Core Model Proposal #392:
Biomass Oil Sharing Bugfix

Product: Global Change Analysis Model (GCAM)

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Related sector: energy

Type of development: bugfix

Purpose: This core model proposal switches the logit formulation used for sharing in the "regional biomassOil" sector from "relative-cost-logit", which causes solution issues under high carbon price scenarios, to "absolute-cost-logit".

Description of Changes

Background

The regional biomassOil sector, for some regions, has multiple "technologies" (i.e., crops: OilPalm, OilCrop, and Soybean) which compete . Some of those also produce the secondary output "DDGS and feedcakes" (OilCrop and Soybean). Whenever the costs of a technology can go negative, either due to carbon subsidies or DDGS, we should be careful with which logit formation we use. In this case we had not and were using the "relative-cost-logit" which creates on/off behavior when prices go negative. Particularly when multiple options go negative at the same time it will be liable to create solution issues.

We have been observing solution issues in SSP 2, 4, and 5 + 2.6 W/m^2 mitigation scenarios for a while. Debugging a solution failure in 2090 / SSP2 + 2.6 we can observe the following discontinuity in the DDGS and feedcakes market for Europe_Non_EU:
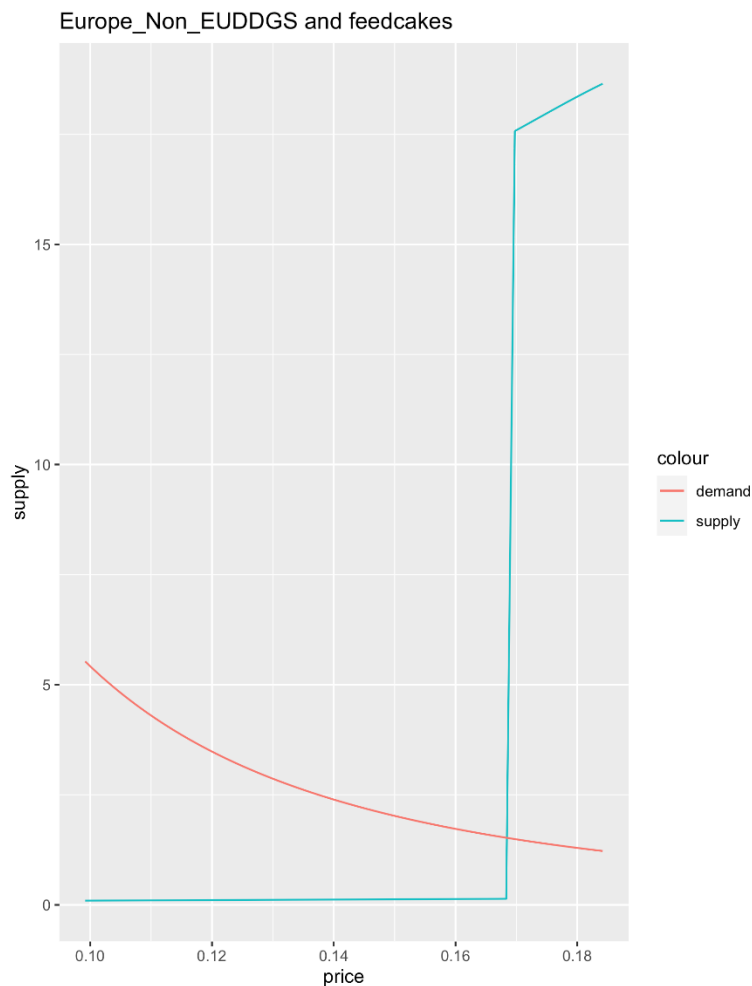
Tracing the supply behavior leads us to the "regional biomassOil" sector. Where at the "low supply" end of the supply curve OilPalm has a negative cost and thus gets all the share. Note that OilPalm does **not** produce DDGS and feedcakes:

```
> get_data(g, query_boil_cost, list("region" = c("=", "Europe_Non_EU"),
"year" = c("=", get_current_year(g))))
# A tibble: 3 x 6
  region         sector                subsector             technology year
cost
  <chr>          <chr>                 <chr>                 <chr>      <int>
<dbl>
1 Europe_Non_EU regional biomassOil regional biomassOil OilCrop     2090
8.80
2 Europe_Non_EU regional biomassOil regional biomassOil OilPalm     2090 -
0.156
3 Europe_Non_EU regional biomassOil regional biomassOil Soybean     2090
3.02
> get_data(g, query, list("region" = c("=", "Europe_Non_EU"), "year" = c("=",
get_current_year(g)))) %>% bind_rows(get_data(g, query_boil, list("region" =
c("=", "Europe_Non_EU"), "year" = c("=", get_current_year(g)))))
# A tibble: 7 x 7
  region         sector                subsector             technology
output            year `physical-outpu…
  <chr>          <chr>                 <chr>                 <chr>
<chr>            <int>            <dbl>
1 Europe_Non_… regional corn for e… regional corn for et… regional corn for
et… DDGS and feedcakes  2090         1.21e- 1
2 Europe_Non_… regional corn for e… regional corn for et… regional corn for
et… regional corn for … 2090         4.05e- 3
3 Europe_Non_… regional biomassOil regional biomassOil   OilCrop
DDGS and feedcakes  2090         2.52e-10
4 Europe_Non_… regional biomassOil regional biomassOil   OilCrop
regional biomassOil 2090         7.90e-12
5 Europe_Non_… regional biomassOil regional biomassOil   OilPalm
regional biomassOil 2090         2.26e- 1
6 Europe_Non_… regional biomassOil regional biomassOil   Soybean
DDGS and feedcakes  2090         2.06e- 9
7 Europe_Non_… regional biomassOil regional biomassOil   Soybean
regional biomassOil 2090         1.84e-11
```

When in the "high supply" end of the supply curve Soybean costs also go negative. Given the "relative-cost-logit" cannot handle negative values this causes a shift into basically 50/50 share between the two negative cost options.

```
> get_data(g, query_boil_cost, list("region" = c("=", "Europe_Non_EU"),
"year" = c("=", get_current_year(g))))
# A tibble: 3 x 6
  region         sector                subsector             technology year
cost
  <chr>          <chr>                 <chr>                 <chr>      <int>
<dbl>
```

```
1 Europe_Non_EU regional biomassOil regional biomassOil OilCrop      2090
7.44
2 Europe_Non_EU regional biomassOil regional biomassOil OilPalm      2090 -
0.156
3 Europe_Non_EU regional biomassOil regional biomassOil Soybean      2090 -
1.74
> get_data(g, query, list("region" = c("=", "Europe_Non_EU"), "year" = c("=",
get_current_year(g)))) %>% bind_rows(get_data(g, query_boil, list("region" =
c("=", "Europe_Non_EU"), "year" = c("=", get_current_year(g)))))
# A tibble: 7 x 7
  region         sector              subsector           technology
output          year `physical-outpu…
  <chr>          <chr>               <chr>               <chr>
<chr>           <int>            <dbl>
1 Europe_Non_… regional corn for e… regional corn for et… regional corn for
et… DDGS and feedcakes   2090      1.45e- 1
2 Europe_Non_… regional corn for e… regional corn for et… regional corn for
et… regional corn for …  2090      4.82e- 3
3 Europe_Non_… regional biomassOil  regional biomassOil   OilCrop
DDGS and feedcakes   2090      1.36e-10
4 Europe_Non_… regional biomassOil  regional biomassOil   OilCrop
regional biomassOil  2090      4.25e-12
5 Europe_Non_… regional biomassOil  regional biomassOil   OilPalm
regional biomassOil  2090      7.37e- 2
6 Europe_Non_… regional biomassOil  regional biomassOil   Soybean
DDGS and feedcakes   2090      1.85e+ 1
7 Europe_Non_… regional biomassOil  regional biomassOil   Soybean
regional biomassOil  2090      1.65e- 1
```

Approach

We simply switch to using the "absolute-cost-logit" which will always have consistent sharing, even when costs go negative. To do so we simply update `inst/extdata/energy/A21.subsector_logit.csv` accordingly.
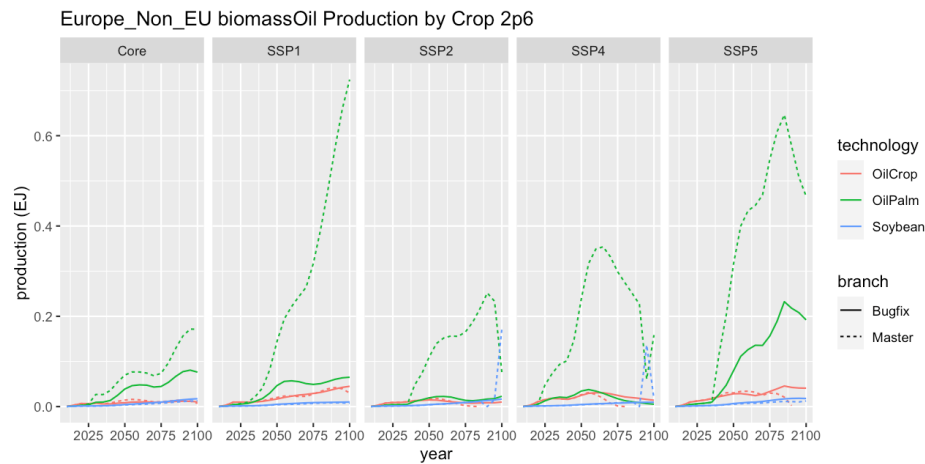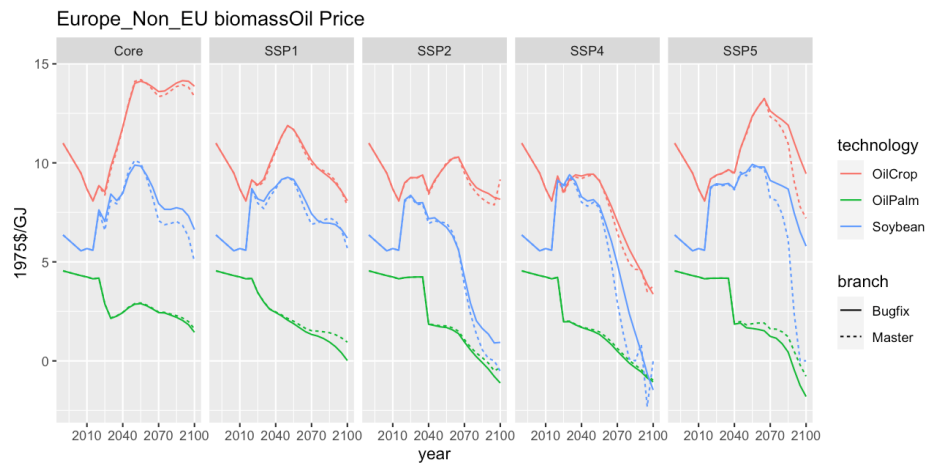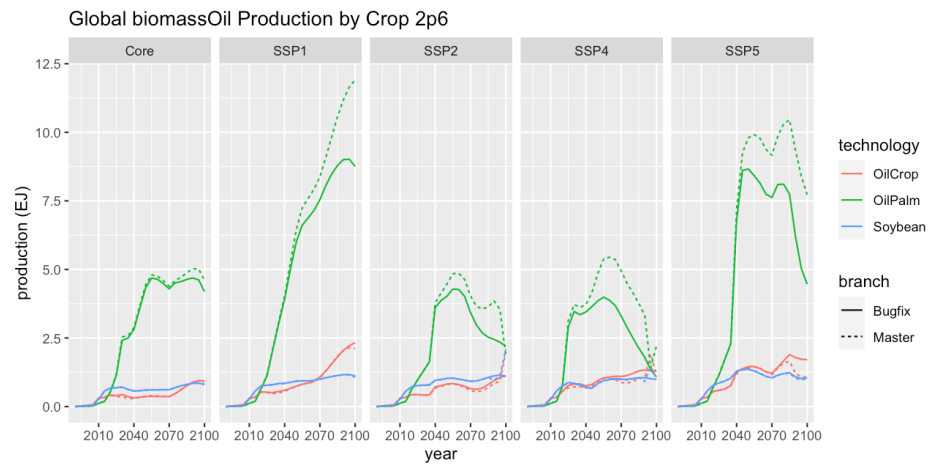
Validation

With these changes we were able to successfully solve validation run scenarios including all dispatch of all 2.6 scenarios. Given this change would really only have impact at high carbon prices we nor would expect this to help with, for instance, the high iteration counts needed to solve 2020.

Changing the logit formulation will have very negligible change in results in Reference scenarios. However, in policy scenarios where the costs of some of these biomassOil technologies can go negative there will be some change in results (Note: Master SSP 2 and 4 + 2.6 scenarios do have some solution failures near the end of the century):
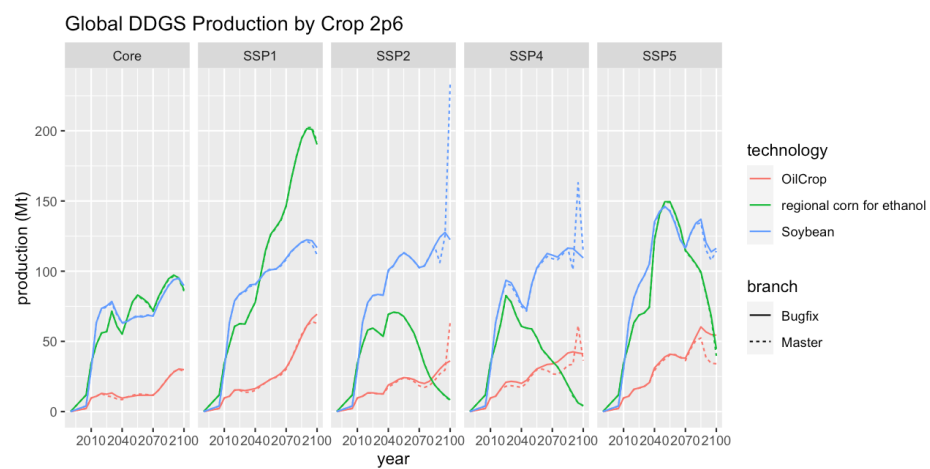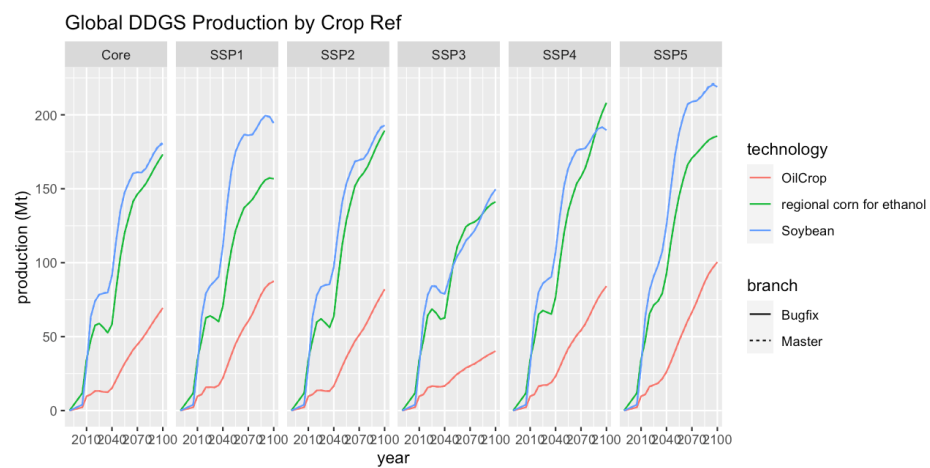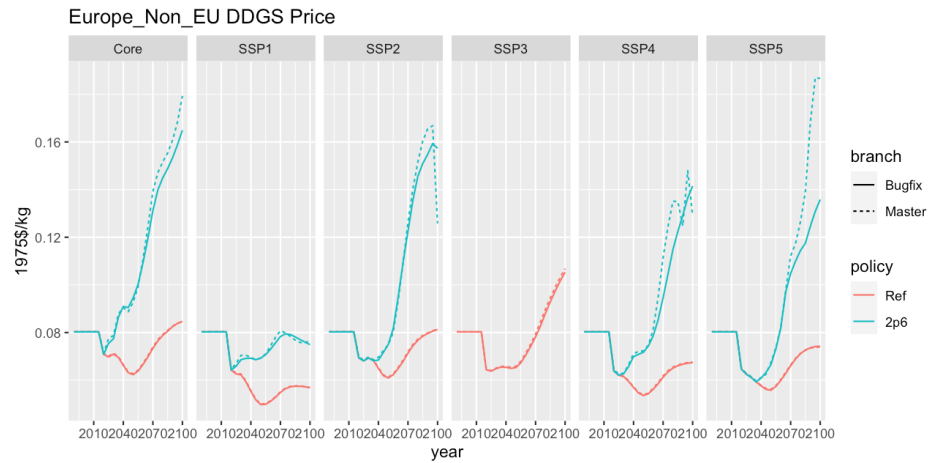
Global biomassOil Production
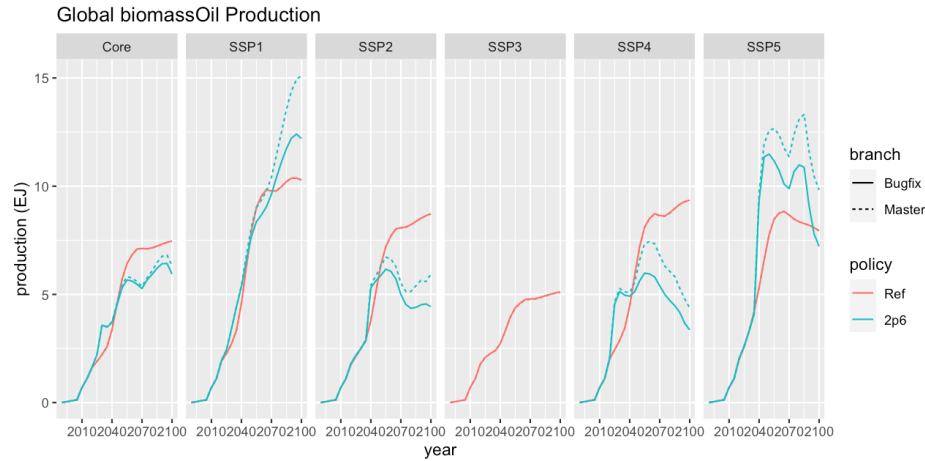
In particular we see a bit less biomassOil in the Bugfix branch in the 2.6. This is due to the non-OilPalm options now maintaining some share when the cost of OilPalm is negative:

Europe_Non_EU biomassOil Price

Europe_Non_EU biomassOil Production by Crop 2p6

Global biomassOil Production by Crop 2p6

DDGS and feedcakes results are consistent with the above:

Global DDGS Production by Crop Ref

Global DDGS Production by Crop 2p6

Europe_Non_EU DDGS Price

While this makes a difference for biomassOil, given its small share, has little impact on the energy system results more broadly:

Dotted is Old. Solid is New.

Dotted is Old. Solid is New.
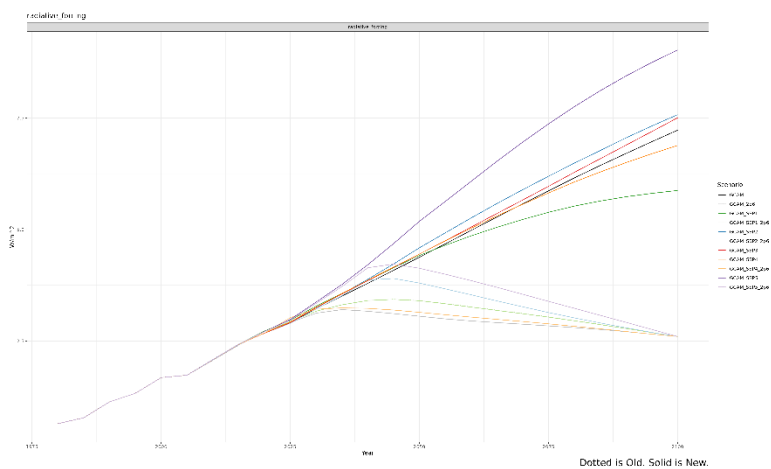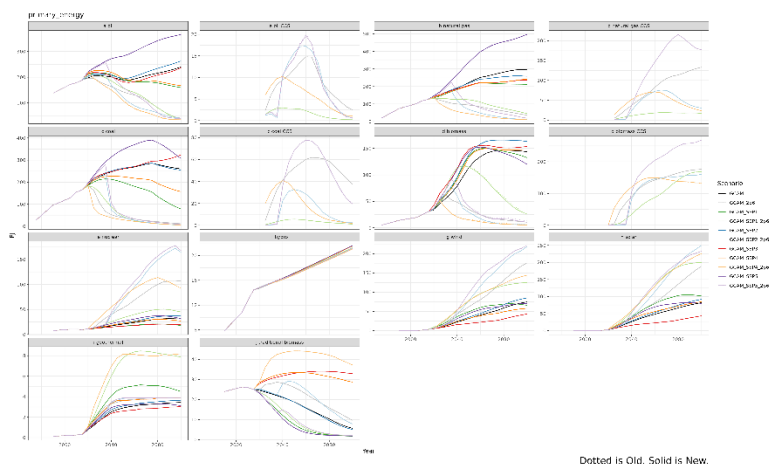
However, in terms of Ag, the demand of OilPalm from regional biomassOil is significant and thus does make a noticeable change to its land allocation for instance:

Dotted is Old. Solid is New.

Dotted is Old. Solid is New.