

Roma 19-11-2019



IRPET reef: un modello biregionale Input-Output economico/energetico

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IRPET

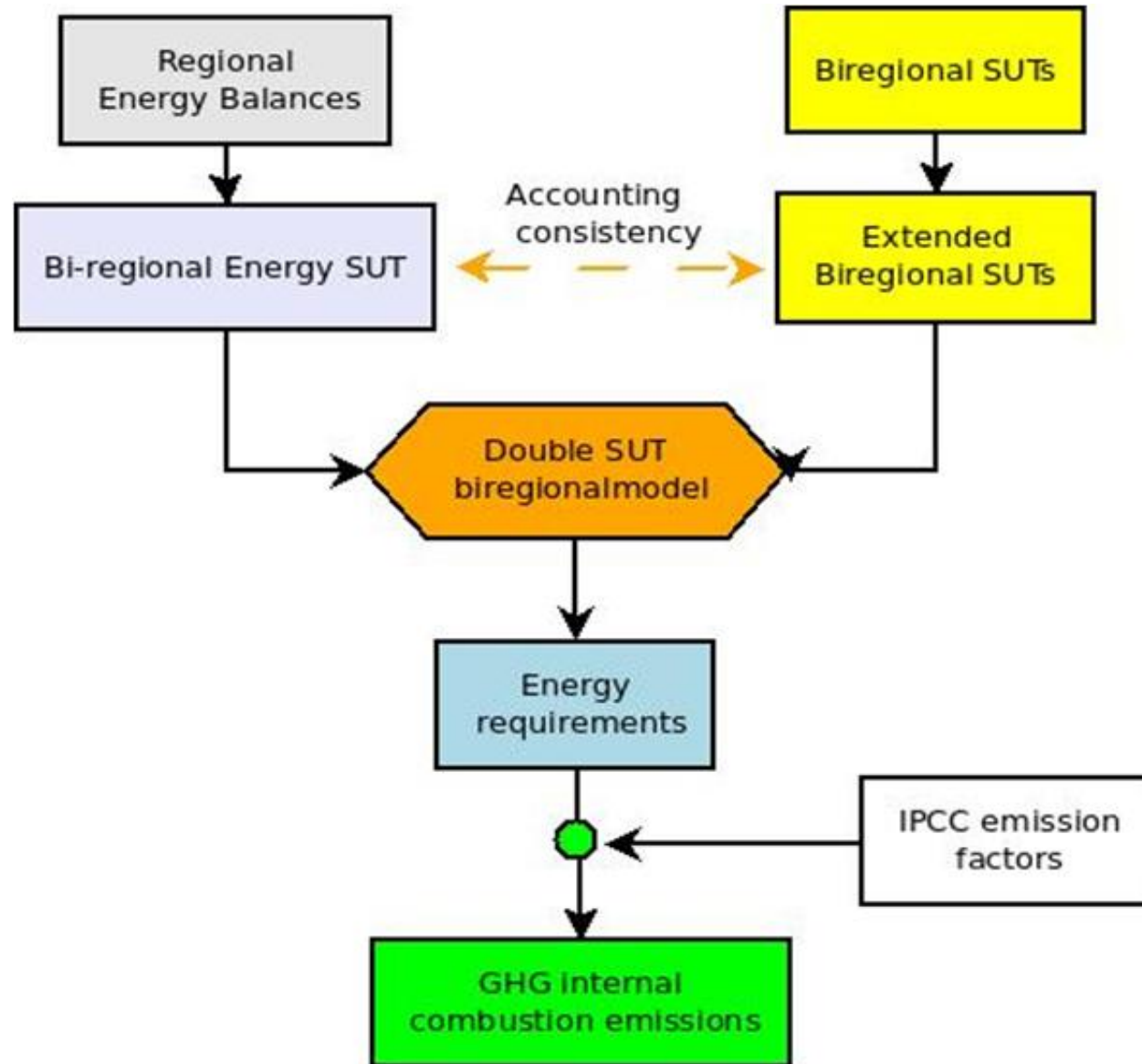


CREIAMO PA

Per un cambiamento sostenibile



IRPET reef: catena di montaggio



Caratteristiche costruttive SUT regionale

Maggiore dettaglio per settori e prodotti energetici in particolare I settori con ulteriore disaggregazione:

B- Estrattivo

1. Estrazione Carbone
2. Estrazione Petrolio greggio
3. Estrazione gas naturale
4. Altri minerali non energetici

D- Elettricità,
gas , vapore
aria
condizionata

1. Produzione Elettricità (per tipo)
2. Trasmissione
3. Distribuzione
4. Gas, vapore Aria condizionata

49 –Trasporti
terrestri

1. Trasporti su strada
2. Trasporti ferroviari
3. Pipelines
4. Altri trasporti



Caratteristiche costruttive energy SUT regionale

Stima attraverso una procedura che consenta di passare da una rappresentazione monodimensionale (T-accounts) tipica del Bilancio Energetico, ad una matriciale (SUT)

- Similarità con la SUT economica:

Prodotti –	Prodotti energetici
Settori –	Tipologia di impianti di trasformazione/elaborazione
Domanda Finale –	Consumi finali dei prodotti per settori e/o destinazione



Energy SUT aggregata toscana: 2015

		Energy Products												Transformation Sectors					Other	Energy	Non Energy	Final uses					Losses			
		Coal	Crude Oil	Oil Products	NGas	Coke&Gas	Hydro	Wind	Solar	OtherBio	Wastes	Geo Thermal	HeatD	Electricity	Electric Power stations	Heat station	Cokery	Refineries	Other stations	Export/Bunkers			Agriculture	Industry	Services	Transport	Residential			
Energy Products	Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-4.9	0.0	8.5	0.0	9.6	0.0	0.0	0.0	0.0	
	Crude Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4410.1	0.0	0.0	67.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Oil Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.2	0.0	0.0	2281.3	133.4	27.1	53.2	221.6	36.5	1033.5	1351.1	0.0	
	NGas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1580.6	0.0	0.0	0.0	0.0	0.0	0.0	24.1	0.0	1.8	321.0	505.9	21.0	1381.0	15.7	
	Coke&Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	
	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	2.4	0.0	8.9	0.0	
	OtherBio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.7	0.0	0.0	0.0	0.0	2.5	300.0	0.0	0.0	2.7	0.0	5.1	70.6	441.2	0.0	
	Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.0	0.0	0.0	0.0	0.0	22.8	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Geo Thermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	531.8	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.2	7.6	0.0	0.1	0.0	
	HeatD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.7	0.0	0.0	195.7	38.3	0.0	157.3	3.4	
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.1	0.0	25.1	587.5	604.0	73.7	339.3	134.2		
Transformation Sectors	Electric Power stations													485.5	1367.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	545.3
	Heat station														13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-9.8
	Cokery															0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Refineries	4348.5														0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.8
	Other stations														70.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-45.6
Production		0.0	0.0	0.0	0.9	0.0	47.7	19.1	88.1	821.5	112.3	546.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Import		13.2	4477.5	634.5	3826.3	0.0	0.0	0.0	0.0	23.6	0.0	0.0	0.0	477.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

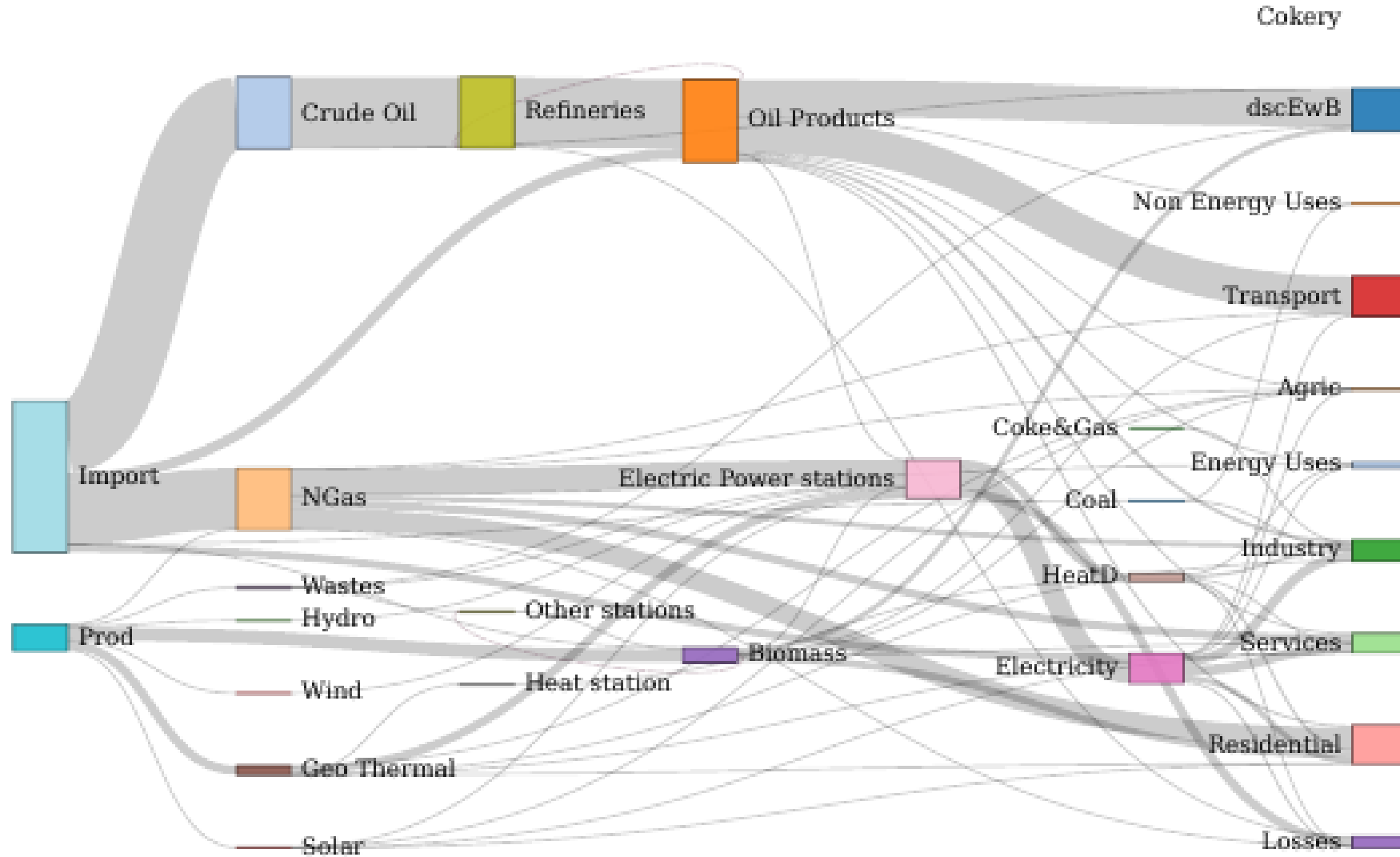


Energy SUT aggregata nazionale: 2015

		Energy Products												Transformation Sectors					Other	Energy	Non Energy	Final uses					Losses					
		Coal	Crude Oil	Oil Products	NGas	Coke&Gas	Hydro	Wind	Solar	OtherBio	Wastes	Geo Thermal	HeatD	Electricity	Electric Power stations	Heat station	Cokery	Refineries	Other stations	Export/Buyers			Agriculture	Industry	Services	Transport	Residential					
Energy Products	Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9704.0	0.0	2308.0	0.0	0.0	-61.0	4.4	92.5	0.0	306.9	0.0	0.0	0.0	0.0				
	Crude Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59633.6	0.0	626.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Oil Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4194.0	0.0	0.0	9906.7	0.0	25042.3	2600.9	4991.0	2112.2	3829.6	686.3	16234.8	19980.6	0.0				
	NGas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17829.1	0.0	0.0	0.0	0.0	814.1	1192.0	509.4	121.2	8546.5	6012.1	299.8	15923.1	272.8				
	Coke&Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	800.7	0.0	1512.4	0.0	0.0	182.9	20.1	0.0	0.0	713.3	0.0	0.0	0.0	0.0				
	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5034.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
	Wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1305.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
	Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1918.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	9.0	35.9	0.0	132.9	0.0			
	OtherBio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4729.3	83.1	0.0	0.0	1079.9	125.3	0.0	0.0	21.4	316.2	84.2	0.0	5675.5	0.0				
	Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1744.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	271.9	0.0	0.0	0.0	0.0	0.0			
	Geo Thermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5087.1	36.5	0.0	0.0	0.0	0.0	0.0	0.0	34.9	2.0	74.0	0.0	0.5	0.0	0.0			
	HeatD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1154.0	0.0	22.5	2629.2	276.9	0.0	818.4	18.2				
	Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	200.3	0.0	0.0	0.0	0.0	260.6	1742.6	0.0	462.0	9709.2	7608.7	895.5	5529.1	1672.5				
Transformation Sectors	Electric Power stations													4835.4	32261.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23706.6		
	Heat station														83.7	56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-20.9	
	Cokery																0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1552.2	
	Refineries																0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1110.8
	Other stations																0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1072.5
Production		54.6	5763.9	219.0	5855.1	0.0	5034.0	1305.1	2097.6	9114.1	2016.2	5235.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Import		12302.8	53832.7	17429.5	45665.1	823.3	0.0	0.0	0.0	2993.4	0.0	0.0	0.0	4019.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			



Flussi da energy SUT Toscana



Dalla energy SUT al modello: i parametri

		Energy Products													Transformation Sectors					Other	Energy	Non Energy	Final uses					Losses		
		Coal	Crude Oil	Oil Products	NGas	Coke&Gas	Hydro	Wind	Solar	OtherBio	Wastes	Geo Thermal	HeatD	Electricity	Electric Power stations	Heat station	Cokery	Refineries	Other stations	Export/Bunkers				Agriculture	Industry	Services	Transport	Residential	Losses	
Energy Products	Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0018	0.2385	0.0000	0.0072	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
	Crude Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	1.0000	0.0000	0.0255	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Oil Products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0019	0.0000	0.0000	0.0000	0.0000	0.8613	0.3896	0.7615	0.6156	0.1659	0.0304	0.8622	0.3673	0.0000		
	NGas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6590	0.0000	0.0000	0.0000	0.0000	0.0000	0.0704	0.0000	0.0210	0.2403	0.4216	0.0175	0.3754	0.1025		
	Coke&Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	
	Hydro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0199	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
	Wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0079	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
	Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0317	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0014	0.0000	0.0020	0.0000	0.0024	0.0000	
	OtherBio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0299	0.0000	0.0000	0.0000	0.1002	0.1133	0.0000	0.0000	0.0310	0.0000	0.0043	0.0589	0.1199	0.0000		
	Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0279	0.0000	0.0000	0.0000	0.8998	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
	Geo Thermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2217	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0405	0.0001	0.0064	0.0000	0.0000	0.0000		
	HeatD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3031	0.0000	0.0000	0.1465	0.0319	0.0000	0.0428	0.0225		
	Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2369	0.0000	0.2905	0.4398	0.5034	0.0615	0.0922	0.8750		
Transformation Sectors	Electric Power stations													0.2620	0.7380	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Heat station													1.0000		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Cokery	1.0000														0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Refineries															0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Other stations															0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Production		0.0000	0.0000	0.0000	0.0002	0.0000	1.0000	1.0000	1.0000	0.8968	1.0000	1.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Import		1.0000	1.0000	0.1273	0.9998	0.0000	0.0000	0.0000	0.0000	0.0258	0.0000	0.0000	0.0000	0.2586	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Losses		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2274	2.6291	0.0000	-0.0140	1.8044	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

C_e = product share

B_e = product input share

H_e = Energy Uses product share

r = transf. Losses coeff

H_{ne} = Non Energy Uses product share



CREIAMO PA

Il solo modello energetico: forma ridotta

Tipo : prodotto \underline{x} prodotto, industry technology

Principali soluzioni : i) il fabbisogno regionale di prodotti energetici ; ii) emissioni regionali di GHG

E' demand driven quindi è attivato da **Utilizzi finali**

$$q_e = \left[\mathbf{I} + \widehat{\mathbf{r}} \cdot \mathbf{C}_e - (\mathbf{B}_e \cdot \mathbf{C}_e + \mathbf{H}_{ne} + \mathbf{H}_e) \right]^{-1} \cdot (\mathbf{z} + \mathbf{X}_e + \mathbf{f}_e)$$

Δ invent, bunkers export

Production, transport

Residential, Household transport



Il modello integrato: forma ridotta

Modello economico

$$\mathbf{x} = \left[\mathbf{I} - \mathbf{T} \cdot (\widehat{\mathbf{D}} \cdot \widehat{\mathbf{B}}) \right]^{-1} \cdot \left[\widehat{\mathbf{D}} \cdot (\mathbf{T} \cdot \mathbf{f} + \mathbf{e}_w) \right]$$

Dove: $\mathbf{T} = (\mathbf{I} - \widehat{\mathbf{M}}_w - \mathbf{M}_r) + \check{\mathbf{M}}_r$

Linkages:

$$\mathbf{X}_e = \widehat{\Theta} \cdot \hat{\mathbf{x}}; \quad \mathbf{f}_e = \widehat{\Phi} \cdot \hat{\mathbf{f}}$$

Modello energetico

$$\mathbf{q}_e = \left[\mathbf{I} + \mathbf{r} \cdot \widehat{\mathbf{C}}_e - (\mathbf{B}_e \cdot \mathbf{C}_e + \mathbf{H}_{ne} + \mathbf{H}_e) \right]^{-1} \cdot (\mathbf{X}_e + \mathbf{f}_e)$$



Esempio impatto: export estero Toscana

Export estero = 33451 (Meuro)

	Toscana	Resto Italia	ratio
PIL	18890	6160	3.067
Output	47080	16588	2.838
Co2 (kT)	3067	1794	1.710

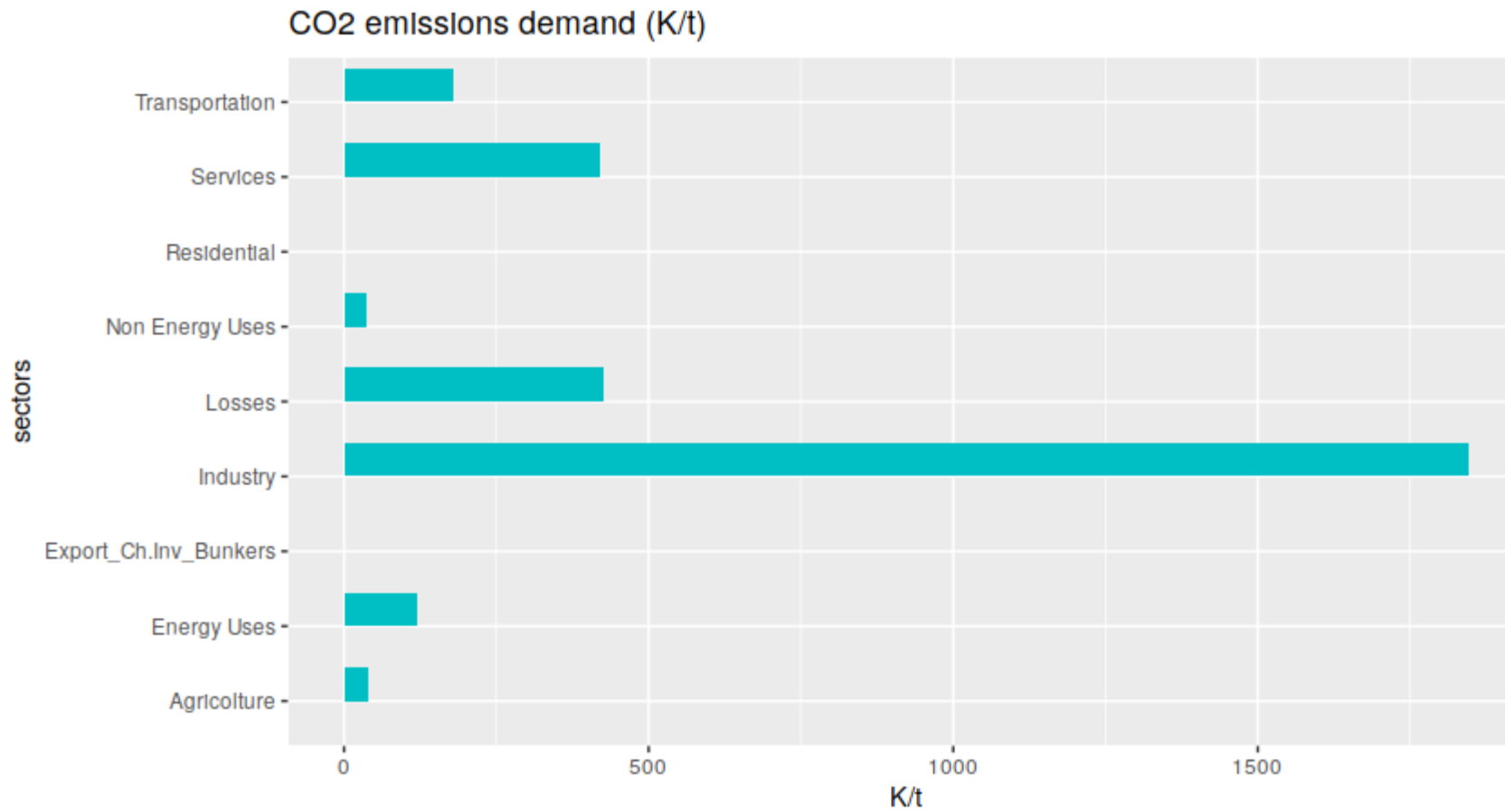


Quantità prodotti energetici attivati (ktep)

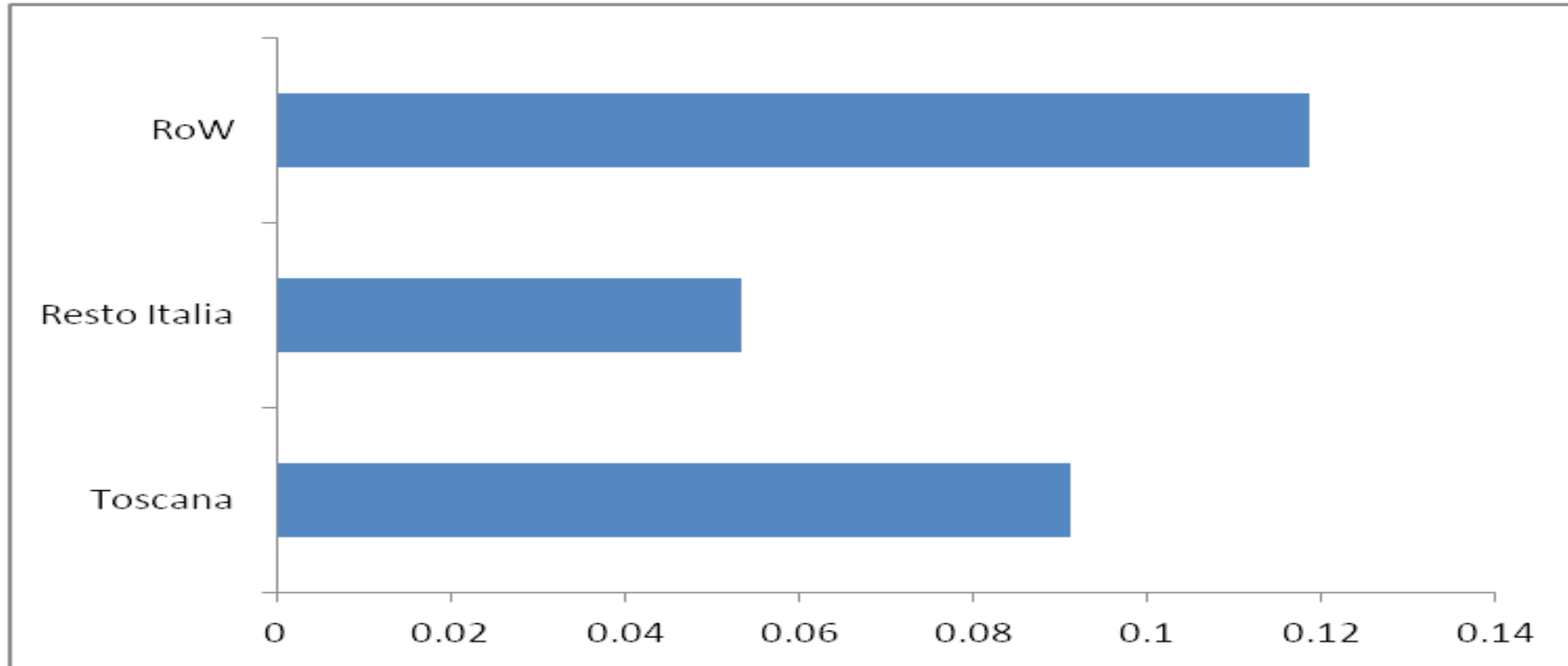
	Totale	Primario	Secondario	Secondario derivato	Importazioni
Coal	0.1	0	0.1	0	7.8
CrudeOil	2530.1	2462.7	67.5	0	2530.1
OilProducts	2508.9	1.1	2507.8	0	115
NGas	618.4	354.6	263.8	0	614.4
CokeGas	-20.5	0	-20.5	0	0
Hydro	10.9	10.9	0	0	0
Wind	4.3	4.3	0	0	0
Solar	17.4	17.3	0	0	0
Biomass	318.7	16.7	302.1	0	0
Wastes	20.2	20.2	0	0	0
GeoThermal	122.7	122	0.7	0	0
HeatD	109.6	0	0	109.6	0
Electricity	420.4	0	0	420.4	108.7



Impatto emissioni CO2 per domanda



Impatto su carbon footprint: (1 Meuro export)



Flussi prodotti energetici attivati (al netto export petroliferi raffinati)

Aggiornamento e miglioramento SUT:

- 1- Conti energetici regionali ISTAT come vincolo
- 2- Ulteriore disaggregazione SUT economica

Modello:

- 1- Chiusura rispetto ai prezzi (soprattutto LCOE) ossia attivazione del circuito energia-sistema economico

Applicazioni:

- 1- Calcolo GHG footprint
- 2- Utilizzo del modello per stimare impatto transizione energetica



Fine presentazione



CReIAMO PA

Per un cambiamento sostenibile

