

# Biofuel markets

Ferike Thom

Thünen Institute of Farm Economics, Braunschweig

These lecture slides are based on the teaching material by Mihaly Himics for the same course in 2022.

# Content

1. Background
2. Biofuels in CAPRI
  1. Bioethanol and Biodiesel
  2. Supply
  3. Demand

} Concept, GAMS implementation,  
mix of biofuel inputs, mix of bio- and fossil fuels
3. Exercise: Simulate a change in the EU biofuel policy

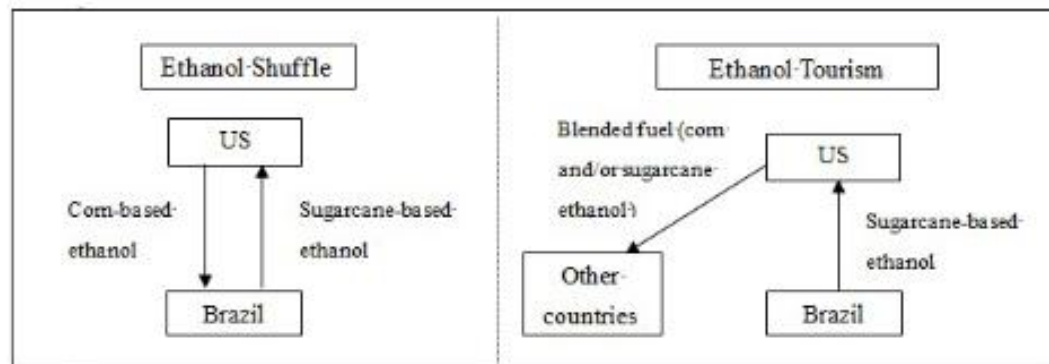
# 1. Background

- Renewable alternative to fossil fuels, but...
- Sustainability considerations:
  - Energy efficiency (scale of operations)
  - Indirect Land Use Change (ILUC) causing food price increase and loss in carbon sinks
  - Biodiversity loss from deforestation
- EU policy: Renewable Energy Directive (RED II) targets for renewable energy
  - 32% by 2030 overall
  - 14% in transport sector
  - Max. 7% share for biofuels from food crops in transport
  - Increase share of advanced biofuels
  - Sustainability criteria (e.g. certification for low ILUC-risk)



# 1. Background: Controversies

- Brazil: sugar cane based production (cost efficient); flexible fuel vehicle fleet, sugar-ethanol industry
- US: huge subsidies in the past for 1<sup>st</sup> generation biofuels (corn-based)
- Policy-driven demand with distorted markets: “Ethanol tourism” between Brazil and USA



Yano et al., 2012

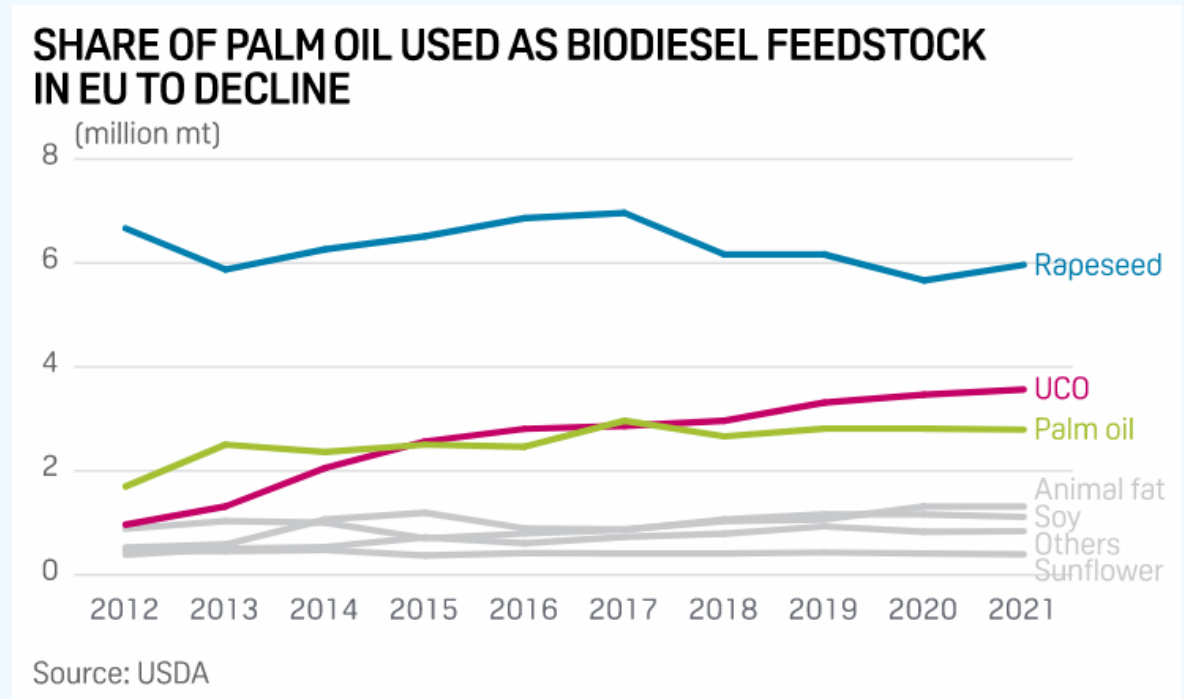
# 1. Background: Controversies

- Food Security: Did biofuel expansion play a role in 2007/08 food spikes?

*The importance of expanded production of biofuels.*<sup>8</sup> Estimates of the contribution of increased demand for biofuels, in particular ethanol in the USA,<sup>9</sup> to the price spike vary from a negligible 3% to an overwhelming 75%. The former estimate was derived by estimating the effect on maize prices, in which

# 1. Background: Controversies

- In Europe: Biodiesel is relatively more important
- Cost efficiency issues relative to the US and Brazil
- Induced deforestation
- palm-oil based biodiesel



# Content

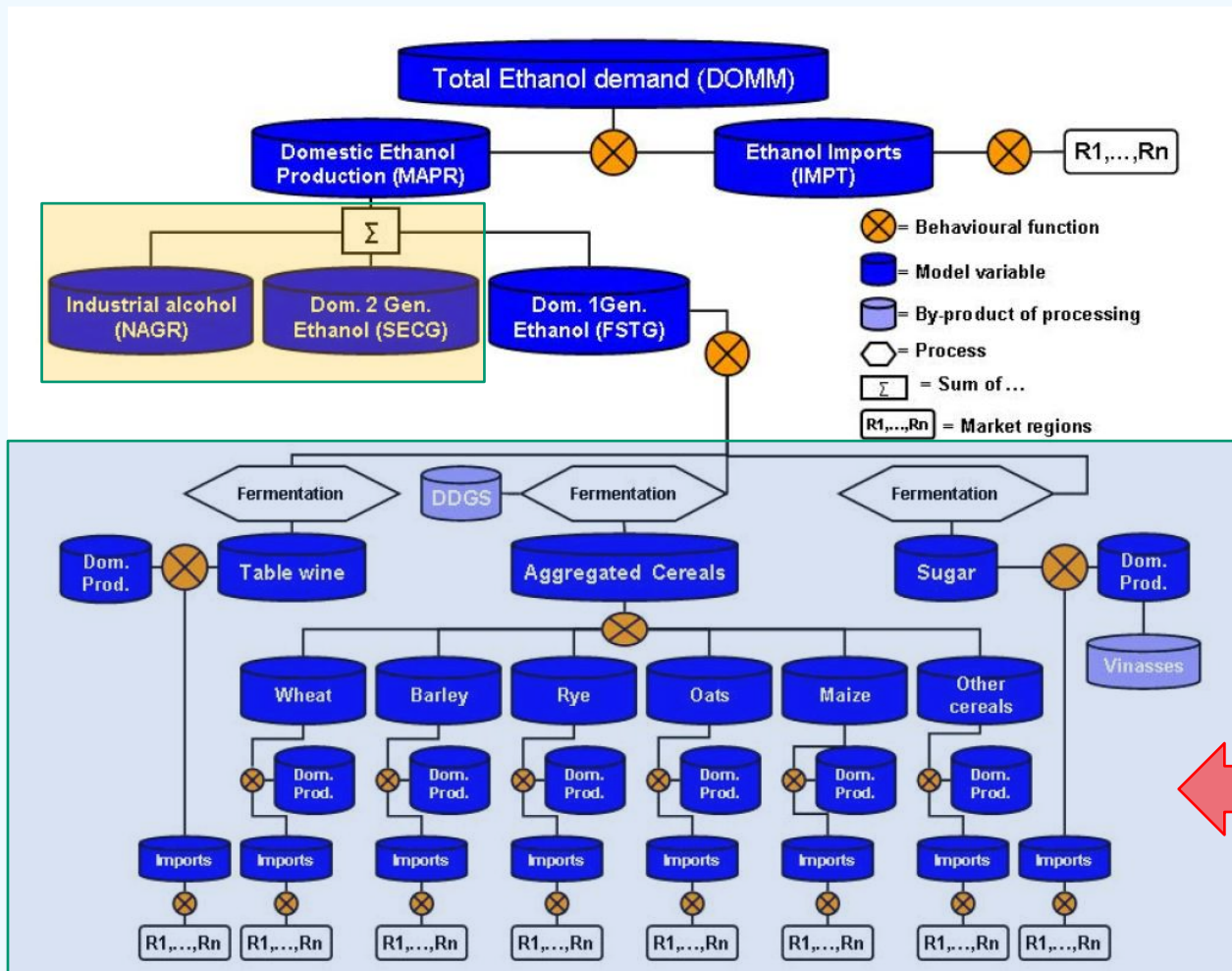
1. Background
2. Biofuels in CAPRI
  1. Bioethanol and Biodiesel
  2. Supply
  3. Demand

} Concept, GAMS implementation,  
mix of biofuel inputs, mix of bio- and fossil fuels
3. Exercise: Simulate a change in the EU biofuel policy

## 2. Biofuels in CAPRI

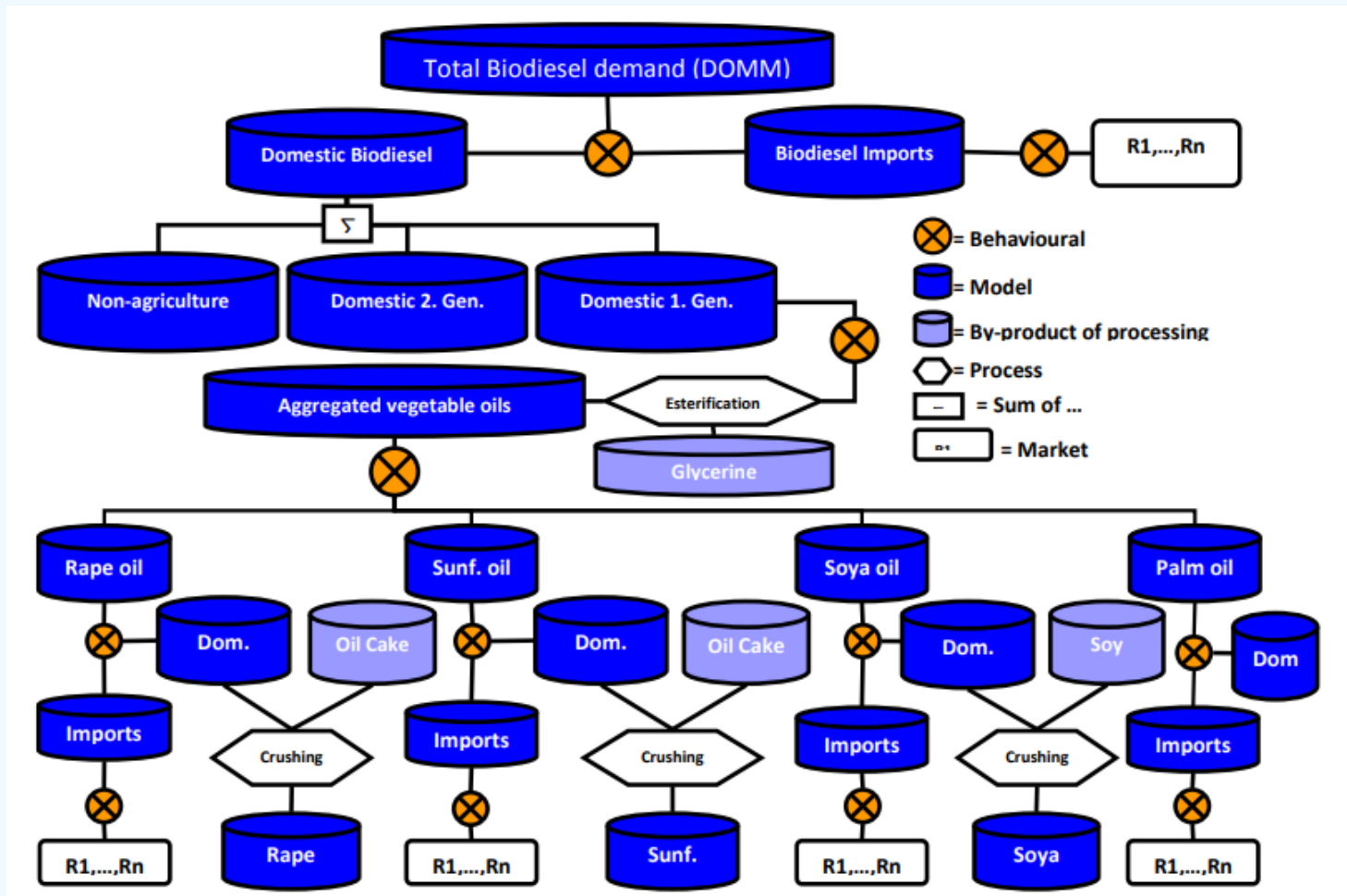
- Bioethanol and biodiesel
- Endogenously modelled demand for biofuels in the transportation sector
- Processing: 1<sup>st</sup> generation biofuels linked to optimal feedstock mix
- By-products:
  - Distilled Dried Grains with Solubles (DDGS) – animal feed
  - Glycerine – chemical industry

# 2.1 The ethanol market in CAPRI



Becker, 2011

# 2.1 The biodiesel market in CAPRI



Becker, 2011

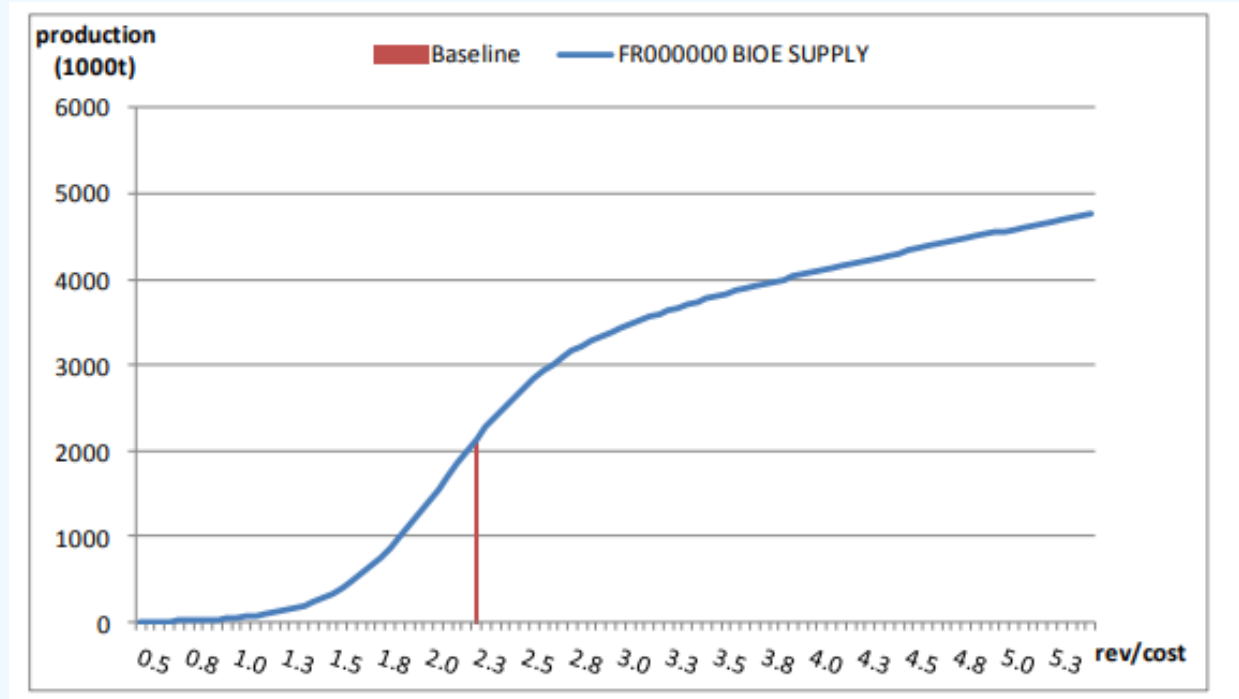
# Content

1. Background
2. Biofuels in CAPRI
  1. Bioethanol and Biodiesel
  2. Supply
  3. Demand

} Concept, GAMS implementation,  
mix of biofuel inputs, mix of bio- and fossil fuels
3. Exercise: Simulate a change in the EU biofuel policy

# 2.2 Biofuel production in CAPRI

- Concept on first generation biofuel production  
Biofuel price vs. average cost of biofuel feedstock drives supply

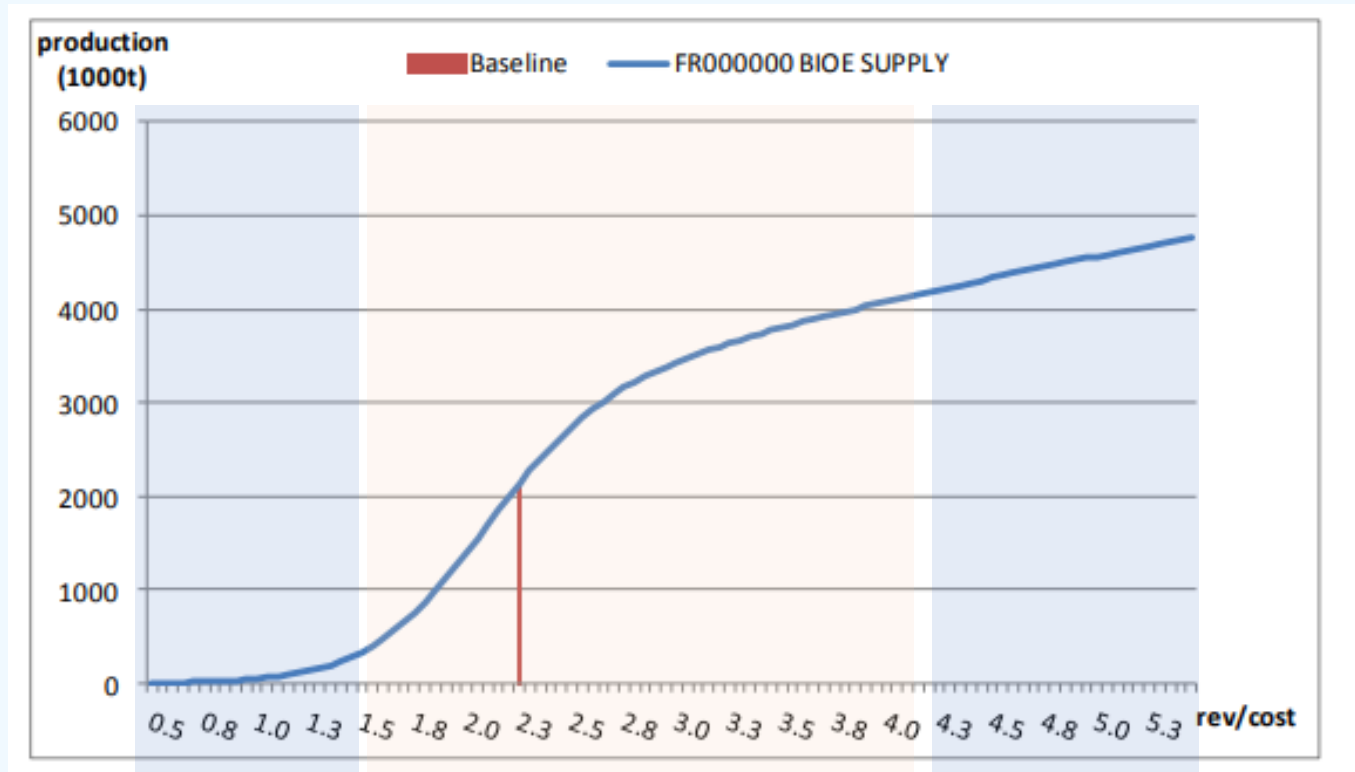


Biofuel supply  
function in France

Blanco et al., 2013

# 2.2 Biofuel production in CAPRI

- Synthetic function with three parts



Biofuel supply

function in France

Blanco et al., 2013

linear

sigmoid

semi-log

## 2.2 Biofuel production in CAPRI

- Synthetic function with three parts: linear, sigmoid and semi-log

gams/arm/market\_model.gms l. 1180

```
SupplyBiof_(RMS,XXBIOF) $      ( DATA(RMS,"BiofPriceRel",XXBIOF,"CUR")
                                $ (SUM(Stock_to_Fuel(XBioStock,XXBioF),
                                      DATA(RMS,"BIOF",XBioStock,"CUR")*DATA(RMS,"PRCB",XBioStock,"CUR"))))
                                $ ((v_prodBiof.lo(RMS,XXBioF) ne v_prodBiof.up(RMS,XXBioF)) or p_trim)
                                $ (v_prodQuant.lo(RMS,XXBioF) ne v_prodQuant.up(RMS,XXBioF))
                                $ DATA(RMS,"PROD",XXBIOF,"CUR")
                                $ XXX1(XXBIOF)
                                $ p_endoBioMarket
                                ) ..

v_prodBiof(RMS,XXBioF)/(DATA(RMS,"Prod",XXBioF,"CUR")+0.1)
=E=
*      --- small linear term to avoid zero production and zero slope..
*      (p_bioSupPar(RMS,XXBIOF,"scale")*v_biofPriceRel(RMS,XXBIOF)
*      --- double log part
*      + exp(p_bioSupPar(RMS,XXBIOF,"alfa") + p_bioSupPar(RMS,XXBIOF,"beta")*log(v_biofPriceRel(RMS,XXBIOF)+1e-2))
*      --- multiplied to sigmoid function that guarantees steeper slope
*          * SIGMOID(p_bioSupPar(RMS,XXBIOF,"SLOPE")
*              *(v_biofPriceRel(RMS,XXBIOF)
*                -p_bioSupPar (RMS,XXBIOF,"Turn"))))/(DATA(RMS,"Prod",XXBioF,"CUR")+0.1);
```

## 2.2 Biofuel production in CAPRI

- Total biofuel production = sum of
  - first generation,
  - second generation (SECG),
  - non-agricultural (NAGR),
  - and agricultural not covered explicitly (EXOG)

gams/arm/market\_model.gms l. 1208

```
MaprBiof_(RMS,XXBioF) $ ((SUM(SAMEAS(XXX,XXBIOF),1)
                        $ (v_prodQuant.lo(RMS,XXBioF) ne v_prodQuant.up(RMS,XXBioF)))
                        $ DATA(RMS,"Prod",XXBioF,"CUR")
                        $ XXX1(XXBIOF) )..

v_prodQuant(RMS,XXBioF)/(DATA(RMS,"Prod",XXBioF,"CUR")+0.1)
=E=
    (
      v_prodBiof(RMS,XXBioF)
      + DATA(RMS,"NAGR",XXBioF,"CUR")
      + DATA(RMS,"SECG",XXBioF,"CUR")
      + DATA(RMS,"EXOG",XXBioF,"CUR"))/(DATA(RMS,"Prod",XXBioF,"CUR")+0.1);
```

## 2.2 Biofuel production in CAPRI

- Only 1<sup>st</sup> generation is endogenous and linked to feedstock in CAPRI (crops modelled endogenously)

gams/arm/market\_model.gms l. 1010

```
MaprBiof_(RMS,XXBioF) $ ((SUM(SAMEAS(XXX,XXBIOF),1)
    $ (v_prodQuant.lo(RMS,XXBioF) ne v_prodQuant.up(RMS,XXBioF)))
    $ DATA(RMS,"Prod",XXBioF,"CUR")
    $ XXX1(XXBIOF) )..

v_prodQuant(RMS,XXBioF)/(DATA(RMS,"Prod",XXBioF,"CUR")+0.1)
=E=
    (
    +   v_prodBiof(RMS,XXBioF)
    +   DATA(RMS,"NAGR",XXBioF,"CUR")
    +   DATA(RMS,"SECG",XXBioF,"CUR")
    +   DATA(RMS,"EXOG",XXBioF,"CUR"))/(DATA(RMS,"Prod",XXBioF,"CUR")+0.1);
```

## 2.2 Biofuel production in CAPRI

- Processing of individual feedstocks and optimal mix

STOCK_TO_FUEL(ROWS, *)		
	BIOE	BIOD
SWHE	Y	
RYEM	Y	
BARL	Y	
OATS	Y	
MAIZ	Y	
OCER	Y	
TWIN	Y	
WHEA	Y	
SUGA	Y	
RAPO		Y
SUNO		Y
SOYO		Y
PLMO		Y
OTHO		Y

Biofuel Feedstock (crops)  
Imported raw material included

## 2.2 Biofuel production in CAPRI

- Processing of individual feedstocks and optimal mix

gams/arm/market\_model.gms l. 1362

```
v_biofProcQuant(RMS,XX)/(DATA(RMS,"Biof",XX,"CUR")+0.1)
=E= [
    SUM(Stock_to_fuel(XX,XXBiof),
*
*      ---- a share of output production quantity
*
*      p_dpCESBiof(RMS,XX) * v_prodBiof(RMS,XXBioF)
*
*      ---- times output prices divided by feedcost cost
*      exponent the substiution elasticity
*
*      * (v_biofFeedCost(RMS,XXBIOF) / v_biofFeedCost(RMS,XX)) ** p_rhoBioFuel(RMS,XXBIOF)
    )
]/(DATA(RMS,"Biof",XX,"CUR")+0.1);
```

Biofuel average (xxbiof) versus individual feedstock (xx)

## 2.2 Biofuel production in CAPRI

- Biofuel feedstock balance
- Sum of all feedstock processing = (price-driven) biofuel production

gams/arm/market\_model.gms l. 1227

```
prodBiof_(RMS,XXBioF) $ (  
    (SUM(Stock_to_fuel(YbioStock,XXBioF), DATA(RMS,"BioF",YbioStock,"CUR")) GT 1)  
*    --- the numerarie is not fixed  
    $ (NOT SUM(BIOF_NUM(RMS,XXBioF,XX) $ (v_BiofProcQuant.LO(RMS,XX) EQ v_biofProcQuant.UP(RMS,XX)),1))  
*  
    --- at least one feedstock in data base  
    $ SUM(Stock_to_fuel(XXX,XXBioF) $ (DATA(RMS,"PRCB",XXX,"CUR") $ DATA(RMS,"BioF",XXX,"CUR")),1)  
    $ DATA(RMS,"Prod",XXBioF,"CUR")) ..  
  
v_prodBiof(RMS,XXBioF)/(DATA(RMS,"Prod",XXBioF,"CUR")+0.1) =E=  
  
    SUM(Stock_to_fuel(XX,XXBioF) $ (DATA(RMS,"PRCB",XX,"CUR") $ DATA(RMS,"BioF",XX,"CUR")),  
        v_biofProcQuant(RMS,XX) * DATA(RMS,"PRCB",XX,"CUR"))  
    /(DATA(RMS,"Prod",XXBioF,"CUR")+0.1);  
*
```

↑  
Processing coefficient

## 2.2 Biofuel production in CAPRI

- Biofuel cost index (average)

gams/arm/market\_model.gms l. 1286

```
v_bioFeedCost (RMS, XXBIOF)
  / (DATA (RMS, "BioFeedCost", XXBIOF, "CUR")+1)
  =E=

  SUM (Stock_to_fuel (XBioStock, XXBiof) $ p_dpCesBiof (RMS, XBioStock),
        p_dpCesBiof (RMS, XBioStock) *
        (v_bioFeedCost (RMS, XBioStock) / (data (RMS, "BioFeedCost", XXBIOF, "CUR")+1))
        ** (1-p_rhoBioFuel (RMS, XXBiof))
        ) ** (1/(1-p_rhoBioFuel (RMS, XXBiof)));
```

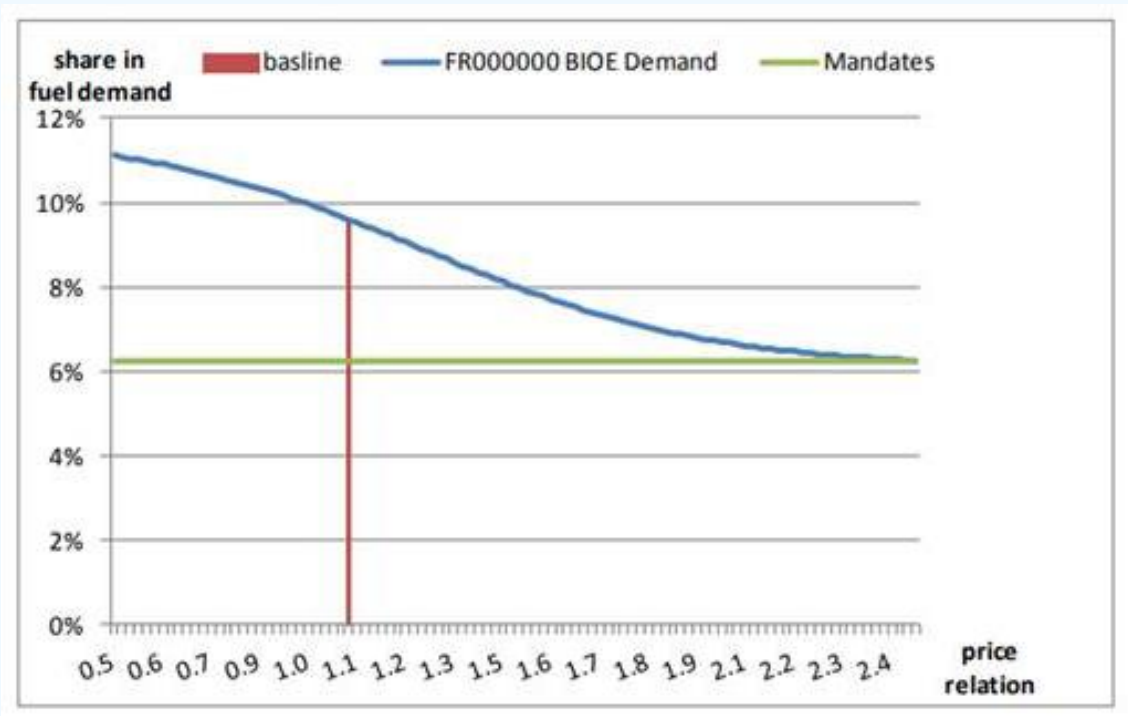
# Content

1. Background
2. Biofuels in CAPRI
  1. Bioethanol and Biodiesel
  2. Supply
  3. Demand

} Concept, GAMS implementation,  
mix of biofuel inputs, mix of bio- and fossil fuels
3. Exercise: Simulate a change in the EU biofuel policy

## 2.3 Biofuel demand in CAPRI

- Share of biofuel in total fuel use. Sigmoid function.
- Total fuel demand exogenous



Biofuel demand  
share in France

Blanco et al., 2013

# 2.3 Biofuel demand in CAPRI

fuelMatch(XXBioF, FUEL\_ROWS): mapping of biofuels to fossil substitute

BIOE	GASL	Y
BIOD	DISL	Y

gams/arm/market\_model.gms l. 1387

```

biofDemShare_(RMS,XXBIOF) $ (
    SUM(fuelMatch(XXBioF,Fuel_Rows), Data(RMS,"CPRI",fuel_rows,"CUR"))
    $ p_bioDemPar(RMS,XXBioF,"Slope")
    $ sum(sameas(XXX,XXBioF),1)
    $ (v_biofProcQuant.range(RMS,XXBIOF) ne 0)
    $ ((v_consShareBioF.range(RMS,XXBIOF) NE 0) or p_trim)
    $ xxx1(XXBIOF)
    $ DATA(RMS,"BIOF",XXBIOF,"CUR")
    $ p_endoBioMarket)..

v_consShareBioF(RMS,XXBioF) =E=
*
*   --- fixed share (= blending quota relative)
*
*   Data(RMS,"QUTS",XXBIOF,"CUR")
*
*   -- sigmoid function, assumes that rather small shares are used even at high prices,
*   "TURN" reflects the quota
*
+ (SIGMOID(p_bioDemPar(RMS,XXBioF,"Slope")
    *(v_consprice(RMS,XXBIOF) / SUM(fuelMatch(XXBioF,Fuel_Rows), Data(RMS,"CPRI",fuel_rows,"CUR"))
    -p_bioDemPar(RMS,XXBioF,"Turn")))*p_bioDemPar(RMS,XXBioF,"Max");

```

← mandate

← relative price →

## 2.3 Biofuel demand in CAPRI

- Total use in the country = consumption + feed use + processing + biofuel processing
- Biofuel processing is handled separately from other processing industries
- other industrial use of ethanol is booked under general processing (v\_procQuant)

## 2.3 Biofuel demand in CAPRI

- Total use in the country = consumption + feed use + processing + biofuel processing

gams/arm/market\_model.gms l. 2596

```
ArmBal1_(RM,XXX) $ (v_arm1Quant.lo(RM,XXX) ne v_arm1Quant.up(RM,XXX)) ..
*
* --- total domestic consumption for a trade block
*
v_arm1Quant(RM,XXX) / (DATA(RM,"arm1",XXX,"CUR") $ (not p_trim) + 1 $ p_trim + 0.1)
=E= SUM(RMS_TO_RM(RMS,RM),
*   --- human consumption
*     v_consQuant(RMS,XXX)      $ DATA(RMS,"HCon",XXX,"CUR")
*   --- feed use
*     + v_feedQuant(RMS,XXX)    $ DATA(RMS,"Feed",XXX,"CUR")
*   --- explicit processing demand (cakes)
*     + v_procQuant(RMS,XXX)   $ DATA(RMS,"Proc",XXX,"CUR")
*   --- demand for biofuel processing
*     + v_biofProcQuant(RMS,XXX) $ (DATA(RMS,"BioF",XXX,"CUR")
*
*                                     --- in case of sguar market quotas, C-sugar is supposed to
*                                     be used for biofuels, and has its own market clearing
*                                     $ ( (not sameas(XXX,"SUGA")) or (data(RMS,"QUTS","SUGA","CUR") le eps)))
*
* ) / ( DATA(RM,"Arm1",XXX,"CUR") $ (not p_trim)
*     + 1 $ p_trim + 0.1);
```

Other industrial use  
Biofuels in transportation

# Content

1. Background
2. Biofuels in CAPRI
  1. Bioethanol and Biodiesel
  2. Supply
  3. Demand

} Concept, GAMS implementation,  
mix of biofuel inputs, mix of bio- and fossil fuels
3. Exercise: Simulate a change in the EU biofuel policy

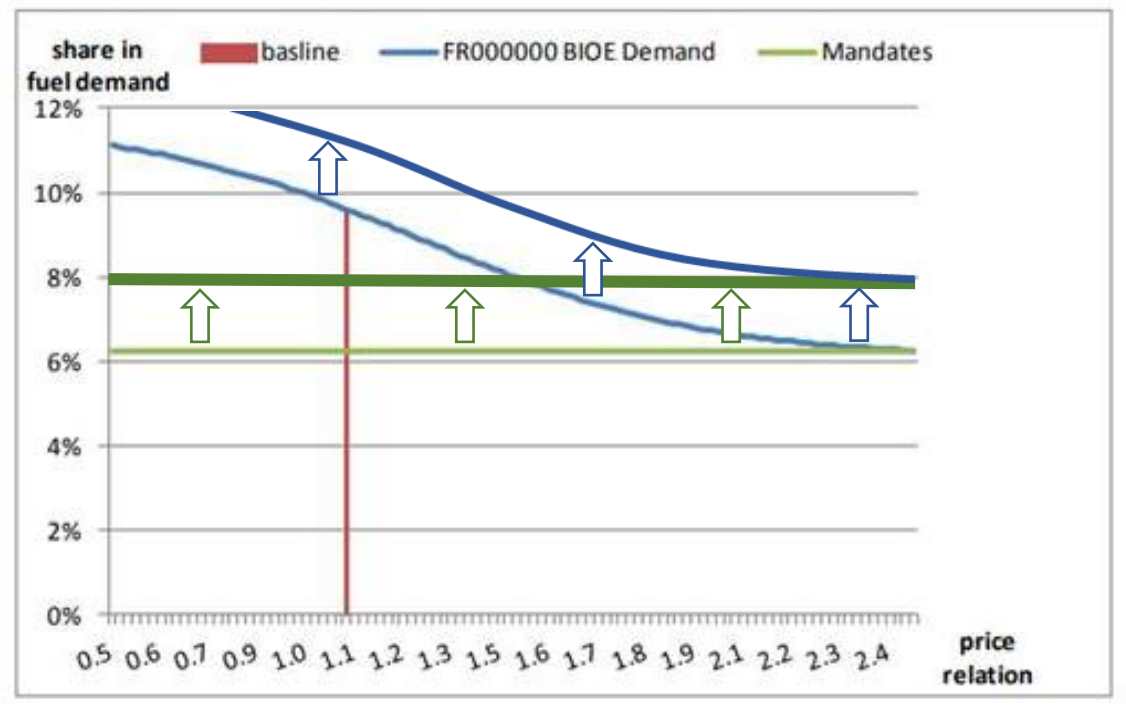
# 3. Exercise

- Increase mandate in order to 'push-up' total biofuel demand

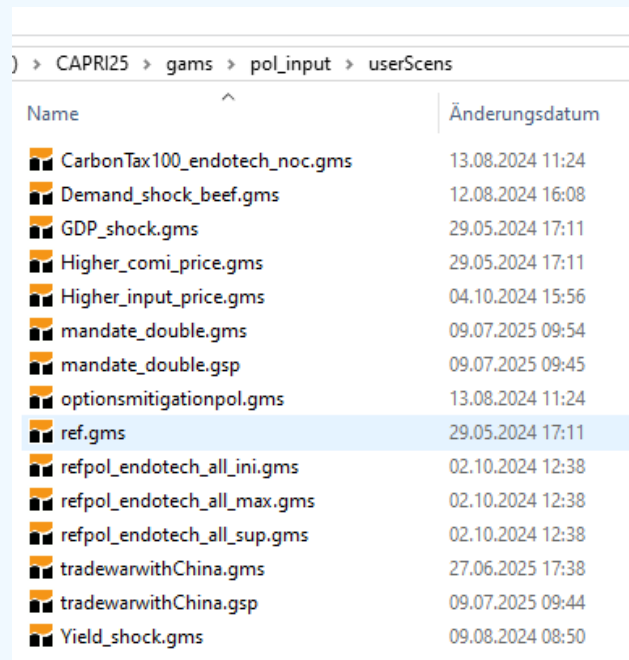
Data(RMS, "QUTS", XXBIOF, "CUR")

Biofuel demand share in France

Blanco et al., 2013



# 3. Exercise: Reference file



The screenshot shows a file explorer window with the following path: CAPRI25 > gams > pol\_input > userScens. The table below lists the files and their modification dates.

Name	Änderungsdatum
CarbonTax100_endotech_noc.gms	13.08.2024 11:24
Demand_shock_beef.gms	12.08.2024 16:08
GDP_shock.gms	29.05.2024 17:11
Higher_comi_price.gms	29.05.2024 17:11
Higher_input_price.gms	04.10.2024 15:56
mandate_double.gms	09.07.2025 09:54
mandate_double.gsp	09.07.2025 09:45
optionsmitigationpol.gms	13.08.2024 11:24
ref.gms	29.05.2024 17:11
refpol_endotech_all_ini.gms	02.10.2024 12:38
refpol_endotech_all_max.gms	02.10.2024 12:38
refpol_endotech_all_sup.gms	02.10.2024 12:38
tradewarwithChina.gms	27.06.2025 17:38
tradewarwithChina.gsp	09.07.2025 09:44
Yield_shock.gms	09.08.2024 08:50

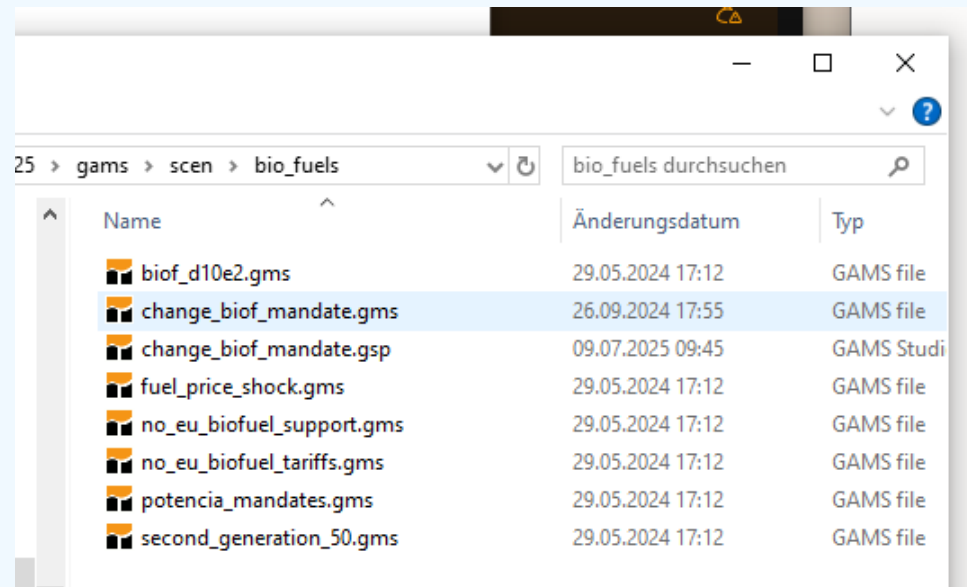
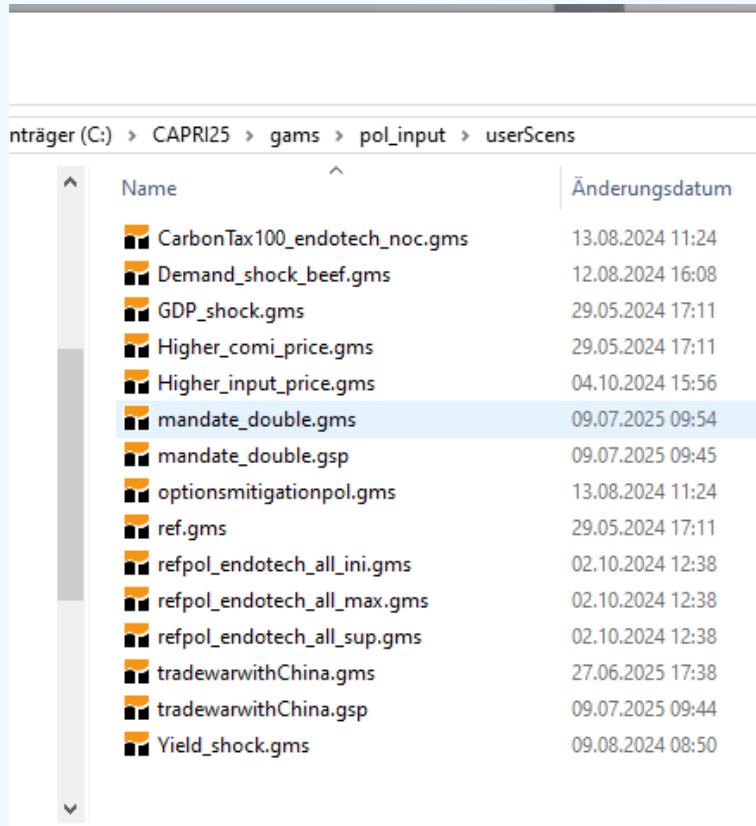
# 3. Exercise: Reference file

The screenshot displays the CAPRI TS 2024 software interface, divided into several sections:

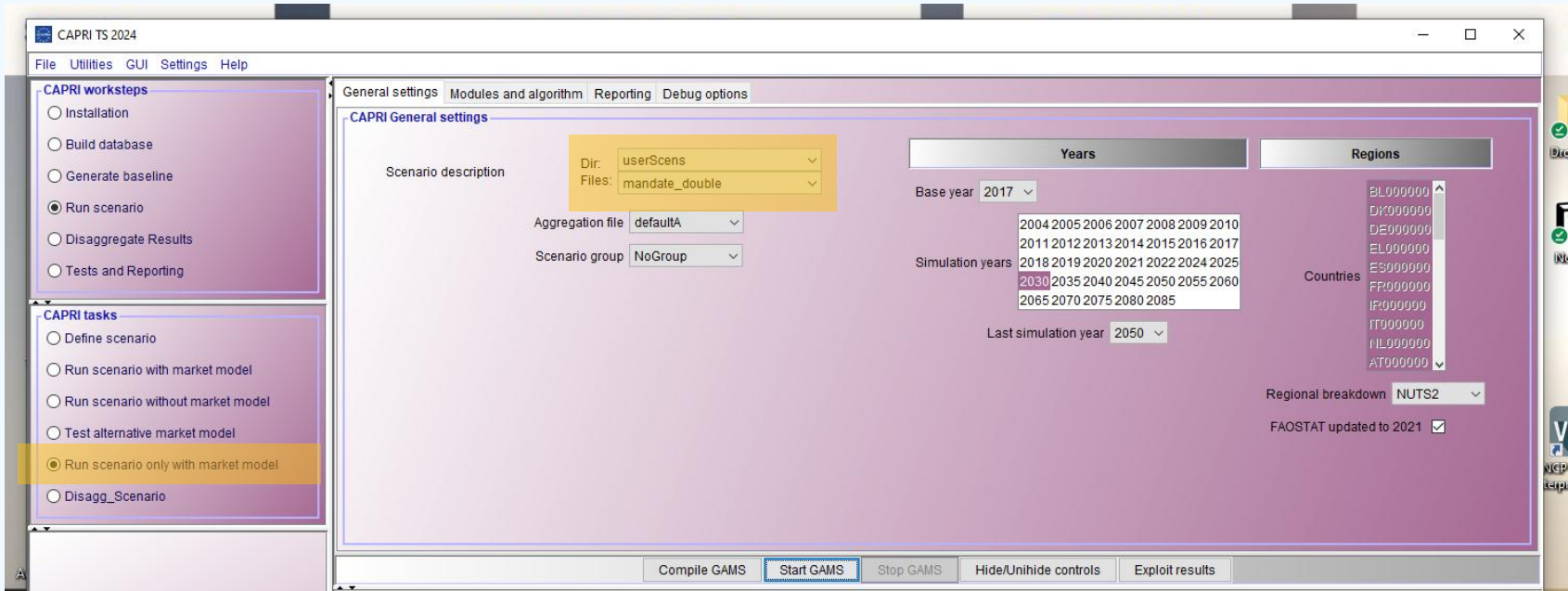
- General settings (CAPRI General settings):**
  - Scenario description: Dir: userScens, Files: ref
  - Aggregation file: defaultA
  - Scenario group: NoGroup
  - Base year: 2017
  - Simulation years: 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2024, 2025, 2030, 2035, 2040, 2045, 2050, 2055, 2060, 2065, 2070, 2075, 2080, 2085
  - Last simulation year: 2050
  - Regions: BL000000, DK000000, DE000000, EL000000, ES000000, FR000000, IP000000, IT000000, NL000000, AT000000
  - Countries: (List of country codes)
  - Regional breakdown: NUTS2
  - FAOSTAT updated to 2021:
- Market model:**
  - Maximum number of pre-steps market model: 15
  - Solution print at preparatory solve:
  - Abort after preparatory solve:
  - Solution print for pre-steps in 1st iteration with abort:
  - Plus iterlim to zero for 1st pre-steps in 1st iteration:
  - Number of presteps before abort: 1
  - Kill simini file:
  - Unload market data to.gdx for evaluation after solving:
- Buttons:** Compile GAMS, Start GAMS, Stop GAMS, Hide/Unhide controls, Exploit results

... or download from the website  
and store in Reference file  
3. Exercise  
.../output/results/capmod

# 3. Exercise: Scenario



# 3. Exercise: Scenario



# 3. Exercise: Scenario

... or download from the website  
and store in  
.../output/results/capmod

# 3. Exercise: Scenario

```
GAMS Studio
File Edit GAMS MIRO Tools View Help
change_biof_mandate.gms mandate_double.gms market_model.gms
1 *****
2 *
3 *   author           : undefined
4 *   date            : 22-09-2023 16:19:01
5 *   purpose         : Scenario definition
6 *
7 *****
8 *
9 * User supplied description :
10 *
11 * double biofuel mandates in EU countries
12 *****
13 $setglobal SCENDES double biofuel mandates in EU countries
14 *
15 *   Baseline scenario
16 *
17 $INCLUDE "pol_input\userScens\ref.gms"
18 *
19 *   Biofuel modifications, set the mandates to almost zero for all regions in the EU27 without UK the unit is 1.000 tones
20 *
21 set RCountrieswithBioFuelPolicy(RALL);
22   RCountrieswithBioFuelPolicy(RALL)$(RMS_TO_RM(RALL,"A_EU_WEST") or RMS_TO_RM(RALL,"A_EU_EAST")) = YES;
23
24 display RCountrieswithBioFuelPolicy;
25
26 DATA(RCountrieswithBioFuelPolicy,"QUTS",XXBIOF,"AbsoluteLevel")$(DATA(RCountrieswithBioFuelPolicy,"QUTS",XXBIOF,"CUR"))
27   = DATA(RCountrieswithBioFuelPolicy,"QUTS",XXBIOF,"CUR") * 2;
28
29
```

# 3. Exercise: Scenario

Policy  
scenario

```
GAMS Studio
File Edit GAMS MIRO Tools View Help
change_biof_mandate.gms | mandate_double.gms | market_model.gms
1 *****
2 $ontext
3
4   CAPRI project
5
6   GAMS file : change_biof_mandate.gms
7
8   @purpose  : increase/decrease biofuel mandates uniformly for all EU Member States
9
10  @author   : Mihaly Himics
11  @date    : 14.10.19
12  @since   :
13  @refDoc  :
14  @seeAlso :
15  @calledBy :
16
17 $offtext
18 *****
19 |
20
21 *
22 * ---  push upwards the sigmoid function for the biofuel share in total fuel demand
23 *      see equation biofDemShare_ for more details
24 *
25
26
27 *
28 * ---  take over shock from the main scenario file
29 *
30
31 $setlocal mandate_shock $!
32
33 set RCountrieswithBioFuelPolicy(RALL);
34 RCountrieswithBioFuelPolicy(RALL)$ (RMS_TO_RM(RALL,"EU_WEST") or RMS_TO_RM(RALL,"EU_EAST")) = YES;
35 display RCountrieswithBioFuelPolicy;
36
37 DATA(RCountrieswithBioFuelPolicy,"QUTS",XXBIOF,"AbsoluteLevel") $(DATA(RCountrieswithBioFuelPolicy,"QUTS",XXBIOF,"CUR"))
38 = DATA(RCountrieswithBioFuelPolicy,"QUTS",XXBIOF,"CUR") * %mandate_shock%;
39
C:\CAPRI25\gams\scen\bio_fuel\change_biof_mandate.gms Navigator: type '?' for help. 43 lines 19 / 1 INS UTF-8
```

# 3. Exercise: Analyze results in GUI

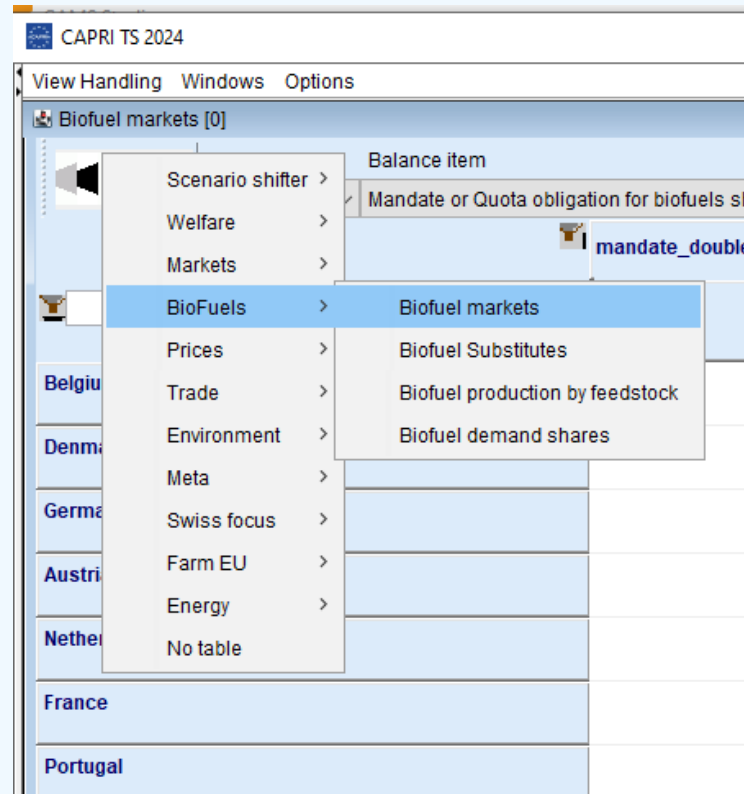
The screenshot displays the CAPRI TS 2024 software interface. On the left, a sidebar contains 'CAPRI worksteps' and 'CAPRI tasks'. The main area is titled 'exploitation' and includes a 'Regional Aggregation' dropdown menu, a 'Regional level' input field set to '029', and a 'Base year selection' dropdown menu with '0408101217' selected. Below these are 'Country selection' and 'Start year selection' lists. On the right, a table lists 16 scenarios, with the first two highlighted in yellow. A 'Select scenarios' button is located at the bottom right.

Scenario	Configuration
Scenario 1	res_2_1730userScens_ref_MMonlydefaultA
Scenario 2	res_2_1730userScens_mandate_double_MMonlydefaultA
Scenario 3	
Scenario 4	
Scenario 5	
Scenario 6	
Scenario 7	
Scenario 8	
Scenario 9	
Scenario 10	
Scenario 11	
Scenario 12	
Scenario 13	
Scenario 14	
Scenario 15	
Scenario 16	

Load results for reference and scenario

# 3. Exercise: Analyze results in GUI

- Check if scenario shock is correctly transmitted
- Find the right table



# 3. Exercise: Analyze results in GUI

- Check if scenario shock correctly transmitted

The screenshot shows the CAPRI TS 2024 interface. The main window displays a table of biofuel market data for the year 2030. The table is titled 'Biofuel markets [0]' and shows the 'Mandate or Quota obligation for biofuels share in total transportation fuel use [% of energy content]' for various countries. The data is presented in a table format with columns for 'Year', 'Balance item', and 'Percentage diff. to Scen ref\_MMonlydefaultA'. The 'Balance item' column is further divided into 'Bio diesel' and 'Bio ethanol'.

Year	Balance item	Percentage diff. to Scen ref_MMonlydefaultA	
2030	Mandate or Quota obligation for biofuels share in total transportation fuel use [% of energy content]		
	mandate_double_MMonlydefaultA		
	Bio diesel	Bio ethanol	
Belgium	16.69	13.54	
	100.00%	100.00%	
Denmark	15.06	18.33	
	100.00%	100.00%	
Germany	15.37	15.46	
	100.00%	100.00%	
Austria	14.12	12.13	
	100.00%	100.00%	
Netherlands	12.39	11.51	
	100.00%	100.00%	
France	16.52	14.43	
	100.00%	100.00%	
Portugal	13.16	7.24	
	100.00%	100.00%	
Spain	14.34	8.98	
	100.00%	100.00%	

# 3. Exercise: Analyze results in GUI

## a. Biofuel balances

Identify impacts on...

- Biodiesel production: \_\_\_\_\_%
- Biodiesel consumer price: \_\_\_%
- Energy share: +/- \_\_\_\_\_ percentage points

The screenshot shows the CAPRI TS 2024 interface with the following data:

	Bio diesel	Bio ethanol
Total Biofuel production [1000 t]	22482.45 36.54%	9271.59 43.12%
First Generation Biofuels (from Agriculture) [1000 t]	18549.60 48.01%	7738.10 56.49%
Second Generation Biofuels [1000 t]	1720.98 0.00%	1214.03 0.00%
Biofuels from non-agricultural sources [1000 t]	2211.87 0.00%	319.46 0.00%
Biofuel-use by transport sector [1000 t]	25770.77 78.22%	9166.90 83.59%
Biofuel-use by industry [1000 t]		
Energy share of biofuels in total transportation fuel use [% of energy content]	14.76 78.90%	11.85 81.01%
Mandate or Quota obligation for biofuels share in total transportation fuel use [% of energy content]	14.44 94.50%	11.70 98.59%
Imports [1000 t]	8529.50 107.18%	1822.23 140.17%
Exports [1000 t]	5197.43 -15.11%	167.72 -65.77%
consumer prices [Euro/ton]	1087.07 26.71%	1466.02 30.71%
consumer taxes [Euro/ton]	58.24 0.34%	120.55 0.23%

# 3. Exercise: Analyze results in GUI

## b. Biofuel feedstock

The screenshot shows the CAPRI TS 2024 interface. The main window displays 'Biofuel markets [0]' for the 'European Union' region. A context menu is open over the 'Biofuel production by feedstock' table, listing options like 'Scenario shifter', 'Welfare', 'Markets', 'BioFuels', 'Prices', 'Trade', 'Environment', 'Meta', 'Swiss focus', 'Farm EU', 'Energy', and 'No table'. The 'BioFuels' option is selected, and its sub-menu is also open, showing 'Biofuel markets', 'Biofuel Substitutes', 'Biofuel production by feedstock', and 'Biofuel demand shares'. The 'Biofuel production by feedstock' table is highlighted in blue.

Region	mandate_double_MMonlydefault	Bio ethanol
European Union	2.45	54%
(Agriculture)	18549.60	48.01%
Farm EU	1720.98	0.00%
Energy	2211.87	0.00%
Other sources	25770.77	

# 3. Exercise: Analyze results in GUI

## b. Biofuel feedstock

- Which biodiesel feedstock use increased the most in relative terms: \_\_\_\_\_
- Which biodiesel feedstock use increased the least in relative terms: \_\_\_\_\_
- Possible impact on traded feedstock?

Biofuel production by feedstock [0]	
Region: European Union	
mandate_double_MMonlydefaultA	
Bio diesel	
First generation biofuels (from Agriculture) [1000 t]	18549.60 48.01%
Second generation biofuels (from Agriculture) [1000 t]	1720.98 0.00%
First generation biofuels (from Agriculture) [1000 t]	18549.60 48.01%
- produced from cereals [1000 t]	
- produced from wheat [1000 t]	
- produced from barley [1000 t]	
- produced from rye [1000 t]	
- produced from oats [1000 t]	
- produced from maize [1000 t]	
- produced from other cereals [1000 t]	
- produced from sugar [1000 t]	
- produced from oils [1000 t]	18549.60 48.01%
- produced from rapeoil [1000 t]	10245.34 28.87%
- produced from sunfloweroil [1000 t]	1339.04 66.34%
- produced from soyoil [1000 t]	1140.00 54.36%
- produced from palmoil [1000 t]	5825.21 91.69%
- produced from exogenous crops [1000 t]	
Second generation biofuels (from Agriculture) [1000 t]	1720.98 0.00%
- produced from new energy crops [1000 t]	55.00 0.00%
- produced residuals [1000 t]	1665.98 0.00%

# 3. Exercise: Analyze results in GUI

## c. Market balances with non-EU countries

The screenshot shows the CAPRI TS 2024 interface. The main window is titled 'Biofuel production by feedstock [0]' and displays data for the year 2030. A context menu is open over the 'Markets' category, listing various options. The 'Market balances without intra trade' option is highlighted. The table below shows the results for this option, along with other categories.

Category	Value	Percentage diff. to Scen redefaultA
Market balances without intra trade	18776.04	49.81%
Yields, levels and production	1720.98	0.00%
Global irrigation	18776.04	49.81%
Global land use and land aggregates	18776.04	49.81%
Product Balances	18776.04	49.81%
Food consumption	18776.04	49.81%
Nutrition details	10326.29	29.88%
Market model balances - decomposition	1360.15	68.96%
Milk fat and protein	1151.56	55.92%
Milk products	5938.04	95.40%

# 3. Exercise: Analyze results in GUI

## c. Market balances with non-EU countries

- Larger import/smaller export of biofuel feedstock
- Can you identify sustainability issues with EU biodiesel production?

Market balances without intra trade [0]

Region: European Union | Year: 2030 | Percentage diff. to Scen ref\_MMonlydefaultA

mandate\_double\_MMonlydefaultA

	Net production [1000 t]	Human consumption plus losses [1000 t]	Processing [1000 t]	Biofuels processing [1000 t]	Feed use [1000 t]	Imports without intra trade [1000 t]	Exports without intra trade [1000 t]	Net trade [1000 t]
Rapeseed oil	3669.99 3.74%	1052.49 -2.71%	1182.56 -20.33%	10689.74 28.87%	171.58 -21.31%	9454.25 24.73%	27.88 -26.50%	-9426.37 -24.99%
Sunflower seed oil	3521.84 1.85%	2730.76 0.55%	732.70 -4.03%	1397.27 66.33%	183.89 -8.46%	1739.88 32.47%	217.11 -13.57%	-1522.77 -43.36%
Soya oil	2139.89 0.91%	902.88 -1.09%	265.11 -9.98%	1189.24 54.36%	259.05 -13.94%	924.11 25.10%	447.72 -22.86%	-476.39 -201.04%
Palm oil		275.87 0.93%	4325.22 -3.71%	6078.13 91.69%		10679.22 34.57%		-10679.22 -34.57%
Rapeseed cake	5619.64 3.24%	36.90 0.41%	119.44 5.86%		6430.22 3.20%	1114.02 3.16%	147.10 3.18%	-966.93 -3.16%
Sunflower seed cake	4382.74 1.69%	27.30 0.24%	33.76 2.91%		10064.63 0.62%	6221.26 0.05%	478.31 2.84%	-5742.95 0.17%
Soya cake	9319.45 0.68%	76.37 0.13%	139.74 1.71%		38573.98 -0.21%	30136.73 -0.45%	666.09 0.68%	-29470.64 0.48%

# Sources

- Becker, Arno (2011), Impacts of European biofuel policies on global biofuel and agricultural markets. Dissertation at Rheinische Friedrich-Wilhelms-Universität zu Bonn. <https://bonndoc.ulb.uni-bonn.de/xmlui/handle/20.500.11811/4751?locale-attribute=en>.
- Blanco, María, Adenäuer, Marcel, Shrestha, Shailesh and Becker, Arno (2013), Methodology to assess EU Biofuel Policies: The CAPRI Approach, JRC Scientific and Policy Reports. Scientific and Technical Research series –ISSN 1831-9424 (online). <https://publications.jrc.ec.europa.eu/repository/handle/JRC80037>.
- Yano, Yuki, Blandford, David and Surry, Yves R., (2012), From Ethanol Shuffle to Ethanol Tourism— Why the RFS Does Not Make Sense, Choices: The Magazine of Food, Farm, and Resource Issues, 27, issue 4, number 143189, <https://EconPapers.repec.org/RePEc:ags:aaeach:143189>.

# Advanced biofuels

## ANNEX IX

Part A. Feedstocks for the production of biogas for transport and advanced biofuels, the contribution of which towards the minimum shares referred to in the first and fourth subparagraphs of Article 25(1) may be considered to be twice their energy content:

- (a) Algae if cultivated on land in ponds or photobioreactors;
- (b) Biomass fraction of mixed municipal waste, but not separated household waste subject to recycling targets under point (a) of Article 11(2) of Directive 2008/98/EC;
- (c) Biowaste as defined in point (4) of Article 3 of Directive 2008/98/EC from private households subject to separate collection as defined in point (11) of Article 3 of that Directive;
- (d) Biomass fraction of industrial waste not fit for use in the food or feed chain, including material from retail and wholesale and the agro-food and fish and aquaculture industry, and excluding feedstocks listed in part B of this Annex;
- (e) Straw;
- (f) Animal manure and sewage sludge;
- (g) Palm oil mill effluent and empty palm fruit bunches;
- (h) Tall oil pitch;
- (i) Crude glycerine;
- (j) Bagasse;
- (k) Grape marcs and wine lees;
- (l) Nut shells;
- (m) Husks;
- (n) Cobs cleaned of kernels of corn;
- (o) Biomass fraction of wastes and residues from forestry and forest-based industries, namely, bark, branches, pre-commercial thinnings, leaves, needles, tree tops, saw dust, cutter shavings, black liquor, brown liquor, fibre sludge, lignin and tall oil;
- (p) Other non-food cellulosic material;
- (q) Other ligno-cellulosic material except saw logs and veneer logs.

Part B. Feedstocks for the production of biofuels and biogas for transport, the contribution of which towards the minimum share established in the first subparagraph of Article 25(1) shall be limited and may be considered to be twice their energy content:

- (a) Used cooking oil;
- (b) Animal fats classified as categories 1 and 2 in accordance with Regulation (EC) No 1069/2009.