GTAP-E: A Global Energy-Economy Dataset

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1 Introduction

This paper provides an overview of some GAMS programs which we have developed for working with the GTAP Version 4 dataset. These program include a reconciliation program which integrates satellite tables related to energy prices and quantities which have been developed during the past year in the collaboration with OECD/IEA.

This text file provides an overview of the GAMS tools we have developed for:

- Extraction of the GTAP data into GAMS-readable format (program SCALE.GMS)
- Adjustment of base year tax rates and filtering of small values from the trade and production data. This uses a new MCP algorithm for matrix balancing. (program CINCH.GMS)
- Flexible aggregation of GTAP datasets (GTAPAGGR.GMS)
- Introduction and reconciliation of the IEA/GERARD energy price and quantity data. (ENERGY.GMS)

2 Extracting Data from GSDDAT.HAR

GAMS program SCALE.GMS resides in the gtap.v4 subdirectory. This reads gsddat.har and writes gtapv4.zip. (The output archive is placed in the gams.dat directory.)

Steps in this program are as follows:

1. Call the GEMPACK program SEEHAR.EXE to translate gsddat.har into a GAMS-readable format. Then call REWRITE.EXE, a Fortran program which translates GSDDAT.GMS into GSDDAT.DAT. Finally, include the file GSDDAT.DAT.
2. Scale all the data, dividing by 1.0e4. All values in the model are then in terms of 10s of billions of dollars.
3. Assign parameter values which are imputed from the base year SAM, including tax rates.
4. Produce an echoprint for consistency on the original data:
    - Value of imports equals value of exports plus taxes and transport margins
    - Global investment equals the value of depreciation plus savings
    - Income equals expenditure (Walras law);
    - Zero profit in production

- Balance of payments
- Transportation services supply and demand
- Market clearance for domestic output
- Market clearance for exported output

5. Export a GAMS ZIP archive with the full dataset specified in terms of tax rates and a minimal set of base year value arrays. Note that even though this dataset is more compact than the original (4.4 vs. 6.1 MB), it contains all the same information. (The ZIP archive is named gtapv4.zip and is placed in the GAMS.DAT directory.)

```
set     i       commodities  (alias j)
        r       regions (alias s)
        f       primary factors

parameter

ty(i,r)         Output tax rate (gross basis)
ti(j,i,r)       Intermediate input tax rate (net basis)
tf(f,i,r)       Factor tax rate (net basis)
tx(i,s,r)       Export tax rate (net basis)
tm(i,s,r)       Import tariff rate (net basis)
tg(i,r)         Tax rates on government demand (net basis)
tp(i,r)         Tax rate on private demand (net basis)

vafm(j,i,r)     Aggregate intermediate inputs (domestic plus imports)
vfm(f,i,r)      Value of factor inputs (net of tax)
vxmd(i,r,s)     Value of commodity trade (fob - net export tax)
vtwr(i,r,s)     Transport services
vst(i,r)        Value of international transport sales
vdgm(i,r)       Government demand (domestic)
vigm(i,r)       Government demand (imported)
vdpm(i,r)       Private demands (domestic)
vipm(i,r)       Private demands (imported);
```

3 Sifting and Recalibration

GAMS program CINCH.GMS resides in the gams.dat subdirectory. This program is used to clear up some problems with the “raw” GTAP data. Two key issues in this procedure. First, it is necessary to eliminate all very small transactions in the benchmark dataset in order to maintain sparsity and improve numerical stability in subsequent equilibrium calculations. Second, it is helpful to be able to adjust benchmark tax rates, permiting the model builder to correct obvious errors and to impose alternative assumptions concerning base year distortions.

The program CINCH.GMS performs the following steps:

1. Read the full dataset, gtapv4.zip, using ZIP2GAMS.GMS from the Colorado LIBINCLUDE library.

2. Load intermediate arrays defined from the archive parameters:

```
vxm(i,r) = sum(s, vxmd(i,r,s));
vim(i,r) = sum(s, (vxmd(i,s,r) * (1+tx(i,s,r)) +
   vtwr(i,s,r) ) * (1+tm(i,s,r)) );
vdm(i,r) = (sum(j, vafm(j,i,r)*(1+ti(j,i,r)))
          + sum(f,  vfm(f,i,r)*(1+tf(f,i,r))))
  / (1-ty(i,r)) - vxm(i,r);
vdfm(i,r) = vdm(i,r) - vst(i,r)  - vdgm(i,r) - vdpm(i,r) - vdm(i,r)$cgd(i);
vifm(i,r) = vim(i,r) - vipm(i,r) - vigm(i,r);
```

3. Use chkeq.gms to verify consistency of the data. Each of the following five arrays should equal zero:

```
profity(r,i) = round( (vdm(i,r) + vxm(i,r)) * (1 - ty(i,r))
        - sum(j, vafm(j,i,r) * (1+ti(j,i,r)))
        - sum(f, vfm(f,i,r)*(1 + tf(f,i,r))) , 3);

profitm(r,i) = round( vim(i,r)
      - sum(s, (vxmd(i,s,r)*(1+tx(i,s,r))+vtwr(i,s,r))
      * (1+tm(i,s,r))) , 3);

marketx(r,i) = round( vxm(i,r) - sum(s, vxmd(i,r,s)) , 3);

marketm(r,i) = round( vim(i,r)
- sum(s,(vxmd(i,s,r)*(1+tx(i,s,r))+vtwr(i,s,r))
          * (1+tm(i,s,r))) , 3);

marketi(r,i) = round( vdfm(i,r) + vifm(i,r) - sum(j, vafm(i,j,r)) , 3);
```

4. Round tax rates to the nearest percentage, and round all values to the nearest $100,000.

5. Filter the data to drop small stuff. All of the following filtering steps involve the scalar parameter TOLERANCE which equals 0.001 in the central application.

   (a) Filter the Trade Matrix

   Eliminate any imports of a good into a region where the total value of imports is less than TOLERANCE times the combined value of import and domestic demand.

   Define the MAGNITUDE of a trade flow as maximum of the ratio of the trade flow net of tax to the associated aggregate export level or the trade flow gross of tax to the associated aggregate import level.

   Drop all trade flows which have MAGNITUDE less than TOLERANCE.

   Rescale remaining trade flows to maintain consistent values of aggregate imports and aggregate transport cost.

   (b) Filter the Production Matrices

   Define the MAGNITUDE of an intermediate input as the maximum of the ratio of the input value gross of tax to total cost, or the ratio of the input value net of tax to total domestic supply.

Define the MAGNITUDE of a factor input as the ratio of the factor payment gross of tax to the value of output gross of tax.

Drop all intermediate inputs and factor inputs which have MAGNITUDE less than TOLERANCE.

Even with a very small TOLERANCE (0.1%), the filtering just described generates a substantial reduction in the number of nonzeros:

```
PARAMETER DENSITY       summary of changes in matrix density

          BEFORE       AFTER

TRADE      53.074      43.357
PROD       81.942      46.824
```

(c) Filter Final Demand

Finally, we do the same thing with final demand (private and public), filtering both imports and domestic demand. We also filter inputs to the international transport activity. This simply assures that we don't have any tiny coefficients in the dataset.

6. Adjust the tax rates.

   I have tried to remove some of the most implausible tax rates. For the time being, we are simply zeroing out tax rates in some countries, because the GTAPV4 dataset has some outliers:

```
tm(i,r,"cam") = 0;
tm(i,r,"rap") = 0;
tm(i,r,"rnf") = 0;
tm(i,r,"rss") = 0;
tm(i,r,"rme") = 0;
ti(j,i,"nzl") = 0;
ti(j,i,"bra") = 0;
```

   The next statement bounds intermediate input tax rates at 250%:

```
ti(j,i,r) = min(ti(j,i,r), 2.5);
```

7. Recalibrate the Dataset

   At this point, we have made a large number of changes to the model data, and it is certain that we have introduced some inconsistencies which show up as violations of the profit and market clearance conditions defined in chkeq. For this reason, at this point we use nonlinear programming to reinstall consistency, holding the international trade matrices fixed and recalibrating each of the regional economic flows.

   This is the step where it is very helpful to use a complementarity formulation and the PATH solver, as the solution is extremely difficult with MINOS or CONOPT due to the large number of accumlated superbasics. There are some other details about how we set up the constraints and objective function which are interesting but not important for understanding the flow. The key point is that at this point we have changed some of the base year value flows to reinstate equilibrium, holding all tax rates fixed.

8. Reconstruct the input-output flows.

   For subsequent energy-related analysis, it is helpful to adopt a process-oriented representation of the oil sector. For this purpose, we route all crude oil demand flows through the refined oil sector. This involves some careful programming to assure that tax payments and all base year transactions remains constant.

9. Move the revised dataset into an archive.

   The default archive name is gtap4001.zip. If you were to change the tolerance to 0.01, then the archive name would be gtap401.zip.

4 Aggregation Tools

GTAPAGGR.GMS is a GAMS program which is driven by the batch file GTAPAGGR.BAT. The program can aggregate using input data from any GTAP model archive, including GTAPV4.ZIP if a user wants to skip the revisions introduced by CINCH. It is also possible to perform aggregation from a model archive which is itself an aggregation of a larger model.

A user must write two files to produce an aggregated dataset, MODEL.SET with set definitions, and MODEL.MAP which defines the source data archive and the correspondences between goods and regions in the source and target datasets. Here is a sample set definition file, 01.set:

```
$TITLE GTAP Public Data 3-01 (3x3) Aug96  GTAP instructional material
        SET I / food,mnfcs,svces,cgd /;
        SET R / USA,EU,ROW/;
        SET F Factors of production / LND Land, LAB Labor, CAP Capital /;
```

One restriction on disaggregation is that there must be one sector named CGD which is used as the savings good in the model.

Here is the associated mapping file, 01.map:

```
$title GTAP Public Data 3-01 (3x3) Aug96  GTAP instructional material

$SETGLOBAL source gtap4001

set mapi /
        (PDR,WHT,GRO,V_F,OSD,C_B,PFB,OCR,CTL,OAP,RMK,WOL,FRS,FSH,
         CMT,OMT,VOL,MIL,PCR,SGR,OFD,B_T).FOOD
        (OIL,GAS,OMN,TEX,WAP,LEA,LUM,PPP,P_C,CRP,NMM,I_S,NFM,FMP,
         MVH,OTN,ELE,OME,OMF).MNFCS
        (ELY,GDT,WTR,CNS,T_T,OSP,OSG,DWE).SVCES
        CGD.CGD /
    mapr /
        (AUS,NZL,JPN,KOR,IDN,MYS,PHL,SGP,THA,VNM,CHN,HKG,TWN,
         IND,LKA,RAS,CAN,MEX,CAM,VEN,COL,RAP,ARG,BRA,CHL,URY,
         RSM,SWE,FIN,EFT,CEA,FSU,TUR,RME,MAR,RNF,SAF,RSA,RSS,ROW).ROW
        USA.USA
```

```
    (GBR,DEU,DNK,REU).EU /

set ff /LND,SKL,LAB,CAP,RES/;
set mapf /LND.LND,SKL.LAB,LAB.LAB,CAP.CAP,RES.CAP/;
```

Note that these files go into subdirectory located in ..\MAPPING relative to the GAMS.DAT working directory under GTAP.

One important dataset which we aggregate from GTAPV4 is named "GTAP-E". This dataset has regional and commodity aggregation which is consistent with Christoph's quantity dataset from OECD/IEA:

```
$TITLE  Energy database constructed for concordance with IEA

        SET   R   Regions /

                AUS     Australia
                NZL     New Zealand
                JPN     Japan
                KOR     Republic of Korea
                IDN     Indonesia
                MYS     Malaysia
                PHL     Philippines
                SGP     Singapore
                THA     Thailand
                vnm     Vietnam
                CHN     China
                HKG     Hong Kong
                TWN     Taiwan
                IND     India
                lka     Sri Lanka
                RAS     Rest of South Asia
                CAN     Canada
                USA     United States of America
                MEX     Mexico
                CAM     Central America and Caribbean
                ven     Venezuela
                col     Columbia
                rap     Rest of Andean Pact
                ARG     Argentina
                BRA     Brazil
                CHL     Chile
                ury     Uruguay
                RSM     Rest of South America
                gbr     United Kingdom
                deu     Germany
                dnk     Denmark
                swe     Sweden
                fin     Finland
                reu     Rest of EU,
                EFT     European Free Trade Area
```

```
                CEA     Central European Associates
                FSU     Former Soviet Union
                tur     Turkey
                rme     Rest of Middle East
                mar     Morocco
                rnf     Rest of North Africa
                saf     South Africa
                rsa     Rest of South Africa
                rss     Rest of South-Saharan Africa
                ROW     Rest of World  /;

Set I Sectors and goods /

                GAS     Natural gas works
                ELY     Electricity and heat
                P_C     Refined oil products
                COL     Coal transformation
                OIL     Crude oil

                I_S     Iron and steel industry (IRONSTL)
                CRP     Chemical industry (CHEMICAL)
                NFM     Non-ferrous metals (NONFERR)
                NMM     Non-metallic minerals (NONMET)
                TRN     Transport equipment (TRANSEQ)
                OME     Other machinery (MACHINE)
                OMN     Mining (MINING)
                FPR     Food products (FOODPRO)
                PPP     Paper-pulp-print (PAPERPRO)
                LUM     Wood and wood-products (WOODPRO)
                CNS     Construction (CONSTRUC)
                TWL     Textiles-wearing apparel-leather (TEXTILES)
                OMF     Other manufacturing (INONSPEC)
                AGR     Agricultural products
                T_T     Trade and transport
                SER     Commercial and public services
                DWE     Dwellings,
                CGD     Investment composite /;

SET   F   Factors of production /
                LND     Land,
                SKL     Skilled labor,
                LAB     Unskilled labor,
                CAP     Capital,
                RES     Natural resources /
```

Following is the file GTAP-E.MAP, the concordance file which associated GTAPV4 commodities and regions with those we have defined in GTAP-E:

```
$TITLE  Energy database constructed for concordance with IEA
```

```
$SETGLOBAL source gtap4001

SET MAPI  /

(GDT,GAS).GAS                            Natural gas works
ELY.ELY                                  Electricity and heat
P_C.P_C                                  Refined oil products
COL.COL                                  Coal transformation
OIL.OIL                                  Crude oil

I_S.I_S                                  Iron and steel industry (IRONSTL)
CRP.CRP                                  Chemical industry (CHEMICAL)
NFM.NFM                                  Non-ferrous metals (NONFERR)
NMM.NMM                                  Non-metallic minerals (NONMET)
(MVH,OTN).TRN                            Transport equipment (TRANSEQ)
(ELE,OME,FMP).OME                        Other machinery (MACHINE)
OMN.OMN                                  Mining (MINING)
(OMT,VOL,MIL,PCR,SGR,OFD,B_T,CMT).FPR    Food products (FOODPRO)
PPP.PPP                                  Paper-pulp-print (PAPERPRO)
LUM.LUM                                  Wood and wood-products (WOODPRO)
CNS.CNS                                  Construction (CONSTRUC)
(TEX,WAP,LEA).TWL                        Textiles-apparel-leather (TEXTILES)
(OMF,WTR).OMF                            Other manufacturing (INONSPEC)
(PDR,WHT,GRO,V_F,OSD,C_B,PFB,
OCR,CTL,OAP,RMK,WOL,FRS,FSH).AGR         Agricultural products
T_T.T_T                                  Trade and transport
(OSP,OSG).SER                            Commercial and public services
DWE.DWE                                  Dwellings,
CGD.CGD                                  Investment composite    /;
```

No MAPF array is specified which instructs GTAPAGGR to keep the set of primary factors the same as in the original dataset.

5 Reconciling the Satellite Energy Data with GTAP

Let us now review where the data adjustment process stands. We have extracted the GTAP version 4 dataset from the HAR file, scaled it to units of 10s of billions of dollars, and written the dataset (in a new sparse format) to GTAPV4.ZIP.

We then used the CINCH program to eliminate small flows and thereby reduce density of the dataset. CINCH also adjusted some tax rates before rebalancing. The balanced data set, produced with tolerance 0.001 is written to an archive named gtapv4001.zip.

We then employ GTAPAGGR to aggregate the data archive gtapv4001.zip into a format compatible with the IEA quantity statistics. The dataset is stored in archive gtap-e.zip.

The final step in this process is to reconcile the economic data with satellite quantity and price statistics. We do this in ENERGY.GMS which reads gtap-e.zip and writes gtap-er.zip (GTAP-E, reconciled).

Steps in the energy.gms program include:

1. The gtap-e dataset and do an initial check of benchmark consistency using chkeq.gms. (This check is really not necessary, but we include it just to be safe...)

2. Read the energy prices and quantity data provided by Chris and Gerard, including:

```
CBP     Basic prices by region and energy good
CUP     User prices by region, energy good and demand category
CTAX    Energy consumption tax rates by demand category
IIVOL   Intermediate energy demand volumes
FCVOL   Energy consumption volumes
EXVOL   Energy export volumes
IMVOL   Energy import volumes
```

(3) We convert the energy volume data in our preferred units of exajoules and trillion kilowatt hours, using the following conversion factors:

```
1 EJ = 1.0E9 GJ
1 EJ = 23.88 MTOE

1EJ  = 0.948E15 BTU
1kwh = 3413 BTU
1EJ  = 0.948e15/3413 kwh
1EJ  = 948/3413 trillion kwh
```

The rescaled energy data is stored in the following arrays:

```
EIND(I,I,R)     Industrial energy demand (EJ&TKWH),
EFD(I,R)        Final energy demand (EJ&TKWH),
EEXP(I,R)       Energy exports (EJ&TKWH),
EIMP(I,R)       Energy imports (EJ&TKWH),
```

3. Adjust the Energy Quantity Data

   We generate a display of parameter CRUDEINPUT which indicates all non-refinery uses of crude oil in the IEA data. We then transfer all replace all crude oil inputs to non-refining sectors by refined oil inputs and we then move an equal quantity of crude oil into the regional refining activity.

   We impute energy production from market clearance, rounding to avoid the introduction of spurious neglible production levels:

```
eprod(elec,r) = round(eexp(elec,r) - eimp(elec,r)
                + sum(i, eind(elec,i,r)) + efd(elec,r), 3);

eprod(e,r)$(not elec(e)) = round(eexp(e,r) - eimp(e,r)
                + sum(i, eind(e,i,r)) + efd(e,r), 1);
```

   We omit own-use of energy inputs in energy production:

```
eind(e,e,r) = 0;
```

We drop intermediate inputs of coal, gas and refined oil products into non-electric activities:

```
eind(nele,e,r)$nele(e) = 0;
```

Note: nele(i) represents non-electric energy (gas,p_c,col) except for crude oil.

We drop inputs of electricity into the production of other energy goods:

```
eind(elec,e,r) = 0;
```

We drop intermediate inputs of gas, coal and oil into crude oil production:

```
eind(gas,cru,r) = 0;
eind(col,cru,r) = 0;
eind(oil,cru,r) = 0;
```

After made these modifications of the energy production data, we do a recalibration of production and demand which maintains zeros and minimizes square deviations from the adjusted arrays.

(5) The price data is at the country level, so we need to assign a representative country for each region in the GTAP dataset and produce two arrays:

```
PE(R,E,*)       Energy price data
TE(E,R,USR)     Energy tax data distinguished by category

SET USR Energy users in the IEA dataset /
                I       Industry
                H       Households
                U       Utilities
                X       Export /;
```

Our mapping from multi-country GTAP regions to countries in the energy dataset is as follows (omitting mappings from a country to itself):

```
CAM.PAN Central America and Caribbean
CEA.POL Central European Associates
EFT.CHE European Free Trade Area
FSU.RUS Former Soviet Union
```

```
RAP.PER Rest of Andean Pact
RAS.BGD Rest of South Asia
REU.FRA Rest of EU,
RME.SAU Rest of Middle East
RNF.TUN Rest of North Africa
ROW.MEX Rest of World  (represented by Mexico?)
RSA.ZAF Rest of South Africa
RSM.BOL Rest of South America
RSS.NGA Rest of Sub-Saharan Africa
```

4. We determined that some of the energy prices were distant outliers, so we employ a temporary patch to assure that the values are not too low:

```
pe(r,e,"basic") = max(0.1,pe(r,e,"basic"));
```

5. We generate several echo-prints to provide a side-by-side comparison of energy- and carbon-intensities of goods produced in different regions.

   (a) Using basic prices and tax rates from Gerard's dataset, we produce an ex-ante comparison of energy costs by sector from GTAP and IEA/GERARD.

```
ENERGYCOST(E,R,"GTAP")$(NOT CRU(E))
= SUM(J, VAFM(E,J,R)*(1+TI(E,J,R))) +
VPM(E,R)*(1+TP(E,R)) + VST(E,R);

ENERGYCOST(E,R,"IEA/GERARD")$(NOT CRU(E))
= PE(R,E,"basic") *
( SUM(J, EIND(E,J,R) *
(1+TE(E,R,"I")$(NOT ELEC(J)) + TE(E,R,"U")$ELEC(J))) +
EFD(E,R)*(1+TE(E,R,"H")) );
```

   (b) We produce reports comparing implied energy value shares from the GTAP and IEA/GERARD energy data:

```
vshare(r,i)$(vom(i,r) and (not e(i))) =
   round( 100 * sum(e, vafm(e,i,r)*(1+ti(e,i,r))) / vom(i,r), 1);
option vshare:1;
display "Energy value shares implicit in original GTAP data:", vshare;

vshare(r,i)$(vom(i,r) and (not e(i))) = round( 100 *
  sum(e, pe(r,e,"basic")*eind(e,i,r)*(1 + te(e,r,"i")$(not elec(i))
  + te(e,r,"u")$elec(i))) / vom(i,r), 1);
option vshare:1;
display "Energy value shares implicit in IEA data:", vshare;
```

(c) We generate a report of the direct carbon contant of goods, computing first the direct carbon content of electricity, and then computing the direct carbon content of non-energy goods incorporating both fossil-fuel and electricity inputs:

```
carbcoef(r,nele) = cecphys(nele);
carbcoef(r,elec) = sum(nele, cecphys(nele) * eind(nele,elec,r));
carbon(r,i)$((vom(i,r) gt 0) and (not nele(i)))
= round(1000 * sum(e, carbcoef(r,e)*eind(e,i,r)) / vom(i,r));
option carbon:0;
display carbon;
```

(d) We produce a summary report of regional electric and non-electric energy prices implied alternatively by GTAP/IEA and by IEA/Gerard.

(e) We provide a comparison of clear inconsistencies in the two datasets, reporting regions and goods for which IEA exports or imports are positive and the corresponding GTAP flows are zero.

6. Having generated an echo-print of energy-economy statistics, we then turn to the construction of consistent bilateral trade matrices for energy goods.

   In constructing the balanced energy flows, we apply average tax rates and transport margins to any flows which are zero in the original GTAP dataset.

   We use a nonlinear programming formulation for recalibration which imposes the following consistency conditions:

   Export supply:

```
eexp(e,r) =g= sum(s, x(e,r,s));
```

   Import demand:

```
eimp(e,r) =g= sum(s, x(e,s,r));
```

   Aggregate transport demand:

```
sum((e,s,r), vtwrcoef(e,s,r) * pe(s,e,"basic") * x(e,s,r) ) =e= vtwr0;
```

   exports at basic prices gross of taxes and transport margins equals the value of imports at the import price level, pme(e,r):

```
sum(s, ( pe(s,e,"basic") * x(e,s,r) *
        (1 + tx(e,s,r)) + vtwrcoef(e,s,r)) * (1 + tm(e,s,r)))
              =e=  eimp(e,r) * pme(e,r);
```

We therefore impute a consistent import price for for each energy good in each region. When we do the minimization, we minimize the square deviations from the GTAP bilateral trade flows together with penalty terms for import prices in excess of basic prices, i.e. we minimize the objective function:

```
OBJ =E=  sum((e,r,s), sqr(pe(r,e,"basic")*x(e,r,s)-vxmd(e,r,s)))
       + sum((e,r), 1000 * max(0, pe(r,e,"basic")-pme(e,r)))
```

The solution to this nonlinear program provides the following revised values for the GTAP energy trade:

```
pe(r,e,"import") = pme.l(e,r);
vxmd(e,r,s) = x.l(e,r,s) * pe(r,e,"basic");
vtwr(e,r,s) = x.l(e,r,s) * pe(r,e,"basic") * vtwrcoef(e,r,s);
```

We then report percentage adjustments in energy exports and imports, transport margins as a percentage of trade costs, and energy export taxes.

(n.b. We may need to look at the export tax rates here – it seems that we forgot to move these values from the energy tax array TE() into the GTAP parameter TX() before running the trade rebalancing.)

7. At this point in the reconciliation, we turn to the individual input-output tables for each of the countries. Here we replace final and intermediate energy demands by the IEA/GERARD values. We assume that oil refineries and electricity producers pay for energy at basic prices while all other agents pay a price which is a weighted average of the basic price and the import price.

   Here are updating equations for energy value flows:

   Value of domestic energy output:

   ```
   vdm(e,r) = edom(r,e) * pe(r,e,"basic");
   ```

   Value of energy production for export:

   ```
   vxm(e,r) = sum(s, vxmd(e,r,s));
   ```

   Value of consumer energy demand:

   ```
   vpm(e,r) = efd(e,r) * pe(r,e,"fd");
   ```

   Value of intermediate energy demand:

```
vafm(e,i,r) = eind(e,i,r) * pe(r,e,i);
```

We then impose tax rates from Gerard's dataset:

```
ti(e,i,r)      = te(e,r,"i");
ti(e,elec,r)   = te(e,r,"u");
tp(e,r)        = te(e,r,"h");
```

For simplicity, we have decided to model the production of energy as arising solely from inputs of primary factors, neglecting intermediate inputs of non-energy goods. Thus, we assign a value:

```
vafm(i,e,r)$(not e(i)) = 0;
```

Before proceding to recalibrating the regional input-output tables, we use chkeq.gms to generate a report of the imbalances introduced through the foregoing adjustments to the dataset.

Finally, we loop through the regions to recalibrate all non-energy value flows and restore benchmark consistency. The energy flows are already consistent and held constant in this calculation, and other values are adjusted to accomodate these changes. The equilibrium constraints on the recalibrated data include:

Zero profit for all non-energy sectors i:

```
(vdmz(i)+vxm(i,r))*(1-ty(i,r)) =e=   sum(j,vafmz(j,i)*(1+ti(j,i,r)))
                                   + sum(f, vfmz(f,i)*(1+tf(f,i,r)));
```

The value of domestic output for non-energy goods equals the value of demand:

```
vdmz(i) =e= sum(d, d0z(d,i)) + vst(i,rb) + investz$cgd(i);
```

Demand for non-energy imports equals the value of supply:

```
sum(d, m0z(d,i)) =e= vim(i,rb);
```

Demand for non-energy intermediate inputs equals the supply:

```
d0z("i",i) + m0z("i",i) =e= sum(j, vafmz(i,j));
```

Demand for non-energy final consumption equals supply:

```
d0z("c",i) + m0z("c",i) =e= vpmz(i);
```

Demand for non-energy public conssumption equals supply:

```
d0z("g",i) + m0z("g",i) =e= vgmz(i);
```

We compute a feasible solution which minimizes the square deviation from the target values.

Table 1: Countries and Regions in GTAP-E

ID	Name
AUS	Australia
NZL	New Zealand
JPN	Japan
KOR	Republic of Korea
IDN	Indonesia
MYS	Malaysia
PHL	Philippines
SGP	Singapore
THA	Thailand
VNM	Vietnam
CHN	China
HKG	Hong Kong
TWN	Taiwan
IND	India
LKA	Sri Lanka
RAS	Rest of South Asia
CAN	Canada
USA	United States of America
MEX	Mexico
CAM	Central America and Caribbean
VEN	Venezuela
COL	Columbia
RAP	Rest of Andean Pact
ARG	Argentina
BRA	Brazil
CHL	Chile
URY	Uruguay
RSM	Rest of South America
GBR	United Kingdom
DEU	Germany
DNK	Denmark
SWE	Sweden
FIN	Finland
REU	Rest of EU,
EFT	European Free Trade Area
CEA	Central European Associates
FSU	Former Soviet Union
TUR	Turkey
RME	Rest of Middle East
MAR	Morocco
RNF	Rest of North Africa
SAF	South Africa
RSA	Rest of South Africa
RSS	Rest of South-Saharan Africa
ROW	Rest of World

Table 2: Countries and Regions in GTAP-E

ID	Name
ELY	Electricity and heat
I_S	Iron and steel industry (IRONSTL)
CRP	Chemical industry (CHEMICAL)
NFM	Non-ferrous metals (NONFERR)
NMM	Non-metallic minerals (NONMET)
T_T	Trade and transport

Table 3: Energy value shares (%)–(original GTAP)

	I_S	CRP	NFM	NMM	T_T
AUS	4.0	2.5	9.0	8.1	3.0
NZL	2.0	4.2	3.0	0.4	2.4
JPN	18.1	12.8	12.1	9.0	2.2
KOR	10.6	4.2	1.3	11.5	4.7
IDN	17.4	2.9	6.4	4.0	5.9
MYS	6.0	3.7	2.8	19.5	5.1
PHL	1.9	9.3		8.9	6.8
SGP	4.4	7.0	72.2	61.1	5.1
THA	3.2	1.7		6.4	4.8
VNM	8.2	15.2		12.0	10.3
CHN	14.3	9.4	7.7	16.3	5.4
HKG	2.9	2.4		8.2	1.3
TWN	8.9	5.5	0.6	11.8	3.2
IND	14.2	11.2	16.8	12.1	5.8
LKA		1.1		12.6	6.6
RAS	13.4	12.5	16.2	12.4	7.2
CAN	10.0	7.0	5.5	7.4	3.5
USA	10.0	5.4	7.0	5.7	2.5
MEX	9.3	21.8	3.8	7.8	4.0
CAM	9.6	6.8	7.5	10.3	10.8
VEN	6.3	22.5	9.0	9.7	7.4
COL	4.8	11.7	6.4	6.4	4.9
RAP		2.2	5.6	5.1	4.9
ARG	7.2	2.5	10.3	4.9	1.5
BRA	5.6	8.4	1.3	2.4	3.3
CHL		1.0	7.3	2.6	3.1
URY	1.5	3.0	1.0	5.6	3.4
RSM	6.9	6.7	7.2	26.4	19.3
GBR	6.6	3.8	3.6	3.0	1.8
DEU	6.7	4.4		2.7	1.8
DNK		2.2		2.3	2.4
SWE	6.1	5.5	5.6	4.1	2.2
FIN	6.8	4.9	6.7	3.9	3.0
REU	6.7	3.5	4.5	6.1	2.6
EFT	5.6	4.2	2.2	3.9	2.3
CEA	14.9	13.9	8.8	12.5	4.8
FSU	25.3	40.2	23.1	24.4	10.3
TUR	17.5	10.2	14.4	15.7	6.9
RME	10.5	10.6	8.6	14.9	7.4
MAR	10.9	2.5	9.5	9.9	1.6
RNF	17.1	4.4	16.9	18.2	3.5
SAF	23.3	6.5	14.6	8.4	5.7
RSA	9.5	10.9	12.8	9.1	3.7
RSS	17.2	24.0	22.3	17.8	9.1
ROW	15.9	5.6	14.6	15.2	4.2

Table 4: CO2 inventories (IEA)–mton – GTAP with aggregate oil, coal, gas use.

	TOTAL	INDUSTRY	FINAL	ELEC.	CO2(kg/$)
AUS	87.2	48.5	38.7	5.2	0.2
NZL	9.8	6.2	3.6	0.2	0.2
JPN	394.6	347.9	46.7	42.6	0.1
KOR	126.8	85.6	41.1	9.8	0.2
IDN	66.5	43.6	22.9	4.6	0.3
MYS	28.3	16.4	11.9	3.5	0.3
PHL	15.4	11.3	4.1	2.2	0.2
SGP	27.4	22.1	5.3	1.9	0.4
THA	47.6	27.3	20.4	6.2	0.3
VNM	6.9	5.5	1.4	0.8	0.5
CHN	1037.5	649.2	388.3	205.7	1.3
HKG	15.4	10.7	4.7	0.1	0.1
TWN	62.7	48.7	14.0	10.0	0.2
IND	283.9	197.7	86.2	62.4	0.9
LKA	2.1	2.0	0.1	0.1	0.2
RAS	31.8	22.0	9.9	3.6	0.4
CAN	154.7	97.0	57.6	17.9	0.3
USA	1759.2	1001.7	757.5	253.0	0.3
MEX	95.1	63.5	31.7	3.7	0.3
CAM	34.5	24.7	9.8	3.8	0.4
VEN	33.2	13.2	20.0	0.7	0.4
COL	19.5	12.4	7.1	0.6	0.3
RAP	14.4	7.4	7.0	0.4	0.2
ARG	34.9	16.2	18.7	1.0	0.1
BRA	83.1	57.7	25.4	0.8	0.1
CHL	12.3	8.3	4.0	0.8	0.2
URY	1.7	1.3	0.4	0.0	0.1
RSM	1.4	1.0	0.4	0.2	0.3
GBR	181.4	108.4	72.9	23.2	0.2
DEU	284.2	161.9	122.3	33.0	0.1
DNK	20.3	14.8	5.5	1.4	0.1
SWE	19.8	16.2	3.6	1.7	0.1
FIN	17.8	14.3	3.5	1.1	0.1
REU	523.0	316.4	206.6	44.4	0.1
EFT	25.5	13.8	11.7	1.2	0.0
CEA	240.9	188.5	52.3	39.0	0.8
FSU	820.7	622.1	198.7	149.2	1.7
TUR	49.8	38.4	11.3	4.1	0.3
RME	239.4	136.0	103.4	5.3	0.5
MAR	7.7	6.1	1.6	0.1	0.3
RNF	60.5	49.8	10.7	1.5	0.5
SAF	148.3	115.5	32.8	51.5	1.0
RSA	9.1	6.1	3.0	1.4	0.6
RSS	35.4	23.7	11.7	4.6	0.2
ROW	65.2	44.3	20.9	12.5	0.3

Table 5: Sectoral CO2 intensities –kg/$ (GTAP scaled by IEA total supply)

	ELY	I_S	CRP	NFM	NMM	T_T
AUS	0.6	0.2	0.1	0.3	0.2	0.1
NZL	0.2	0.0	0.1	0.0	0.0	0.1
JPN	0.2	0.3	0.2	0.1	0.1	0.0
KOR	0.6	0.2	0.1	0.0	0.2	0.2
IDN	1.3	0.6	0.1	0.7	0.2	0.1
MYS	1.1	0.1	0.1	0.1	0.3	0.1
PHL	1.1	0.1	0.3		0.3	0.1
SGP	1.2	0.1	0.1	1.3	1.1	0.1
THA	1.3	0.1	0.0		0.3	0.1
VNM	0.8	0.1	1.2		0.6	0.3
CHN	2.9	1.2	0.4	0.3	1.0	0.2
HKG	0.1	0.1	0.0		0.3	0.0
TWN	0.9	0.2	0.1	0.0	0.3	0.1
IND	2.2	1.1	0.4	0.4	1.0	0.2
LKA	0.3		0.0		0.2	0.3
RAS	0.6	0.3	0.3	0.2	0.3	0.2
CAN	0.9	0.5	0.2	0.1	0.2	0.1
USA	1.5	0.4	0.1	0.1	0.1	0.1
MEX	0.7	0.4	0.6	0.0	0.1	0.1
CAM	0.6	0.2	0.1	0.1	0.2	0.2
VEN	0.1	0.1	0.2	0.0	0.0	0.0
COL	0.2	0.1	0.3	0.0	0.1	0.0
RAP	0.2		0.0	0.1	0.0	0.1
ARG	0.2	0.1	0.1	0.1	0.0	0.0
BRA	0.0	0.2	0.2	0.0	0.0	0.1
CHL	0.3		0.0	0.3	0.0	0.1
URY	0.0	0.0	0.1	0.0	0.1	0.1
RSM	0.0	0.0	0.0	0.0	0.1	0.1
GBR	1.0	0.3	0.1	0.1	0.1	0.0
DEU	0.5	0.1	0.1		0.0	0.0
DNK	0.5		0.0		0.1	0.0
SWE	0.1	0.1	0.1	0.1	0.1	0.0
FIN	0.2	0.1	0.1	0.2	0.1	0.0
REU	0.4	0.2	0.0	0.1	0.1	0.0
EFT	0.1	0.0	0.0	0.0	0.0	0.0
CEA	2.6	1.0	0.4	0.3	0.5	0.1
FSU	3.1	0.9	2.2	0.8	0.8	0.3
TUR	0.6	0.7	0.2	0.2	0.3	0.2
RME	0.3	0.2	0.2	0.1	0.2	0.1
MAR	0.1	0.4	0.0	0.3	0.2	0.0
RNF	0.3	0.4	0.1	0.4	0.4	0.1
SAF	3.5	2.6	0.3	0.5	0.5	0.2
RSA	1.4	0.5	0.3	0.3	0.4	0.1
RSS	0.2	0.1	0.2	0.1	0.1	0.1
ROW	1.0	0.6	0.1	0.3	0.5	0.1

Table 6: Coal statistics (original IEA) – EJ

	IMPORTS	EXPORTS	DEMAND	PRODUCTION
AUS		3.7	1.6	5.3
NZL				0.1
JPN	3.4	0.1	3.5	0.1
KOR	1.1		1.2	0.1
IDN		0.8	0.3	1.1
MYS	0.1		0.1	
THA	0.1		0.3	0.2
VNM		0.1	0.1	0.1
CHN		0.9	27.6	28.4
HKG	0.2		0.2	
TWN	0.7		0.8	
IND	0.2		5.8	5.6
RAS			0.1	0.1
CAN	0.3	1.0	1.1	1.7
USA	0.2	2.3	20.0	22.1
MEX	0.1		0.2	0.2
VEN		0.2		0.2
COL		0.5	0.2	0.7
BRA	0.4		0.5	0.1
CHL	0.1		0.1	
GBR	0.5		1.9	1.4
DEU	0.5	0.1	3.8	3.4
DNK	0.3		0.3	
SWE	0.1		0.1	
FIN	0.2		0.3	0.1
REU	2.7	0.2	3.6	1.1
EFT	0.1		0.1	
CEA	0.5	1.3	5.0	5.7
FSU	1.0	0.9	8.7	8.5
TUR	0.2		0.7	0.5
RME	0.2		0.2	
MAR	0.1		0.1	
RNF	0.1		0.1	
SAF		1.6	3.1	4.7
RSA			0.2	0.2
ROW	0.1		1.3	1.3

Table 7: Crude Oil statistics (original IEA) – EJ

	IMPORTS	EXPORTS	DEMAND	PRODUCTION
AUS	0.7	0.4	1.5	1.2
NZL	0.2		0.3	0.1
JPN	9.5		9.6	
KOR	3.6		3.6	
IDN	0.4	1.7	1.9	3.2
MYS	0.1	0.8	0.8	1.6
PHL	0.6		0.6	
SGP	2.2		2.2	
THA	1.0		1.1	0.2
VNM		0.4		0.4
CHN	0.7	0.8	6.2	6.2
TWN	1.2		1.2	
IND	1.1		2.6	1.5
LKA	0.1		0.1	
RAS	0.2		0.3	0.1
CAN	1.3	2.6	3.6	4.9
USA	17.4	0.1	33.8	16.5
MEX		3.0	3.5	6.6
CAM	1.1	0.2	1.3	0.4
VEN		4.2	2.2	6.4
COL		0.7	0.6	1.3
RAP	0.1	0.6	0.7	1.2
ARG		0.6	1.1	1.6
BRA	1.2		3.1	1.9
CHL	0.3		0.4	
URY	0.1		0.1	
GBR	2.1	3.7	4.1	5.7
DEU	4.3		4.4	0.2
DNK	0.3	0.2	0.4	0.4
SWE	0.8		0.8	
FIN	0.4		0.4	
REU	14.7	0.2	15.1	0.6
EFT	0.3	5.5	0.7	5.9
CEA	2.0		2.4	0.4
FSU	1.6	5.7	10.7	14.8
TUR	1.0		1.2	0.1
RME	1.1	30.6	11.8	41.4
MAR	0.2		0.2	
RNF	0.1	4.6	3.2	7.7
SAF	0.7		1.0	0.3
RSA	0.1	1.0	0.1	1.1
RSS	0.4	4.9	1.1	5.6
ROW	0.3	0.7	0.5	0.8

Table 8: Refined Oil statistics (original IEA) – EJ

	IMPORTS	EXPORTS	DEMAND	PRODUCTION
AUS	0.1	0.1	1.6	1.6
NZL			0.3	0.3
JPN	2.3	0.4	10.9	8.9
KOR	1.2	0.7	4.0	3.5
IDN	0.4	0.5	1.7	1.8
MYS	0.3	0.3	0.8	0.8
PHL	0.1		0.6	0.5
SGP	1.2	1.9	1.2	2.0
THA	0.4		1.4	1.0
VNM	0.2		0.2	
CHN	0.7	0.2	6.5	6.0
HKG	0.8	0.3	0.5	
TWN	0.4	0.1	1.5	1.3
IND	0.9	0.1	3.3	2.6
LKA			0.1	0.1
RAS	0.5		0.8	0.3
CAN	0.3	0.5	3.5	3.7
USA	1.8	1.6	35.3	35.0
MEX	0.3	0.2	3.5	3.5
CAM	0.7	0.6	1.3	1.2
VEN		1.5	0.9	2.3
COL	0.1	0.1	0.6	0.6
RAP	0.1	0.1	0.6	0.6
ARG	0.1	0.1	0.9	1.0
BRA	0.5	0.1	3.1	2.7
CHL	0.1		0.4	0.3
URY			0.1	0.1
RSM	0.1		0.1	
GBR	0.4	0.9	3.6	4.1
DEU	2.0	0.6	5.8	4.5
DNK	0.2	0.2	0.5	0.4
SWE	0.3	0.4	0.7	0.8
FIN	0.2	0.2	0.4	0.4
REU	5.3	5.0	15.5	15.2
EFT	0.5	0.4	1.0	0.8
CEA	0.5	0.5	2.3	2.3
FSU	1.0	2.3	9.1	10.4
TUR	0.2	0.1	1.2	1.2
RME	1.2	4.8	7.8	11.4
MAR			0.3	0.3
RNF	0.1	1.2	1.9	3.0
SAF	0.1	0.1	0.9	1.0
RSA	0.1		0.2	0.1
RSS	0.5	0.2	1.4	1.1
ROW	0.3	0.1	0.7	0.5

Table 9: Natural gas statistics (original IEA) – EJ

	IMPORTS	EXPORTS	DEMAND	PRODUCTION
AUS		0.3	0.7	1.0
NZL			0.2	0.2
JPN	2.1		2.4	0.3
KOR	0.4		0.4	0.1
IDN		1.2	1.5	2.7
MYS		0.5	0.5	1.0
SGP	0.1		0.1	
THA			0.4	0.4
CHN			0.8	0.8
TWN	0.1		0.2	
IND			0.7	0.7
RAS			0.8	0.8
CAN		2.7	2.9	5.6
USA	2.8	0.2	21.3	18.6
MEX	0.1		1.1	1.0
CAM			0.2	0.2
VEN			1.1	1.1
COL			0.2	0.2
RAP		0.1	0.1	0.1
ARG	0.1		1.0	0.9
BRA			0.2	0.2
CHL			0.1	0.1
GBR	0.1		2.7	2.7
DEU	2.3	0.1	2.8	0.6
DNK		0.1	0.1	0.2
FIN	0.1		0.1	
REU	3.5	1.2	5.7	3.5
EFT	0.1	1.0	0.2	1.2
CEA	1.4		2.3	0.9
FSU	3.5	7.4	19.3	23.3
TUR	0.2		0.2	
RME		0.2	4.4	4.6
RNF	0.1	1.6	1.4	2.9
SAF			0.1	0.1
RSS			0.2	0.2
ROW		0.3	0.3	0.6

Table 10: Electricity statistics (original IEA) – TKWT

	IMPORTS	EXPORTS	DEMAND	PRODUCTION
AUS			0.2	0.2
JPN			1.0	1.0
KOR			0.2	0.2
IDN			0.1	0.1
THA			0.1	0.1
CHN			1.0	1.0
TWN			0.1	0.1
IND			0.4	0.4
RAS			0.1	0.1
CAN			0.5	0.6
USA			3.6	3.6
MEX			0.2	0.2
CAM			0.1	0.1
VEN			0.1	0.1
ARG			0.1	0.1
BRA			0.3	0.3
GBR			0.3	0.3
DEU			0.5	0.5
SWE			0.1	0.1
FIN			0.1	0.1
REU	0.1	0.1	1.2	1.2
EFT			0.2	0.2
CEA			0.4	0.4
FSU	0.1	0.1	1.3	1.3
TUR			0.1	0.1
RME			0.3	0.3
RNF			0.1	0.1
SAF			0.2	0.2
RSS			0.1	0.1
ROW			0.1	0.1

Table 11: CO2 inventories (original IEA)–mton

	TOTAL	INDUSTRY	FINAL	ELEC.	CO2(kg/$)
AUS	119.7	91.7	28.0	43.9	0.3
NZL	10.4	8.2	2.2	0.9	0.2
JPN	428.3	325.4	102.9	101.4	0.1
KOR	141.7	104.7	36.9	27.7	0.3
IDN	79.1	54.8	24.3	20.1	0.4
MYS	32.4	25.6	6.8	8.6	0.4
PHL	16.6	11.3	5.3	4.2	0.2
SGP	31.5	28.8	2.7	7.0	0.5
THA	54.2	38.4	15.8	14.4	0.4
VNM	6.9	4.9	2.0	1.0	0.5
CHN	1132.7	994.7	138.0	371.9	1.5
HKG	21.2	19.8	1.5	6.8	0.2
TWN	69.8	57.2	12.6	19.6	0.2
IND	323.5	270.4	53.0	127.6	1.0
LKA	2.2	1.1	1.1	0.1	0.2
RAS	36.3	26.2	10.1	10.2	0.5
CAN	166.0	117.1	48.9	32.5	0.3
USA	2070.9	1562.2	508.8	653.4	0.3
MEX	113.1	75.5	37.6	26.1	0.4
CAM	37.1	30.1	6.9	8.7	0.4
VEN	39.9	28.4	11.4	9.2	0.5
COL	21.5	13.6	7.8	4.0	0.3
RAP	15.9	10.7	5.2	2.4	0.2
ARG	40.0	25.6	14.3	7.9	0.1
BRA	80.4	49.8	30.6	4.9	0.1
CHL	13.6	9.0	4.6	2.4	0.2
URY	1.7	1.3	0.5	0.1	0.1
RSM	1.3	0.4	0.9	0.1	0.3
GBR	203.9	138.5	65.4	54.0	0.2
DEU	339.4	238.4	101.0	101.9	0.1
DNK	26.8	19.7	7.0	9.3	0.2
SWE	20.7	13.1	7.7	2.9	0.1
FIN	22.5	17.3	5.3	6.3	0.2
REU	586.5	416.0	170.5	124.6	0.2
EFT	25.6	15.1	10.5	1.4	0.0
CEA	306.2	253.3	52.9	132.5	1.0
FSU	994.1	861.4	132.7	408.1	2.1
TUR	58.4	43.2	15.2	15.7	0.3
RME	277.5	207.6	69.9	64.7	0.6
MAR	10.5	8.6	1.9	3.2	0.4
RNF	77.3	62.3	15.0	20.0	0.6
SAF	139.3	119.2	20.1	51.7	0.9
RSA	10.0	8.3	1.6	2.6	0.6
RSS	34.9	23.1	11.8	4.9	0.2
ROW	73.0	62.9	10.1	28.8	0.3

Table 12: Sectoral CO2 intensities (original IEA-GTAP) –kg per $output

	ELY	I_S	CRP	NFM	NMM	T_T
AUS	4.2	0.5	0.2	1.4	0.2	0.0
NZL	0.5	0.5	0.3	0.1	0.1	0.1
JPN	0.5	0.2	0.1	0.0	0.1	0.0
KOR	1.6	0.2	0.3	0.0	0.3	0.1
IDN	4.8	0.6	0.3	0.1	1.1	0.0
MYS	2.4	0.2	0.2	0.4	0.5	0.1
PHL	1.7	0.2	0.1	0.1	0.8	0.0
SGP	3.8	0.2	0.2	0.0	0.0	0.3
THA	2.7	0.4	0.2	0.4	0.8	0.1
VNM	0.8	0.1	1.2		0.5	0.1
CHN	4.3	1.2	1.0	0.8	1.3	0.1
HKG	3.6	0.1	0.0	0.0	0.0	0.0
TWN	1.5	0.1	0.2	0.0	0.3	0.1
IND	3.7	1.0	0.7	1.2	1.5	0.1
LKA	0.3	0.0	0.1		0.1	0.2
RAS	1.3	0.4	0.5	0.4	2.4	0.1
CAN	1.4	0.3	0.4	0.3	0.2	0.1
USA	3.4	0.3	0.3	0.2	0.2	0.1
MEX	4.3	0.4	0.4	0.0	0.4	0.0
CAM	1.1	0.4	0.3	0.3	0.5	0.2
VEN	1.4	0.9	0.4	0.7	0.5	0.1
COL	0.9	0.1	0.1	0.9	1.0	0.1
RAP	1.0	0.1	0.0	0.1	0.1	0.1
ARG	1.3	0.0	0.0	0.1	0.1	0.1
BRA	0.2	0.2	0.1	0.1	0.1	0.0
CHL	0.8	1.1	0.1	0.1	0.2	0.0
URY	0.2	0.0	0.0		0.1	0.1
RSM	0.0		0.0		0.2	0.0
GBR	2.1	0.3	0.2	0.1	0.1	0.0
DEU	1.4	0.1	0.1	0.1	0.1	0.0
DNK	2.9	0.2	0.1	0.1	0.2	0.0
SWE	0.2	0.2	0.1	0.0	0.1	0.0
FIN	0.8	0.2	0.2	0.1	0.3	0.0
REU	1.0	0.3	0.2	0.1	0.1	0.0
EFT	0.1	0.1	0.0	0.0	0.0	0.0
CEA	6.9	1.2	0.5	0.5	0.7	0.1
FSU	6.8	3.0	1.4	1.9	1.1	0.4
TUR	1.9	0.5	0.3	0.2	0.2	0.0
RME	2.8	0.2	0.3	0.3	0.4	0.1
MAR	4.0	0.2	0.0	0.3	0.1	0.0
RNF	3.1	0.5	0.4	0.2	0.5	0.1
SAF	2.9	1.0	0.5	0.4	0.4	0.1
RSA	2.3	0.6	0.2	0.5	0.4	0.2
RSS	0.2	0.1	0.1	0.2	0.1	0.2
ROW	1.7	0.3	0.2	0.1	1.1	0.0

Table 13: Coal statistics (adjusted IEA) – EJ

	IMPORTS	EXPORTS	DEMAND	PRODUCTION
AUS		3.7	1.6	5.3
NZL		0.1		0.1
JPN	3.4	0.1	3.5	0.1
KOR	1.1		1.2	0.1
IDN		0.8	0.3	1.1
MYS	0.1		0.1	
THA	0.1		0.3	0.2
VNM			0.1	0.1
CHN		0.9	27.6	28.4
HKG	0.2		0.2	
TWN	0.8		0.8	
IND	0.2		5.8	5.6
RAS			0.1	0.1
CAN	0.3	1.0	1.1	1.7
USA	0.2	2.3	20.0	22.1
MEX			0.2	0.2
VEN		0.2		0.2
COL		0.5	0.2	0.7
BRA	0.4		0.5	0.1
CHL	0.1		0.1	
GBR	0.5		1.9	1.4
DEU	0.5	0.1	3.8	3.4
DNK	0.3		0.3	
SWE	0.1		0.1	
FIN	0.2		0.3	0.1
REU	2.6	0.2	3.6	1.1
EFT	0.1		0.1	
CEA	0.5	1.3	5.0	5.7
FSU	1.0	0.8	8.7	8.5
TUR	0.2		0.7	0.5
RME	0.2		0.2	
MAR	0.1		0.1	
RNF	0.1		0.1	
SAF		1.6	3.1	4.7
RSA			0.2	0.2
ROW	0.1		1.3	1.3

Table 14: Crude Oil statistics (adjusted IEA)–EJ

	IMPORTS	EXPORTS	DEMAND	PRODUCTION
AUS	0.7	0.4	1.5	1.2
NZL	0.2		0.3	0.1
JPN	9.6		9.6	
KOR	3.6		3.6	
IDN	0.4	1.7	1.9	3.2
MYS	0.1	0.8	0.8	1.6
PHL	0.6		0.6	
SGP	2.2		2.2	
THA	1.0		1.1	0.2
VNM		0.4		0.4
CHN	0.7	0.8	6.2	6.2
TWN	1.2		1.2	
IND	1.1		2.6	1.5
LKA	0.1		0.1	
RAS	0.2		0.3	0.1
CAN	1.3	2.6	3.6	4.9
USA	17.4	0.1	33.8	16.5
MEX		3.0	3.5	6.6
CAM	1.1	0.2	1.3	0.4
VEN		4.2	2.2	6.4
COL		0.7	0.6	1.3
RAP	0.1	0.6	0.7	1.2
ARG		0.6	1.1	1.6
BRA	1.2		3.1	1.9
CHL	0.4		0.4	
URY	0.1		0.1	
GBR	2.1	3.7	4.1	5.7
DEU	4.3		4.4	0.2
DNK	0.3	0.2	0.4	0.4
SWE	0.8		0.8	
FIN	0.4		0.4	
REU	14.7	0.2	15.1	0.6
EFT	0.3	5.4	0.7	5.9
CEA	2.0		2.4	0.4
FSU	1.6	5.7	10.7	14.8
TUR	1.0		1.2	0.1
RME	1.0	30.6	11.8	41.4
MAR	0.2		0.2	
RNF		4.6	3.2	7.7
SAF	0.7		1.0	0.3
RSA		1.0	0.1	1.1
RSS	0.4	4.9	1.1	5.6
ROW	0.3	0.7	0.5	0.8

Table 15: Refined Oil statistics (adjusted IEA)–EJ

	IMPORTS	EXPORTS	DEMAND	PRODUCTION
AUS	0.1	0.2	1.6	1.7
NZL		0.1	0.3	0.4
JPN	2.4	0.3	11.6	9.5
KOR	1.2	0.7	4.0	3.5
IDN	0.4	0.5	1.7	1.9
MYS	0.3	0.4	0.8	0.9
PHL	0.1	0.1	0.6	0.6
SGP	1.2	2.0	1.2	2.0
THA	0.4	0.1	1.4	1.1
VNM	0.2		0.2	
CHN	0.8	0.1	6.6	5.9
HKG	0.5		0.5	
TWN	0.3	0.1	1.5	1.4
IND	0.9	0.1	3.3	2.6
LKA		0.1	0.1	0.2
RAS	0.4	0.1	0.8	0.4
CAN	0.3	0.4	3.5	3.6
USA	2.5	0.9	35.3	33.7
MEX	0.3	0.2	3.5	3.4
CAM	0.6	0.7	1.4	1.4
VEN		1.5	0.9	2.4
COL		0.2	0.6	0.7
RAP	0.1	0.2	0.6	0.7
ARG		0.2	0.9	1.1
BRA	0.5	0.1	3.4	3.0
CHL			0.4	0.4
URY		0.1	0.1	0.2
RSM	0.1		0.1	
GBR	0.4	0.9	3.6	4.0
DEU	2.0	0.6	5.8	4.4
DNK	0.1	0.2	0.5	0.5
SWE	0.3	0.4	0.7	0.9
FIN	0.1	0.2	0.4	0.5
REU	5.6	4.8	15.5	14.7
EFT	0.5	0.4	1.0	0.9
CEA	0.5	0.5	2.3	2.3
FSU	1.2	2.2	9.2	10.2
TUR	0.1	0.1	1.2	1.3
RME	1.3	4.7	8.4	11.8
MAR		0.1	0.3	0.4
RNF	0.1	1.2	1.9	3.1
SAF		0.2	0.9	1.1
RSA		0.1	0.2	0.2
RSS	0.4	0.3	1.4	1.2
ROW	0.3	0.2	0.7	0.6

Table 16: Natural gas statistics (adjusted IEA)–EJ

	IMPORTS	EXPORTS	DEMAND	PRODUCTION
AUS		0.4	0.7	1.1
NZL			0.2	0.2
JPN	2.0		2.4	0.4
KOR	0.3		0.4	0.2
IDN		1.1	1.5	2.6
MYS		0.6	0.5	1.1
SGP	0.1		0.1	
THA			0.4	0.4
CHN			0.8	0.8
TWN	0.2		0.2	
IND			0.7	0.7
RAS			0.8	0.8
CAN		2.7	2.9	5.6
USA	3.1		21.3	18.1
MEX			1.1	1.1
CAM			0.2	0.2
VEN			1.1	1.1
COL			0.2	0.2
RAP		0.1	0.1	0.2
ARG			1.0	1.0
BRA			0.2	0.2
CHL			0.1	0.1
GBR		0.1	2.7	2.8
DEU	2.3	0.1	2.8	0.7
DNK		0.2	0.1	0.3
FIN	0.1		0.1	
REU	3.4	1.3	5.7	3.6
EFT	0.1	1.1	0.2	1.3
CEA	1.4		2.3	1.0
FSU	3.6	7.4	19.3	23.2
TUR	0.2		0.2	
RME	0.2	0.1	4.4	4.3
RNF	0.1	1.6	1.4	2.9
SAF			0.1	0.1
RSS			0.2	0.2
ROW		0.3	0.3	0.7

Table 17: Electricity statistics (adjusted IEA)–TKWT

	IMPORTS	EXPORTS	DEMAND	PRODUCTION
AUS			0.2	0.2
JPN			1.0	1.0
KOR			0.2	0.2
IDN			0.1	0.1
MYS				0.1
THA			0.1	0.1
CHN	0.1		1.0	0.9
HKG				0.1
TWN			0.1	0.1
IND			0.4	0.4
RAS			0.1	0.1
CAN			0.5	0.6
USA	0.3		3.6	3.3
MEX			0.2	0.2
CAM			0.1	0.1
VEN			0.1	0.1
ARG			0.1	0.1
BRA			0.3	0.3
RSM		0.1		0.1
GBR			0.3	0.3
DEU			0.5	0.5
DNK				0.1
SWE			0.1	0.2
FIN			0.1	0.1
REU	0.1	0.1	1.2	1.1
EFT		0.1	0.2	0.2
CEA			0.4	0.3
FSU	0.2		1.3	1.1
TUR			0.1	0.1
RME			0.3	0.3
RNF			0.1	0.1
SAF			0.2	0.2
RSA				0.1
RSS			0.1	0.1
ROW			0.1	0.1

Table 18: Basic Energy Prices

	GAS	CRUDE	REFINED	ELECTRIC	COAL
AUS	1.9	3.3	4.0	59.1	1.4
NZL	2.3	3.8	5.4	53.6	1.4
JPN	3.1	4.7	6.7	210.7	2.2
KOR	2.4	3.2	4.6	73.3	1.1
IDN	1.8	3.1	3.6	64.7	1.3
MYS	1.8	3.2	4.0	67.0	1.5
PHL	1.8	3.4	4.9	104.2	1.1
SGP	2.9	2.8	3.8	107.6	1.9
THA	2.3	4.0	5.7	73.7	1.1
VNM	1.2	3.2	4.5	61.5	1.3
CHN	1.0	3.5	5.0	31.2	1.0
HKG	3.0	3.5	4.9	88.1	1.9
TWN	2.7	3.6	5.1	90.1	1.8
IND	1.9	3.0	4.3	62.9	1.0
LKA	1.0	4.9	7.0	65.3	1.1
RAS	1.7	3.6	5.2	40.7	1.3
CAN	1.7	3.4	4.1	47.2	1.5
USA	1.6	3.0	3.8	65.4	1.4
MEX	1.0	2.2	2.4	26.9	1.0
CAM	1.1	2.5	2.7	76.6	1.9
VEN	1.0	1.8	1.9	64.6	1.2
COL	1.4	2.5	2.8	54.8	1.0
RAP	2.1	3.0	3.8	70.4	1.3
ARG	1.7	5.6	8.0	63.4	1.6
BRA	1.9	3.4	4.8	60.2	1.1
CHL	1.1	2.9	4.2	79.5	1.1
URY	3.0	2.5	2.8	89.4	1.9
RSM	1.0	2.7	3.7	39.0	1.0
GBR	2.0	3.1	4.1	89.9	1.7
DEU	2.7	3.0	4.3	117.5	1.9
DNK	2.8	3.1	4.4	72.5	1.4
SWE	2.0	3.1	3.7	47.7	1.0
FIN	1.8	3.0	4.2	70.9	1.7
REU	2.7	3.0	3.9	94.2	1.8
EFT	2.3	3.2	4.6	69.6	1.9
CEA	1.5	3.0	4.2	52.7	1.2
FSU	1.3	2.3	2.6	30.9	1.0
TUR	2.4	3.3	3.6	67.5	1.3
RME	1.5	2.2	2.5	55.3	1.7
MAR	3.2	3.5	5.0	115.7	1.9
RNF	1.7	2.2	2.5	53.0	1.5
SAF	1.9	5.2	7.4	68.6	1.5
RSA	1.8	3.9	5.5	71.4	1.0
RSS	1.4	2.9	4.2	62.1	1.0
ROW	2.2	3.0	4.1	77.8	1.3

Table 19: Implied Heat Rates (EJ Input to EJ/TKWH Output)

	ELECTRICITY	REFINING
AUS	9.7	0.9
NZL	3.2	0.7
JPN	8.5	1.0
KOR	12.6	1.0
IDN	21.4	1.0
MYS	6.4	0.9
PHL	14.7	0.9
SGP	14.6	1.1
THA	6.6	1.0
VNM	3.7	
CHN	14.3	1.1
HKG	3.7	
TWN	11.3	0.9
IND	11.7	1.0
LKA	2.3	0.4
RAS	7.0	0.7
CAN	6.7	1.0
USA	10.7	1.0
MEX	7.6	1.0
CAM	6.9	1.0
VEN	10.5	0.9
COL	5.8	0.8
RAP	7.1	0.9
ARG	7.1	1.0
BRA	5.3	1.0
CHL	7.7	0.8
URY	0.4	0.3
RSM	0.1	
GBR	9.0	1.0
DEU	10.9	1.0
DNK	5.2	0.8
SWE	8.0	0.8
FIN	7.0	0.7
REU	8.5	1.0
EFT	12.7	0.8
CEA	13.8	1.0
FSU	35.7	1.0
TUR	6.3	0.9
RME	11.3	1.0
MAR	10.7	0.6
RNF	9.5	1.0
SAF	9.1	0.9
RSA	1.9	0.5
RSS	3.7	0.9
ROW	9.8	0.8

Table 20: Cost Ratios (fuel input costs to output value)

	ELECTRICITY	REFINING
AUS	0.2	0.7
NZL	0.1	0.5
JPN	0.1	0.7
KOR	0.2	0.7
IDN	0.5	0.9
MYS	0.2	0.7
PHL	0.2	0.7
SGP	0.5	0.8
THA	0.3	0.7
VNM	0.1	
CHN	0.5	0.7
HKG	0.1	
TWN	0.2	0.6
IND	0.2	0.7
LKA	0.1	0.3
RAS	0.4	0.5
CAN	0.1	0.8
USA	0.2	0.8
MEX	0.5	0.9
CAM	0.2	0.9
VEN	0.1	0.8
COL	0.1	0.7
RAP	0.2	0.7
ARG	0.2	0.7
BRA	0.0	0.7
CHL	0.1	0.6
URY	0.0	0.3
RSM	0.0	
GBR	0.1	0.8
DEU	0.1	0.7
DNK	0.1	0.6
SWE	0.0	0.7
FIN	0.1	0.5
REU	0.1	0.8
EFT	0.0	0.6
CEA	0.4	0.7
FSU	0.7	0.9
TUR	0.1	0.8
RME	0.4	0.9
MAR	0.3	0.4
RNF	0.3	0.9
SAF	0.2	0.6
RSA	0.0	0.3
RSS	0.1	0.6
ROW	0.2	0.6

Table 21: Implicitly Determined Subsidy Rates (%)

	ELECTRICITY	REFINING
IDN	6.0	
CHN	7.0	
IND		12.0
MEX		3.0
DEU		-22.0
REU		-16.0
FSU	46.0	4.0
TUR		-9.0
RME		1.0
RNF		2.0

Table 22: Crude Oil Prices ($ per GJ)

	BASIC	IMPORT	REFINERY
AUS	3.3	3.3	3.3
NZL	3.8	3.8	3.8
JPN	4.7	2.8	2.8
KOR	3.2	3.2	3.2
IDN	3.1	3.1	3.1
MYS	3.2	3.2	3.2
PHL	3.4	3.4	3.4
SGP	2.8	2.8	2.8
THA	4.0	4.0	4.0
VNM	3.2		
CHN	3.5	3.5	3.5
HKG	3.5		
TWN	3.6	3.6	3.6
IND	3.0	3.0	3.0
LKA	4.9	4.9	4.9
RAS	3.6	3.8	3.7
CAN	3.4	3.4	3.4
USA	3.0	2.3	2.6
MEX	2.2		2.2
CAM	2.5	2.5	2.5
VEN	1.8		1.8
COL	2.5		2.5
RAP	3.0	3.0	3.0
ARG	5.6	5.6	5.6
BRA	3.4	3.4	3.4
CHL	2.9	2.9	2.9
URY	2.5	2.5	2.5
RSM	2.7		
GBR	3.1	3.1	3.1
DEU	3.0	3.0	3.0
DNK	3.1	3.1	3.1
SWE	3.1	3.1	3.1
FIN	3.0	3.0	3.0
REU	3.0	2.8	2.9
EFT	3.2	3.2	3.2
CEA	3.0	3.0	3.0
FSU	2.3	2.2	2.3
TUR	3.3	3.3	3.3
RME	2.2	2.4	2.2
MAR	3.5	3.5	3.5
RNF	2.2	2.4	2.2
SAF	5.2	4.9	5.0
RSA	3.9	3.9	3.9
RSS	2.9	2.9	2.9
ROW	3.0	3.0	3.0

Table 23: Refined Oil Prices ($ per GJ)

	BASIC	IMPORT	UTILITY	MARKET
AUS	4.0	4.2	4.0	4.0
NZL	5.4		5.4	5.4
JPN	6.7	6.2	6.7	6.6
KOR	4.6	4.6	4.6	4.6
IDN	3.6	3.6	3.6	3.6
MYS	4.0	4.0	4.0	4.0
PHL	4.9	4.9	4.9	4.9
SGP	3.8	3.8	3.8	3.8
THA	5.7	5.7	5.7	5.7
VNM	4.5	4.5	4.5	4.5
CHN	5.0	5.0	5.0	5.0
HKG	4.9	4.9	4.9	4.9
TWN	5.1	5.1	5.1	5.1
IND	4.3	4.3	4.3	4.3
LKA	7.0		7.0	7.0
RAS	5.2	5.2	5.2	5.2
CAN	4.1	4.1	4.1	4.1
USA	3.8	3.8	3.8	3.8
MEX	2.4	2.4	2.4	2.4
CAM	2.7	2.7	2.7	2.7
VEN	1.9		1.9	1.9
COL	2.8	2.8	2.8	2.8
RAP	3.8	3.8	3.8	3.8
ARG	8.0	8.0	8.0	8.0
BRA	4.8	4.8	4.8	4.8
CHL	4.2	4.2	4.2	4.2
URY	2.8		2.8	2.8
RSM	3.7	3.7	3.7	3.7
GBR	4.1	4.1	4.1	4.1
DEU	4.3	4.3	4.3	4.3
DNK	4.4	4.4	4.4	4.4
SWE	3.7	3.7	3.7	3.7
FIN	4.2	4.2	4.2	4.2
REU	3.9	3.6	3.9	3.8
EFT	4.6	4.6	4.6	4.6
CEA	4.2	4.2	4.2	4.2
FSU	2.6	3.7	2.6	2.8
TUR	3.6	3.6	3.6	3.6
RME	2.5	2.8	2.5	2.5
MAR	5.0		5.0	5.0
RNF	2.5	3.4	2.5	2.5
SAF	7.4		7.4	7.4
RSA	5.5	5.5	5.5	5.5
RSS	4.2	4.2	4.2	4.2
ROW	4.1	4.1	4.1	4.1

Table 24: Natural Gas Prices ($ per GJ)

	BASIC	IMPORT	UTILITY	MARKET
AUS	1.9		1.9	1.9
NZL	2.3		2.3	2.3
JPN	3.1	2.0	3.1	0.5
KOR	2.4	2.4	2.4	2.4
IDN	1.8		1.8	1.8
MYS	1.8		1.8	1.8
PHL	1.8	1.8	1.8	1.8
SGP	2.9	2.8	2.9	2.4
THA	2.3		2.3	2.3
VNM	1.2	1.4	1.2	1.7
CHN	1.0		1.0	1.0
HKG	3.0	2.7	3.0	2.7
TWN	2.7	2.7	2.7	2.7
IND	1.9		1.9	1.9
LKA	1.0			
RAS	1.7		1.7	1.7
CAN	1.7	1.7	1.7	1.7
USA	1.6	1.6	1.6	1.6
MEX	1.0	1.4	1.0	1.0
CAM	1.1		1.1	1.1
VEN	1.0		1.0	1.0
COL	1.4		1.4	1.4
RAP	2.1		2.1	2.1
ARG	1.7	1.7	1.7	1.7
BRA	1.9		1.9	1.9
CHL	1.1		1.1	1.1
URY	3.0	3.0	3.0	3.0
RSM	1.0			
GBR	2.0	2.0	2.0	2.0
DEU	2.7	2.5	2.7	2.5
DNK	2.8		2.8	2.8
SWE	2.0	2.0	2.0	2.0
FIN	1.8	1.8	1.8	1.8
REU	2.7	1.4	2.7	1.7
EFT	2.3	2.3	2.3	2.3
CEA	1.5	1.4	1.5	1.4
FSU	1.3	1.9	1.3	1.5
TUR	2.4	2.4	2.4	2.4
RME	1.5	1.5	1.5	1.5
MAR	3.2	3.2	3.2	3.2
RNF	1.7	1.7	1.7	1.7
SAF	1.9		1.9	1.9
RSA	1.8	1.8	1.8	1.8
RSS	1.4		1.4	1.4
ROW	2.2		2.2	2.2

Table 25: Coal Prices ($ per GJ)

	BASIC	IMPORT	UTILITY	MARKET
AUS	1.4		1.4	1.4
NZL	1.4		1.4	1.4
JPN	2.2	1.6	2.2	1.0
KOR	1.1	1.2	1.1	1.2
IDN	1.3		1.3	1.3
MYS	1.5	1.5	1.5	1.5
PHL	1.1	1.3	1.1	1.4
SGP	1.9			
THA	1.1	1.5	1.1	1.3
VNM	1.3	1.3	1.3	1.3
CHN	1.0	1.3	1.0	1.0
HKG	1.9	1.9	1.9	
TWN	1.8	1.8	1.8	1.8
IND	1.0	1.7	1.0	1.1
LKA	1.1	1.6	1.1	1.6
RAS	1.3	2.2	1.3	1.3
CAN	1.5	1.5	1.5	1.5
USA	1.4	1.4	1.4	1.4
MEX	1.0	1.3	1.0	1.1
CAM	1.9	1.9	1.9	1.9
VEN	1.2		1.2	1.2
COL	1.0		1.0	1.0
RAP	1.3	1.3	1.3	1.3
ARG	1.6	1.6	1.6	1.6
BRA	1.1	1.3	1.1	1.3
CHL	1.1	1.7	1.1	2.6
URY	1.9	1.9	1.9	1.9
RSM	1.0			
GBR	1.7	1.7	1.7	1.7
DEU	1.9	1.8	1.9	1.9
DNK	1.4	1.4	1.4	1.4
SWE	1.0	1.2	1.0	1.4
FIN	1.7	1.7	1.7	1.7
REU	1.8	1.7	1.8	1.5
EFT	1.9	1.9	1.9	1.9
CEA	1.2	1.4	1.2	1.3
FSU	1.0	1.4	1.0	1.1
TUR	1.3	1.3	1.3	1.3
RME	1.7	1.7	1.7	1.7
MAR	1.9	1.9	1.9	1.9
RNF	1.5	1.5	1.5	1.5
SAF	1.5		1.5	1.5
RSA	1.0		1.0	1.0
RSS	1.0	1.4	1.0	1.8
ROW	1.3	1.9	1.3	1.4

Table 26: Electricity Prices ($ per TKWH)

	BASIC	IMPORT	MARKET
AUS	59.1		59.1
NZL	53.6		53.6
JPN	210.7		210.7
KOR	73.3		73.3
IDN	64.7		64.7
MYS	67.0		67.0
PHL	104.2		104.2
SGP	107.6		107.6
THA	73.7		73.7
VNM	61.5		61.5
CHN	31.2	49.7	32.6
HKG	88.1		88.1
TWN	90.1		90.1
IND	62.9	62.9	62.9
LKA	65.3		65.3
RAS	40.7		40.7
CAN	47.2	47.2	47.2
USA	65.4	65.4	65.4
MEX	26.9		26.9
CAM	76.6		76.6
VEN	64.6		64.6
COL	54.8		54.8
RAP	70.4		70.4
ARG	63.4		63.4
BRA	60.2	60.2	60.2
CHL	79.5		79.5
URY	89.4		89.4
RSM	39.0		39.0
GBR	89.9	95.1	90.0
DEU	117.5	95.2	115.7
DNK	72.5		72.5
SWE	47.7		47.7
FIN	70.9		70.9
REU	94.2	91.2	93.9
EFT	69.6	69.6	69.6
CEA	52.7	68.9	54.1
FSU	30.9	50.4	33.5
TUR	67.5		67.5
RME	55.3		55.3
MAR	115.7		115.7
RNF	53.0		53.0
SAF	68.6		68.6
RSA	71.4		71.4
RSS	62.1		62.1
ROW	77.8		77.8

Table 27: Energy value shares (%) – rebalanced dataset

	I_S	CRP	NFM	NMM	T_T
AUS	7.3	6.1	33.9	5.8	1.0
NZL	36.4	10.9	4.5	3.3	2.4
JPN	9.0	5.8	8.4	5.3	0.8
KOR	3.2	7.7	2.0	5.3	1.9
IDN	15.9	6.6	5.6	19.8	0.9
MYS	8.0	4.4	10.4	11.3	1.6
PHL	8.7	5.4	9.3	18.7	1.0
SGP	12.4	4.3	3.2	3.0	5.4
THA	18.0	6.7	10.0	14.6	2.3
VNM	22.3	12.9		8.4	2.1
CHN	8.5	10.0	9.3	9.2	2.2
HKG	9.3	1.5	3.4	3.0	0.9
TWN	3.6	5.3	2.3	7.8	1.8
IND	11.5	14.4	34.9	25.0	3.5
LKA	7.5	4.2		12.9	6.2
RAS	6.3	8.4	15.4	39.4	2.0
CAN	6.6	10.7	20.3	7.7	1.5
USA	8.5	7.6	9.0	6.3	1.1
MEX	5.3	5.9	2.9	7.4	0.5
CAM	11.4	7.2	19.7	17.1	2.8
VEN	24.5	5.9	44.8	11.6	1.1
COL	7.9	2.9	16.2	16.6	1.0
RAP	10.5	1.9	4.4	5.9	2.0
ARG	2.3	1.8	6.3	5.8	3.2
BRA	5.2	3.5	15.1	5.0	1.8
CHL	30.9	2.1	10.6	7.7	1.1
URY	1.3	3.1		8.7	1.9
RSM		2.8		3.2	0.6
GBR	7.4	6.4	6.8	6.1	1.0
DEU	4.0	4.9	8.0	4.8	0.8
DNK	8.9	2.7	9.3	5.9	1.3
SWE	4.9	4.2	5.1	4.6	0.8
FIN	5.4	8.7	5.4	7.4	0.6
REU	8.2	6.6	10.1	6.1	1.6
EFT	6.4	2.9	14.3	2.6	1.0
CEA	15.1	10.4	14.0	13.2	1.9
FSU	28.5	19.1	27.9	15.9	5.7
TUR	12.7	9.5	12.2	10.7	0.7
RME	6.4	6.2	11.7	8.6	2.0
MAR	9.5	2.1	14.2	5.8	1.5
RNF	7.1	7.4	7.8	9.9	2.0
SAF	20.4	7.4	17.3	13.1	5.0
RSA	6.9	6.0	24.3	9.0	7.6
RSS	3.3	3.6	17.0	3.8	3.3
ROW	6.8	3.5	11.5	15.1	0.9

Table 28: CO2 inventories (IEA)– mton – rebalanced dataset

	TOTAL	INDUSTRY	FINAL	ELEC.	CO2(kg/$)
AUS	119.9	91.2	28.7	37.9	0.3
NZL	10.5	8.1	2.4	0.9	0.2
JPN	456.7	349.1	107.7	104.8	0.1
KOR	141.9	104.5	37.4	24.9	0.3
IDN	80.1	54.4	25.7	18.2	0.4
MYS	32.6	25.5	7.0	7.7	0.4
PHL	16.7	11.2	5.4	3.5	0.2
SGP	31.7	28.7	3.0	6.1	0.5
THA	54.4	38.5	16.0	13.0	0.4
VNM	6.9	4.9	2.0	0.8	0.5
CHN	1135.6	992.3	143.2	302.5	1.5
HKG	21.3	19.7	1.6	6.1	0.2
TWN	69.9	57.0	12.9	17.3	0.2
IND	324.4	269.6	54.8	102.8	1.0
LKA	2.2	1.1	1.1	0.1	0.2
RAS	36.3	26.0	10.3	8.0	0.5
CAN	167.0	117.1	49.9	29.5	0.3
USA	2074.1	1556.6	517.5	569.3	0.3
MEX	113.5	75.1	38.4	22.0	0.4
CAM	38.9	31.6	7.2	8.1	0.5
VEN	40.1	28.3	11.8	7.5	0.6
COL	22.3	14.3	8.0	3.3	0.3
RAP	16.0	10.7	5.3	2.0	0.2
ARG	40.5	26.0	14.5	6.6	0.1
BRA	86.7	55.7	31.0	4.4	0.1
CHL	13.6	8.9	4.7	2.2	0.2
URY	1.8	1.3	0.5	0.1	0.1
RSM	1.3	0.4	0.9	0.1	0.2
GBR	205.7	139.1	66.6	48.2	0.2
DEU	339.8	237.5	102.3	88.1	0.1
DNK	27.6	20.3	7.2	8.7	0.2
SWE	20.7	13.0	7.7	2.6	0.1
FIN	22.6	17.2	5.3	5.9	0.2
REU	587.6	414.8	172.9	109.0	0.2
EFT	25.7	15.1	10.6	1.4	0.1
CEA	306.5	251.5	55.0	103.5	1.0
FSU	997.0	858.2	138.8	325.0	2.1
TUR	58.5	43.1	15.4	12.8	0.3
RME	298.8	224.8	74.0	64.7	0.6
MAR	10.5	8.6	1.9	2.9	0.4
RNF	77.6	62.1	15.4	18.6	0.7
SAF	140.3	118.4	21.9	43.4	0.9
RSA	10.0	8.3	1.7	2.3	0.5
RSS	35.1	23.1	12.0	4.3	0.2
ROW	73.2	62.4	10.7	20.5	0.3

Table 29: Sectoral CO2 intensities –kg per $output Rebalanced dataset

	ELY	I_S	CRP	NFM	NMM	T_T
AUS	3.7	0.5	0.3	1.5	0.3	0.0
NZL	0.5	0.6	0.4	0.1	0.1	0.1
JPN	0.5	0.2	0.1	0.1	0.1	0.0
KOR	1.8	0.2	0.3	0.1	0.3	0.1
IDN	4.6	0.9	0.4	0.3	1.6	0.0
MYS	1.5	0.3	0.2	0.4	0.6	0.1
PHL	1.1	0.3	0.1	0.2	0.8	0.0
SGP	2.6	0.4	0.2	0.1	0.1	0.3
THA	1.6	0.4	0.2	0.5	0.9	0.1
VNM	0.9	0.2	1.2		0.5	0.1
CHN	10.5	1.3	1.0	1.0	1.4	0.1
HKG	1.0	0.2	0.0	0.1	0.1	0.0
TWN	1.6	0.2	0.2	0.0	0.3	0.1
IND	4.1	1.1	0.8	1.7	1.8	0.1
LKA	0.3	0.2	0.1		0.2	0.2
RAS	2.1	0.4	0.5	0.6	2.6	0.1
CAN	1.1	0.3	0.4	0.3	0.3	0.1
USA	2.6	0.4	0.3	0.3	0.2	0.1
MEX	4.7	0.5	0.5	0.2	0.5	0.0
CAM	1.3	0.5	0.4	0.6	0.7	0.2
VEN	1.6	1.0	0.5	0.9	0.7	0.1
COL	1.3	0.2	0.1	1.2	1.2	0.1
RAP	1.0	0.3	0.1	0.1	0.2	0.1
ARG	1.1	0.1	0.0	0.1	0.1	0.1
BRA	0.3	0.2	0.1	0.1	0.1	0.1
CHL	1.0	1.2	0.1	0.1	0.3	0.0
URY	0.0	0.1	0.0		0.1	0.1
RSM	0.0		0.0		0.2	0.0
GBR	1.6	0.3	0.2	0.1	0.2	0.0
DEU	1.4	0.1	0.1	0.1	0.1	0.0
DNK	1.6	0.3	0.1	0.3	0.3	0.0
SWE	0.3	0.2	0.1	0.0	0.1	0.0
FIN	0.8	0.2	0.2	0.1	0.3	0.0
REU	1.0	0.3	0.2	0.1	0.2	0.0
EFT	0.1	0.1	0.0	0.0	0.1	0.0
CEA	5.6	1.3	0.6	0.8	0.9	0.1
FSU	9.4	3.3	1.5	2.2	1.6	0.4
TUR	1.7	0.5	0.3	0.3	0.3	0.0
RME	3.5	0.4	0.4	0.7	0.5	0.1
MAR	2.0	0.3	0.1	0.4	0.2	0.1
RNF	2.7	0.6	0.5	0.5	0.5	0.1
SAF	3.1	1.2	0.6	0.8	0.9	0.1
RSA	0.6	0.6	0.2	0.5	0.4	0.2
RSS	0.8	0.1	0.1	0.3	0.1	0.2
ROW	2.1	0.4	0.2	0.3	1.3	0.0