

Sustainable Energy with Carbon Utilization

* pread2@attglobal.net

motivation springs from related paper

**Bio-Energy with Carbon Storage (BECS):
a Sequential Decision Approach to the threat of
Abrupt Climate Change**

Peter Read and Jonathan Lermitt
(forthcoming in *Energy*)

Global energy related emissions are ~ 8 GtC p.a.

Terrestrial biosphere emits ~ 100 , absorbs $\sim 100+2$

Oceans absorb ~ 3

Net annual increase ~ 3

?

Is it easier to

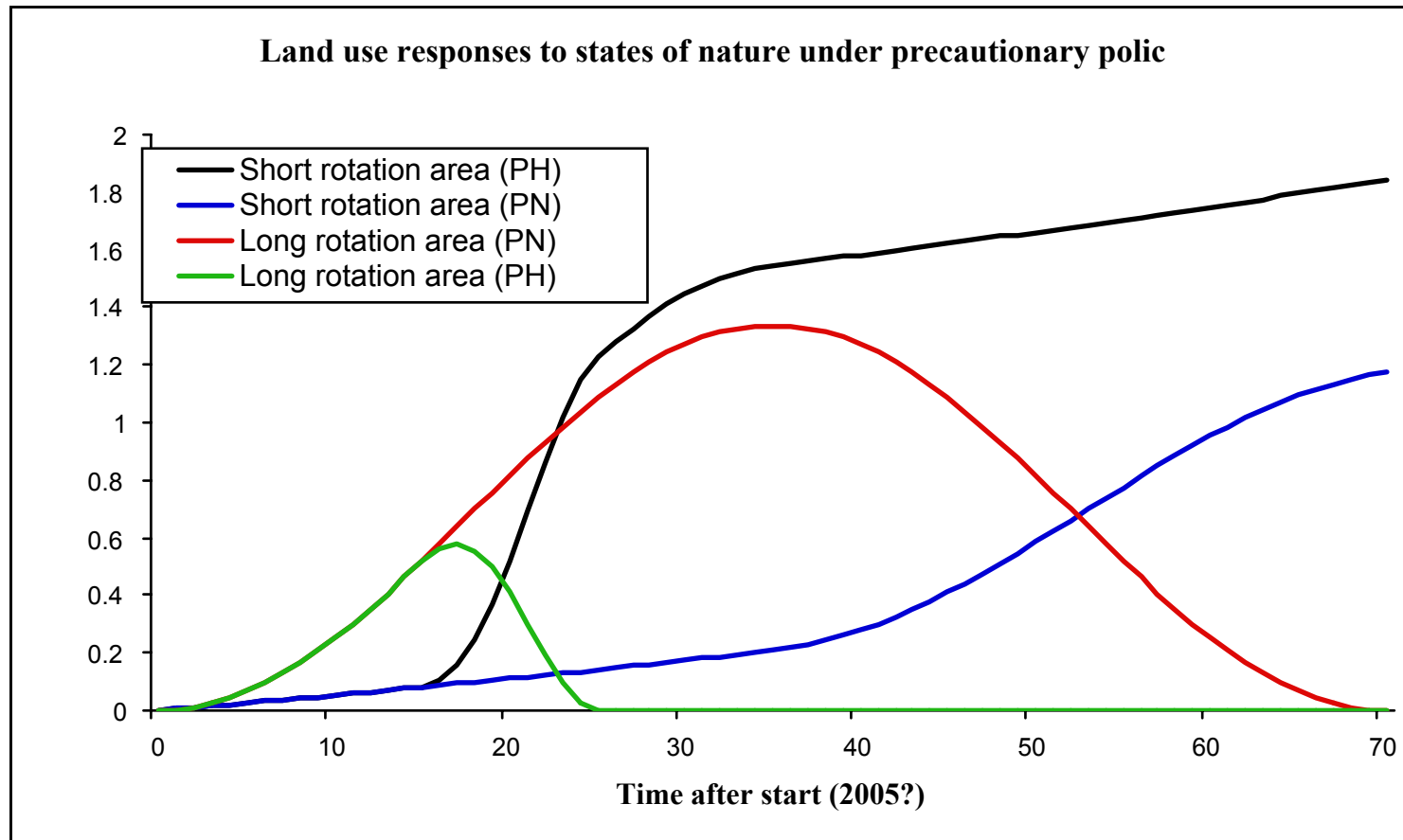
change the balance of terrestrial biosphere by 4 per cent

OR to

Cut global energy related emissions by 50 per cent

?

Policy driven global land allocations under a ‘be prepared For Abrupt Climate Change with and without precursor signals two decades hence (H=nature horrid, N=nature nice)



By way of motivation for this presentation: why model landowner behavior?
A back of Envelope calculation

Energy security

500 GJ/Ha-yr x 500 million Ha = 250 EJ annually

[[half current best commercial practice in Brazil

x

**40 per cent of cultivable land said by IPCC to be
available after allowing for growing food supplies]]**

30 per cent conversion displaces 75 EJ gasoline annually

= 120 EJ crude (assuming 5/8 high value fractions)

= 12,000EJ per century = 12,000 x 24 mtoe

= ~ 2.2 millions of millions of barrels of oil, over twice global proved reserves

Say 1½ allowing for a slow start in first few decades.

Manhattan Project style actions taken over the following decade in response to scientific news of Abrupt Climate Change precursors

- 1 Retrofitting of all large point source fossil and bio fuel emitters with CCS technology
- 2 All new large fossil and bio fuel plant fitted with CCS technology
- 3 A system of gathering pipelines installed to collect captured CO₂ and deliver to below ground storages
- 4 All long rotation policy land converted to short rotation mainly bio-fuel production with the part grown bio-mass material used wholly for biofuel
- 5 Shift from half to full atp for non-fuel renewable energy and technological progress.

(These could be outcomes of shift to very high C-price, but other measures, such as absorption portfolios protect consumers and may be preferable)

The effect of these measures is that emissions per ton of fossil fuel fall from .025tC/GJ to .015tC/GJ and per ton of biofuel from zero to – 0.01tC/GJ, with biofuel supply rapidly dominating the market.

Another back of Envelope calculation

Carbon in atmosphere under ‘Manhattan Project’ urgency (in response to ‘H’)

Area under long seq curve = $\frac{1}{2} \times 20\text{yrs} \times .6 \text{ GHa} \times 3\text{tC}/\text{Ha-yr} = 18\text{Gt C}$

Area under short rotation curve to 2030 =

$$\frac{1}{2} \times 10 \text{ yrs} \times 1.2\text{Gha} \times 10\text{tC}/\text{Ha-yr} = 60\text{Gt C}$$

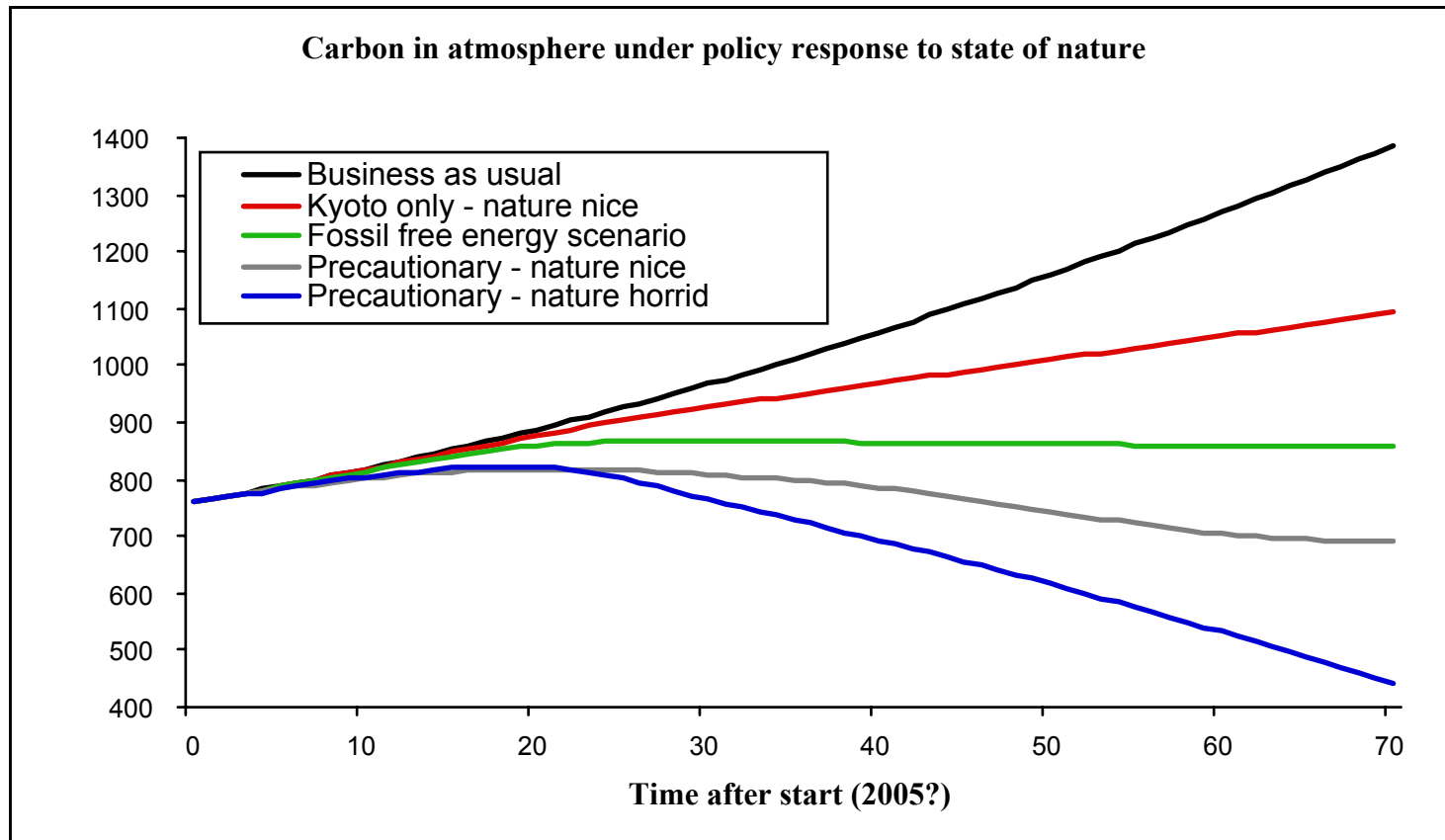
Assume 90 per cent replacement of Fossil fuel C emissions (see related IAEE paper) = $\sim 70 \text{ Gt C}$ not emitted =

35 ppm below “f.f.e.s.” trajectory or $\sim 400\text{ppm}$

By 2040 a further $10 \text{ yrs} \times 1.4\text{Gha} \times 12\text{tC}/\text{Ha-yr} = \sim 150\text{Gt C}$ not emitted

Total = $\sim 80 \text{ ppm}$ below “Kyoto” trajectory by 2040. Remaining reductions under ‘Manhattan Project’ urgency, as illustrated in fig 2, is due to CCS technology used with fossil fuel point source emissions, to increased energy efficiency and to more non-fuel renewables (wind etc.).

Gigatons C in atmosphere ($= \sim 2 \times \text{ppm } C_{\text{at}}$) for three reference scenarios and with ‘be prepared’ policy related to ‘Kyoto’ case with and without response to ACC precursors after 2020. Note that negative emissions energy system is needed to get below 330ppm.



Two Models

Common features of FLAMES (simulation) and LOLA (optimization)

Partial equilibrium approach modeling dynamic demand and supply in three markets:

- “Fuel”: basic $C_xH_yO_z$ raw material with global current price ~\$2/GJ.
- “Timber”: basic timber product industry raw material price ~\$130/ton
after separation from joint product bio-fuel at process cost ~\$90/ton.
- “Land”: ~6bHa of non-barren, non conservation forest land that can be used
commercially for farming or forestry or otherwise left to wilderness.

Demands grow with population and per-capita living standards; supplies of fuel and land products grow with technological progress.

Parameters are adjusted to achieve, in the without-policy case :

- Constant real prices broadly consistent with historic patterns
- Emissions paths to mimic reference case (i.e. no new scenarios)

Policy is represented by land allocations to two activities – long rotation plantations and short rotations which are both joint producers of timber and bio-mass for energy in proportions (different for the two activities) determined by relative prices.

Net policy costs are met by a tax on fossil carbon emissions.

<u>Scenario</u>	<u>b.a.u.</u>	<u>f.f.e.s.</u>	<u>'Kyoto'</u>
<u>Parameter</u>			
Growth of per capita fuel demand ^a	.0274	.0274-atp ^b	.0274-atp/2
Tech progress with fossil fuel supply	.035	.02 ^c	.0275
Growth of fossil fuel emissions ^d	.015	0	.0075

^a population increase averages .0076 (World Bank central projection) giving balanced supply and demand growth of 3.5 per cent and long term constant energy prices under b.a.u.

^b accelerated technical progress with renewable energy and energy efficiency from year 10 to 30 with compensating later slowing to represent technical limits (see Read, 1999)

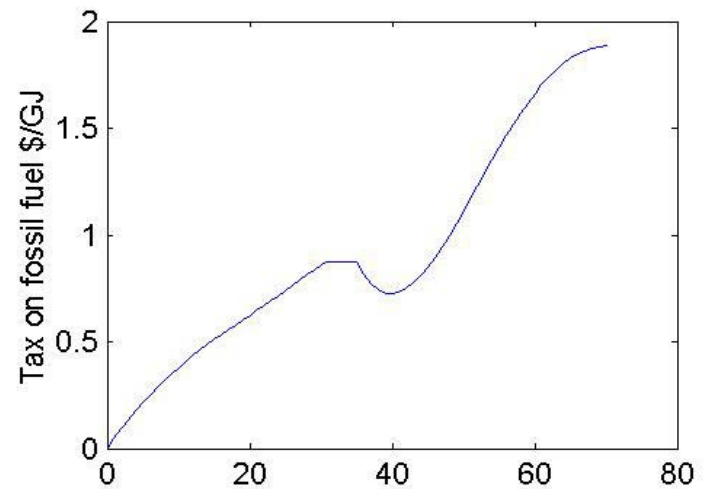
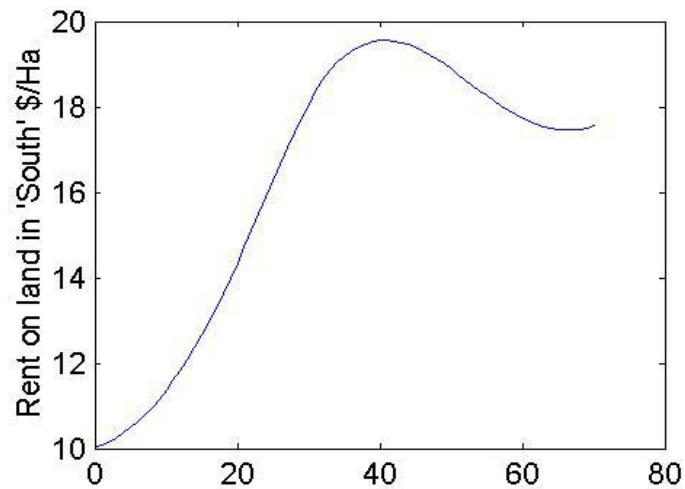
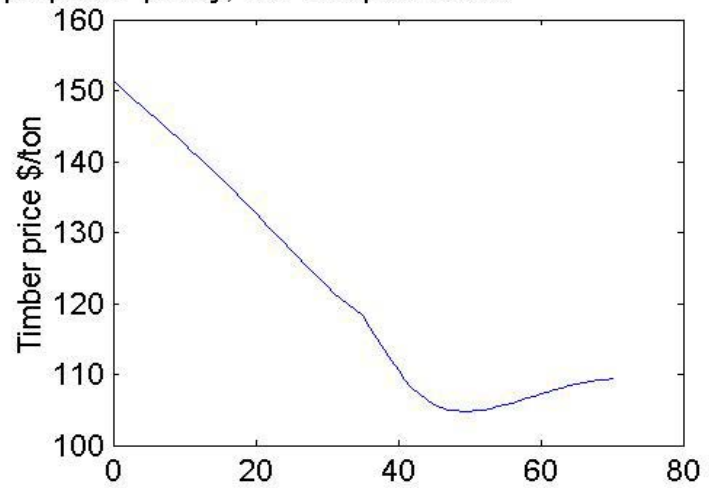
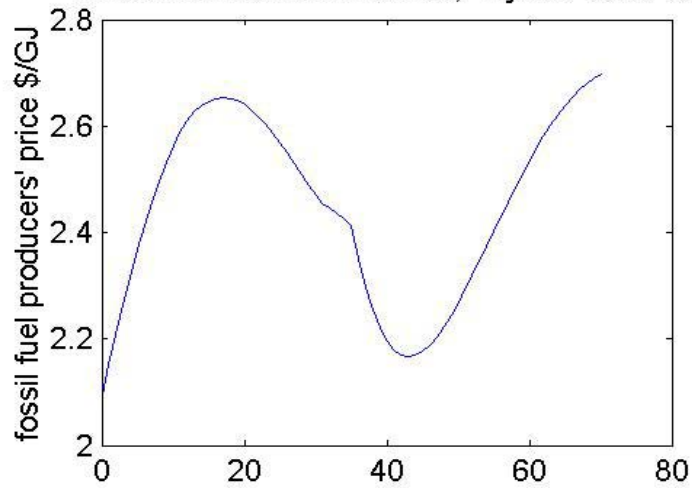
^c fossil fuel research discouraged by policy, leading to more rapid cost increases

^d assumes 2 % p.a. de-carbonization from fuel switching

FLAMES: progress, features and results

- Recent work has seen the development of multi-region models, with trade in fossil fuel, in bio-fuel, and in timber.
- Also of an ACC response variant of the global model. Here we report on the global model and this variant.
- Rotation lengths are fixed (35 years for long rotation = half the modeled time horizon, 1 year for short rotation)
- Technological progress is nil at 3tons C per Ha-yr for long rotation; rises from 6 to 18 tons C per Ha-yr for short rotation over 70 years (240 to 720 GJ/Ha cf current best commercial practice 1300 for sugar cane, 1000 for eucalypt).
- Post-harvest land use is 50% to short rotation, 50% to farming for long rotation, 100% to continued short rotation for short rotation
- Reference scenarios two cases considered mimicking, respectively, IS92 business as usual and Tellus/Greenpeace fossil free energy scenarios; “Kyoto” is treated as half way between

Price Profiles from Flames, "Kyoto" case with 'be prepared' policy, no ACC precursors



LOLA: progress, features and results

N.B. the LOLA presentation was subtitled

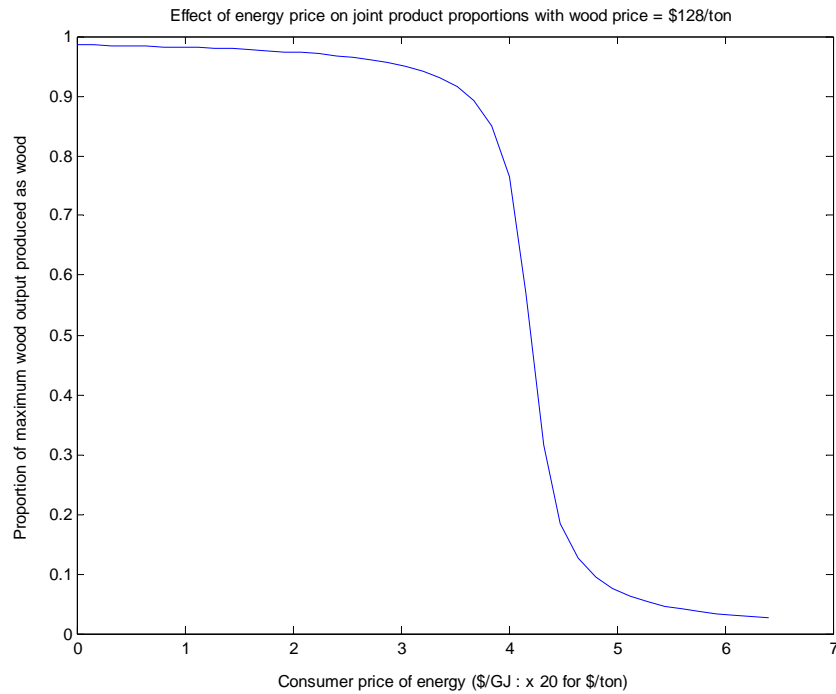
“towards incentive-compatible modeling of land use change policy impacts.”

The implausible price profiles generated by FLAMES show need for optimizing model in which inter-temporal arbitrage (mediated by landowners' felling and replanting decisions) smoothes out the sharp shifts in price trends.

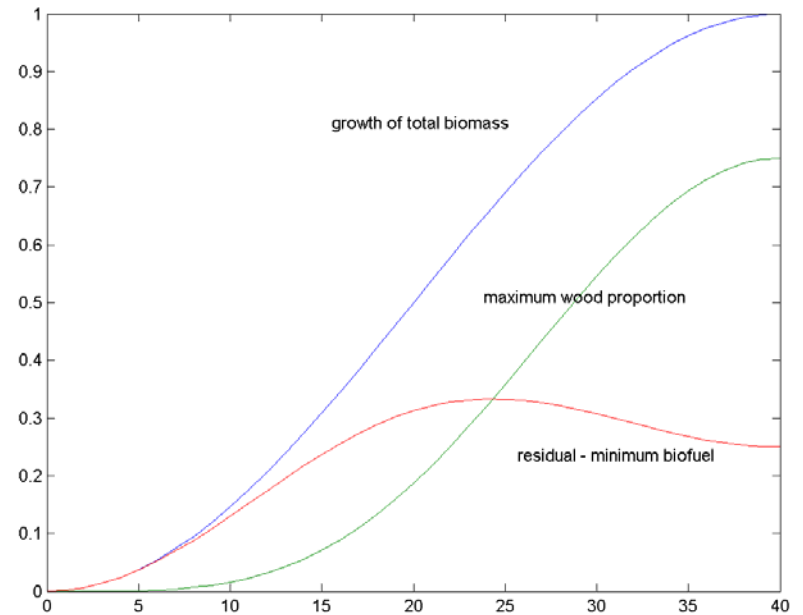
So far the behaviour of landowners growing existing forests and policy-induced long rotations has been modeled. Features include:

- Non-linear (S-shaped) growth of which a non-linear (S-shaped) proportion is usable as timber, but can be used for fuel, rising to 75 per cent of total biomass.
- After full growth in 40 years there is a plateau for 20, followed by linear decline (due to e.g. forest fires ?) over a final 40 years.
- Proportions of harvested woody material to each use is price dependent, as in FLAMES
- A tax transfer to meet costs of policy land planting and rents until end of land use change (35 years)
- Objective function is to maximize welfare (consumer surplus minus variable costs) implying price taking, jointly in the markets for timber and, in competition with fossil fuel.
- Landowners commercial rate of return is a constraint on welfare maximisation

Relative Price and Age dependency of joint products of long rotation plantation



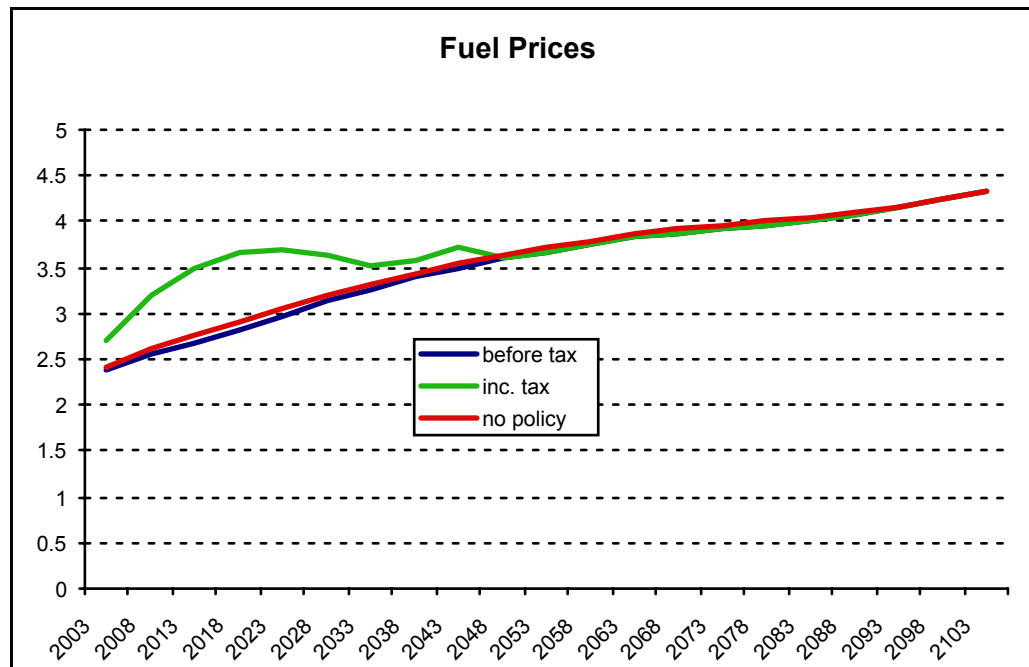
Price effect



Age effect

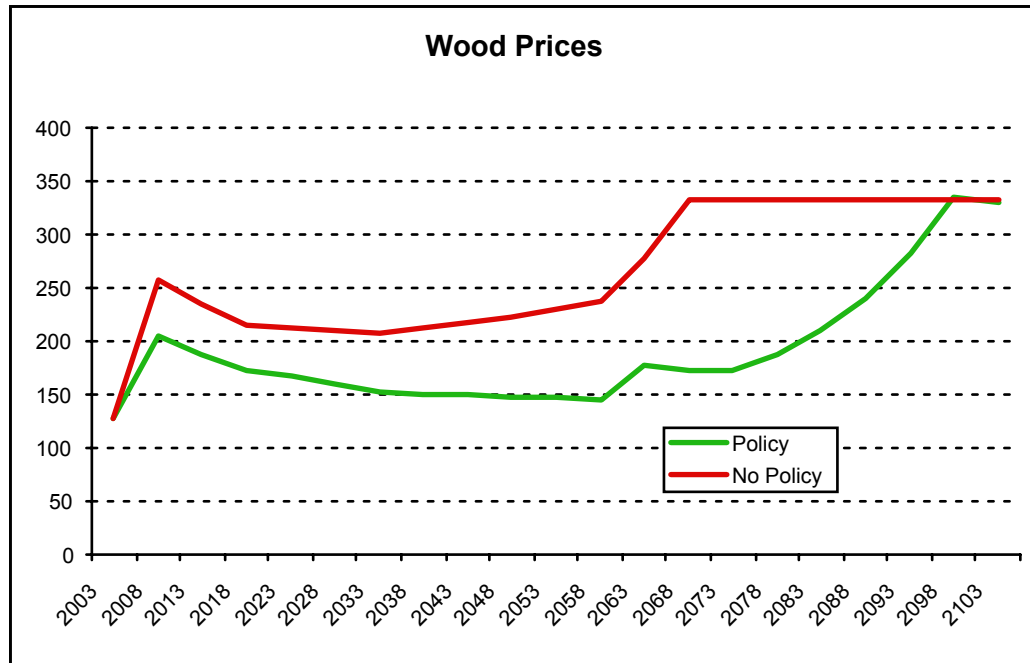
Price Profiles

fuel price with and without policy land at 10% commercial return along with the policy transfer (fossil fuel tax) needed to fund the policy – computation at 5 year intervals.



Price Profiles

Wood price with and without policy land at 10% commercial Return.



Provisional inferences

- Price profiles are smoothed out by optimizing behaviour.
- Policy driven land use change induces policy leakage through reduced replanting by existing foresters (this is anticipated in FLAMES).
- Providing landowners are price-takers, their required rate of return does not greatly impact on the pattern of harvesting and replanting.

Caveats

1. Optimization modeling (LOLA) in early stages
2. Low C_{at} levels require, in addition, high energy efficiency and increased use of non-fuel renewables as in f.f.e.s. scenario [but note that driven by ACC precursors not GCC as in f.f.e.s.]
3. Land use is assumed 'Maximal'
4. Need for capacity building

IN CONCLUSION: A question

Why, given its win-win-win-win potential, is the global bio-energy solution to the Climate Change issue ignored or down-played in policy formation ??

Win 1 – early and effective stabilisation and medium term reductions in atmospheric carbon.

Win 2 – potential to respond effectively to Abrupt Climate Change

Win 3 – increased energy security and resistance to potential oil price increases

Win 4 – sustainable economic prospects for landowners both in developed and developing countries

A Possible answer

- Market co-ordination failure between suppliers of bio-energy raw material and potential users separated by decades, oceans, language and culture
- Unfortunate self-perpetuating error in the negotiations [that ended, almost – i.e. all bar Russia – at Marrakesh] due to maintained assumption that best policy is to price up carbon through TEPs, ignoring need to drive technology change, particularly land use change.

Maybe it's time to try again in context of Art 3.3 of the 1992 Rio Convention, looking at the grounds for early action provided by threats of ACC.

International Framework for Bioenergy Action

Scenarios	A1	B1	A2	B2
Tech	Hi	Hi	Lo	Lo
Pop	Lo	Lo	Hi	v. Hi
Globalise	Yes	Yes	No	No
Values	Econ	Enviro	Econ	Enviro

Bioenergy Potential

In 2050

North Am	111	137	4	34
Latin Am	253	315	46	178
Africa	363	449	42	151
S Asia	21	24	14	21
W Eu	32	40	0	14
E Eu & CIS	125	153	3	76
E Asia	178	221	10	21
Oceania	100	125	15	60
Total	1183	1464	134	555

Clearly the outcome in 2050 depends upon choices soon

**NEGOTIATING A HEDGE AGAINST A.C.C.
PROVIDES A CHANCE TO AVOID THE ERRORS
OF KYOTO AND FOR THE RIO TREATY TO DELIVER:**

- ENERGY SECURITY
(NEEDS TRADE BUT NOT WITH OPEC)
- JOBS FOR SURPLUS AGRICULTURAL WORKERS
(AND BASIS FOR RURAL INDUSTRY)
- SUSTAINABLE RURAL DEVELOPMENT
(AND END OF 'ENERGY POVERTY')

It's got something for everyone in a world of technological progress
Kyoto is a beggar-your-neighbour zero sum game