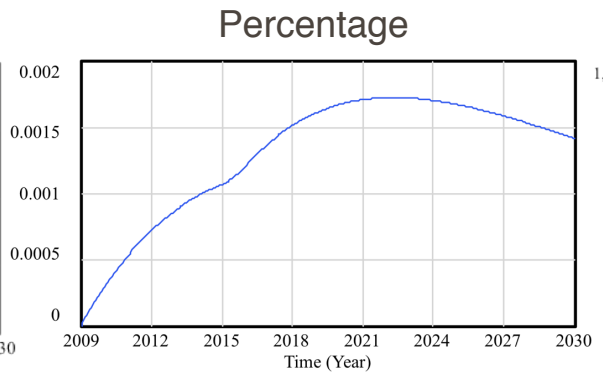
3. January 2010

MAY 2009 SIMULATION OUTPUT



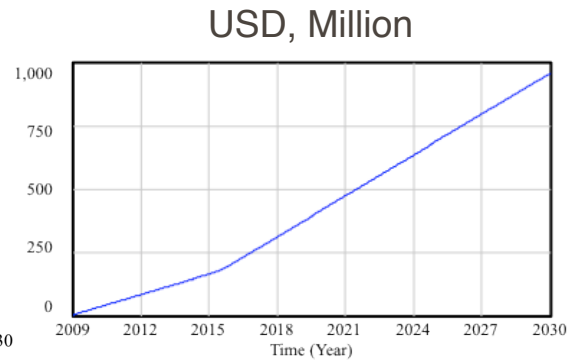
CUMULATIVE CSP CAPACITY

New trajectory for deployment that accounts for project slippage.



PERCENTAGE FROM CSP

The May 2009 plan provide for meeting the governments' stated renewable energy goals and as well as adopting a longer time horizon.



SUBSIDIES

The explicit recognition of a rising subsidy burden.

1. August 2008

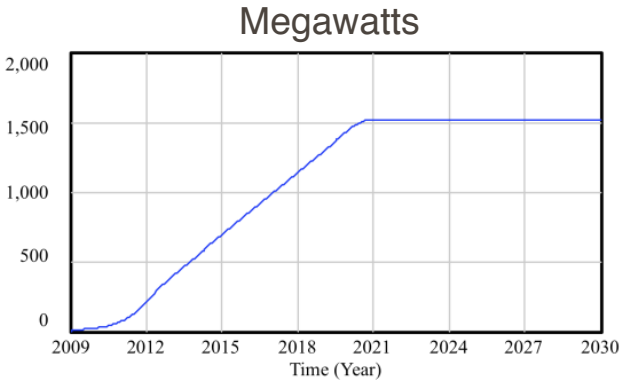
2. May 2009

3. January 2010

The January 2010 involves a core shift in technology choice – the inclusion of photovoltaic (PV) capacity, as well as expanded subsidy plans.

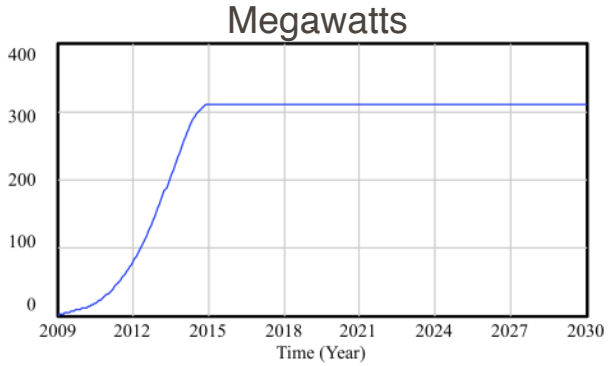
In particular, the addition of two types of photovoltaic deployment: PV Utility Scale & PV Small Scale. The total subsidies are now nearly halve of those in the May 2009 plan, mostly due to the shift to Utility Scale PV, which has a lower cost of production. For the first time, the RE plan incorporates endogenous drivers of renewable energy deployment, namely cost reductions from gaining experience additional costs calculations for subsidies.

JANURARY 2010 SIMULATION OUTPUT

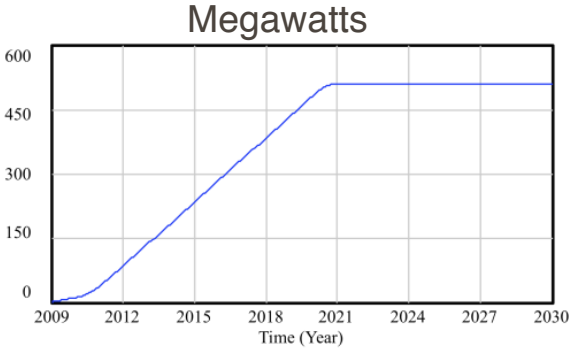


CUMULATIVE CSP CAPACITY

The results show that the goal of 1,500 MW Solar power plants is achieved in 2020.

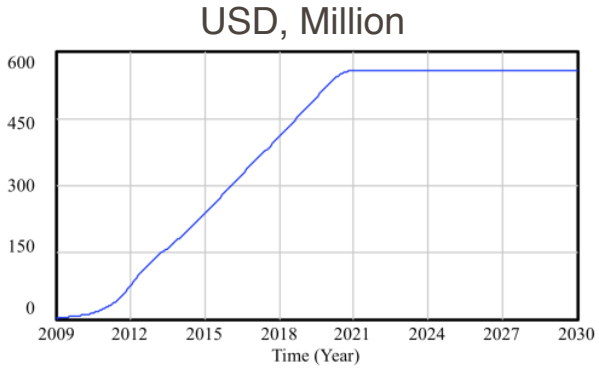


UTILITY SCALE CUMULATIVE PV CAPACITY



SMALL SCALE CUMULATIVE PV CAPACITY

Instead of solely relying on CSP technology, the plan now calls for the deployment of both utility scale PV



SUBSIDIES

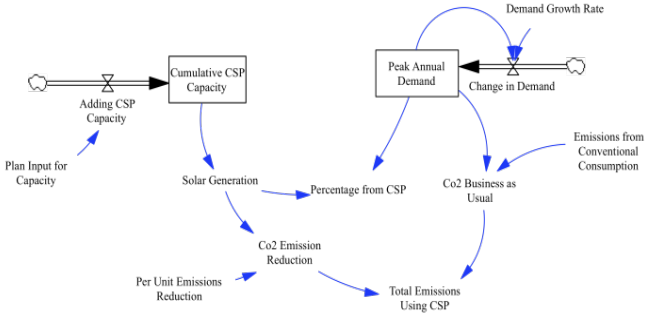
The total subsidies are now nearly halve of those in the May 2009 plan, mostly due to the shift to Utility Scale PV, as well as endogenous feedback

	August 2008 Plan	May 2009 Plan	January 2010 Plan
Project Features	Basic RE Deployment	Policy supports - subsidies	New technology choice
RE-Readiness	Important declarative step but low on policy mechanisms	Inclusion of partial but incomplete logic for policy mechanisms and planning limitations	Changing technology choice yet potential scope reduction
Supply Demand Gap	Higher on supply by limited demand	Subsidies driving demand but supply problems remain	Change in both supply and demand, though no connection

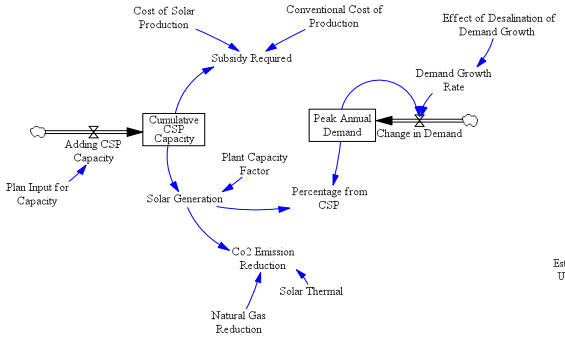
CONCLUSIONS

- The decision to support renewable energy development is declarative at best, and remains to be fully articulated in its more fundamental and operational terms.
- Because the policy seemed to be adopted on a stand-alone basis – and a target identified in seemingly arbitrary terms – it is difficult to anchor the policy or the target in a framework that is consistent with national objectives.
- Since a project-based approach has dominated discussion in the area of renewable energy, by necessity these discussions remain unconnected to the remainder of the country's policy plans and are largely de-contextualized. In essence, the UAE is trying to develop an additional energy asset—namely renewable energy sources—to augment its core energy resources.
- At a very minimum, this and all other policy initiatives must be viewed not on a standalone basis, or in terms of project-based validity, but rather in the context of an overall integrated asset management strategy. The authoritative plans for the country's future are framed more in terms of general blueprints than in terms of operational strategies.

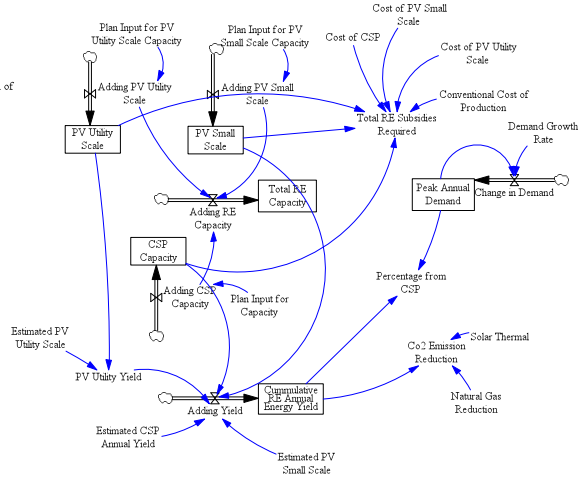
AUGUST 2008



MT MAY 2009



JANURARY 2010



BACKUP: JANURARY 2010