Urban Nitrogen Budgets Comparison Across Cities

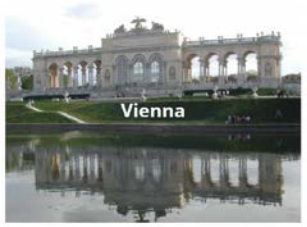
Katrin Kaltenegger[1]*, Xiangwen Fan[2], Samuel Guéret[1], Monika Suchowska-Kisielewicz[3], Wilfried Winiwarter[1,3]

[1] International Institute for Applied Systems Analysis (IIASA), Vienna, Austria
[2] Chinese Academy of Sciences, Shijiazhuang, China
[3] Institute of Environmental Engineering, University of Zielona Góra, Poland

Urban Nitrogen

- 2050: around 60% of population in urban area (UN, 2018)
- Pollution and potential (Svirejeva-Hopkins & Reis, 2011)
- Nr budgets focus on agriculture
- No consistent approach for urban environment (Winiwarter et al., 2020)

Objectives



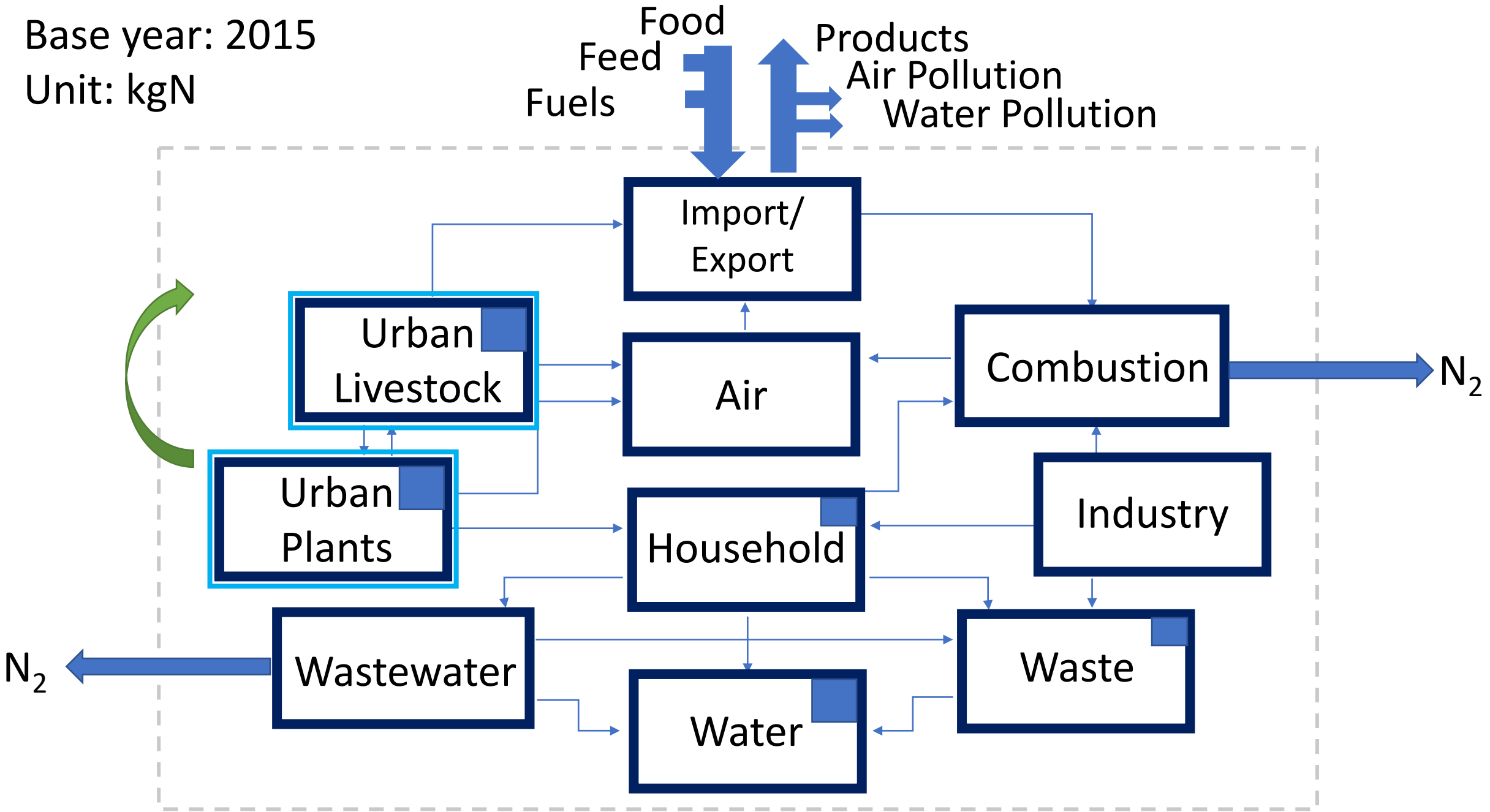
- Develop a framework for urban nitrogen budgets
  - Implement as stock and flow model
- Apply to 4 cities (urban and a peri-urban area)
- Characterize system & find patterns through comparison
  - Biggest flows per pool and in overall budget
  - Identification of Nr sinks and sources
  - Flows per capita & per area where relevant
  - Evaluate (environmental) impacts
- Identifying potentials/solutions supporting the development of a circular economy

IIASA

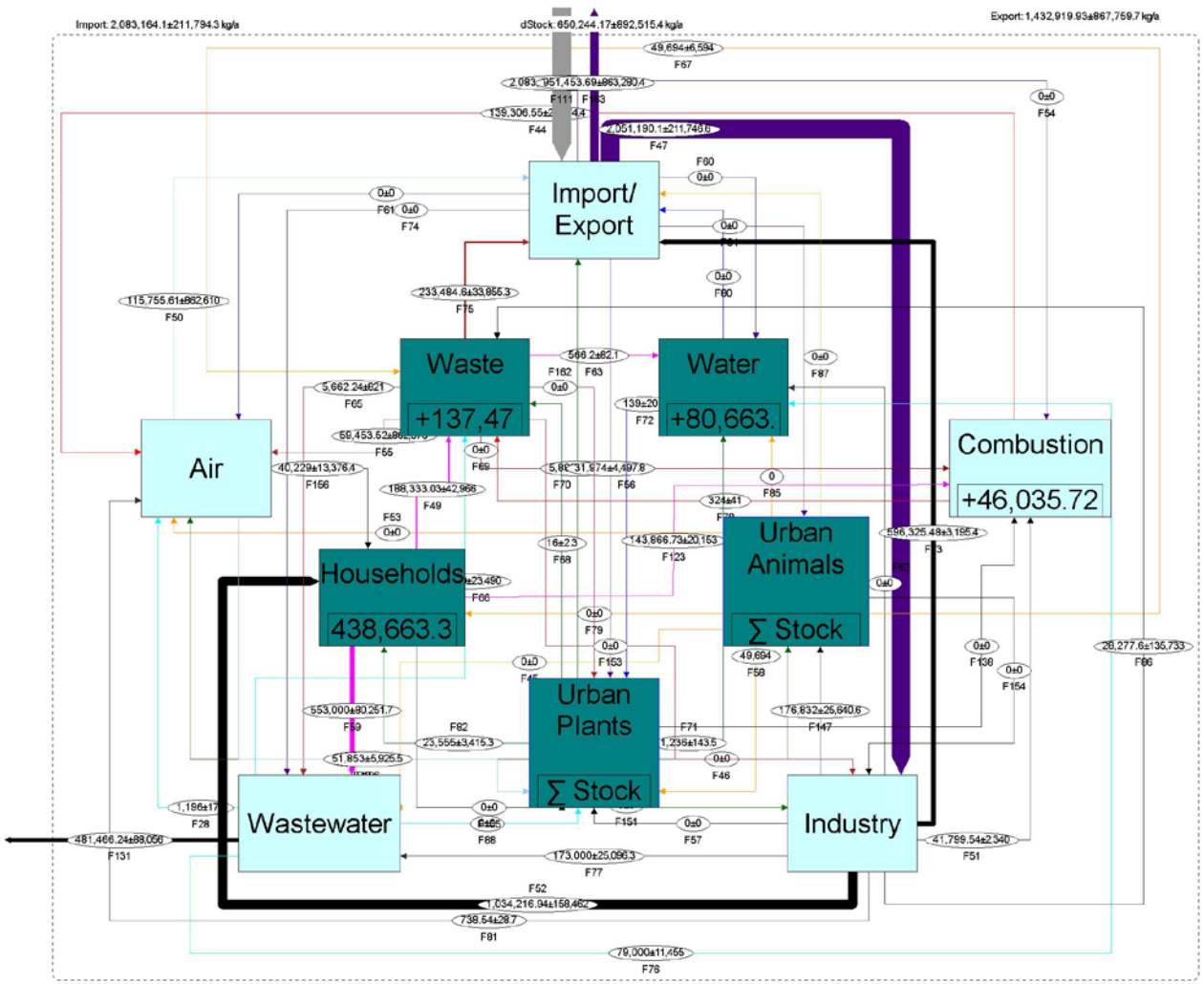
UNIWERSYTET ZIELONOGÓRSKI

E.C.O. Institut für Ökologie

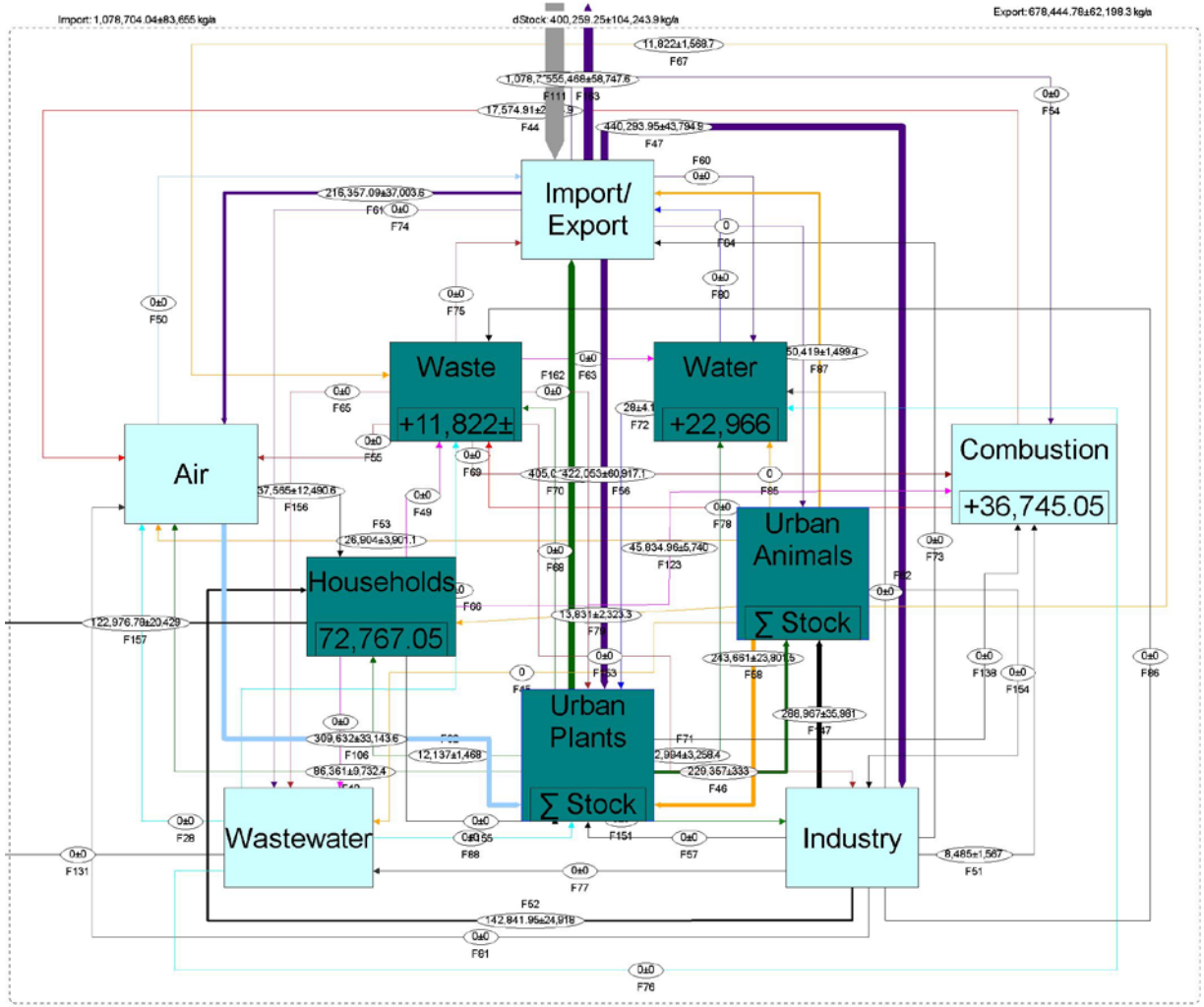
brainflows


Base year: 2015
Unit: kgN
Food
Feed
Fuels
Products
Air Pollution
Water Pollution
Import/
Export
Urban
Livestock
Air
Combustion
N_2
Urban
Plants
Household
Industry
N_2
Wastewater
Waste
Water

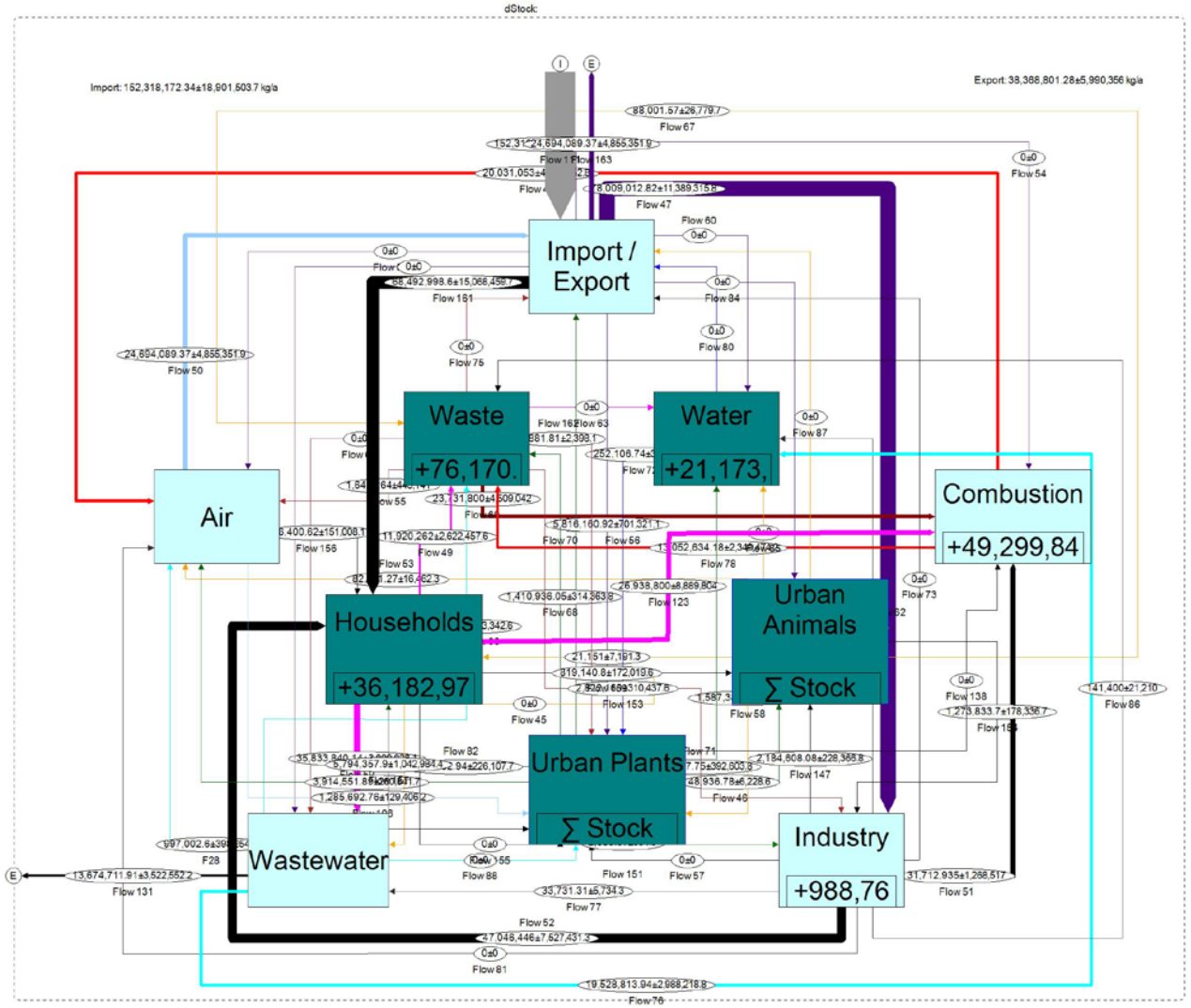
Zielona Gora Core



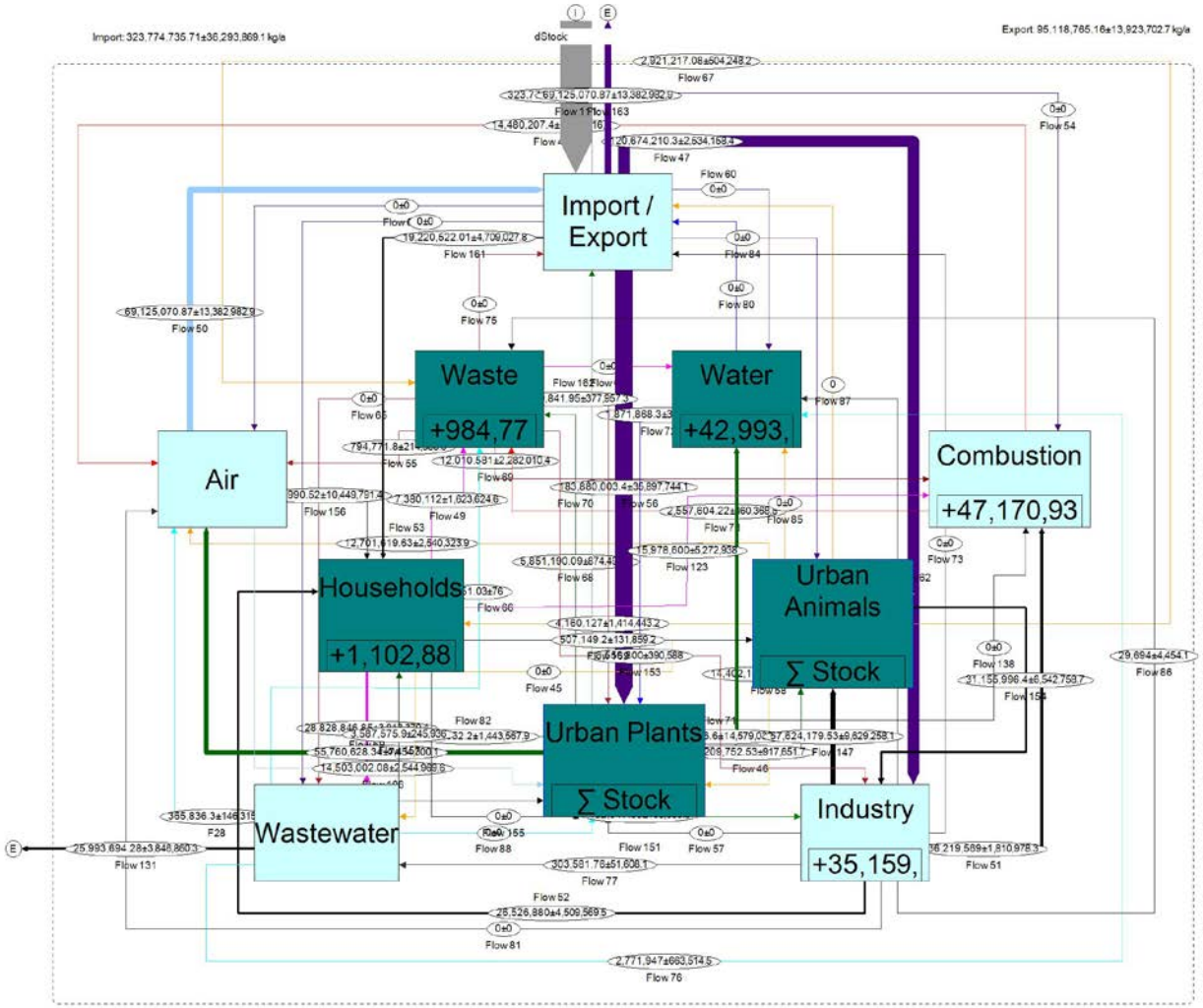
Zielona Gora Surrounding



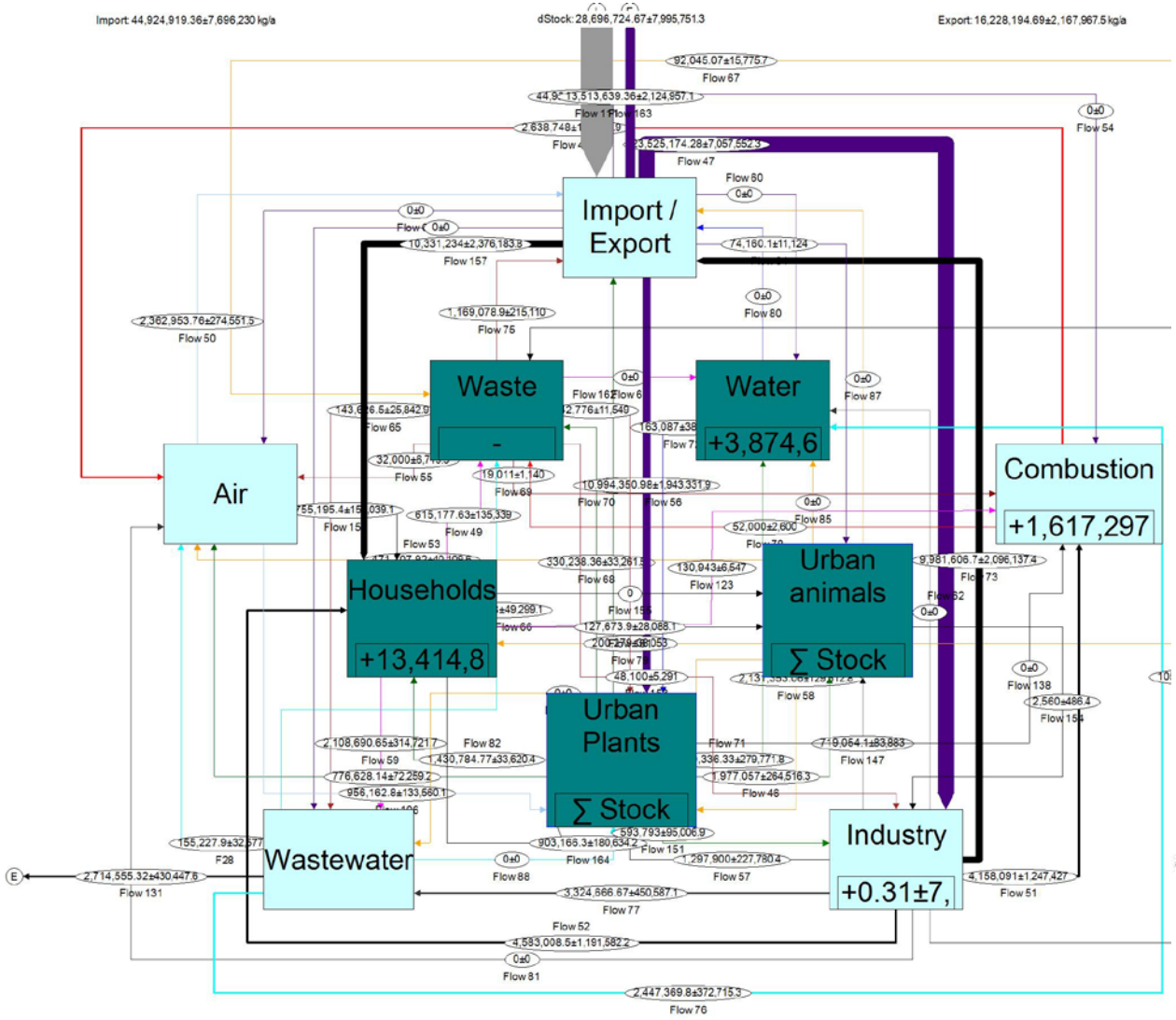
Beijing Core



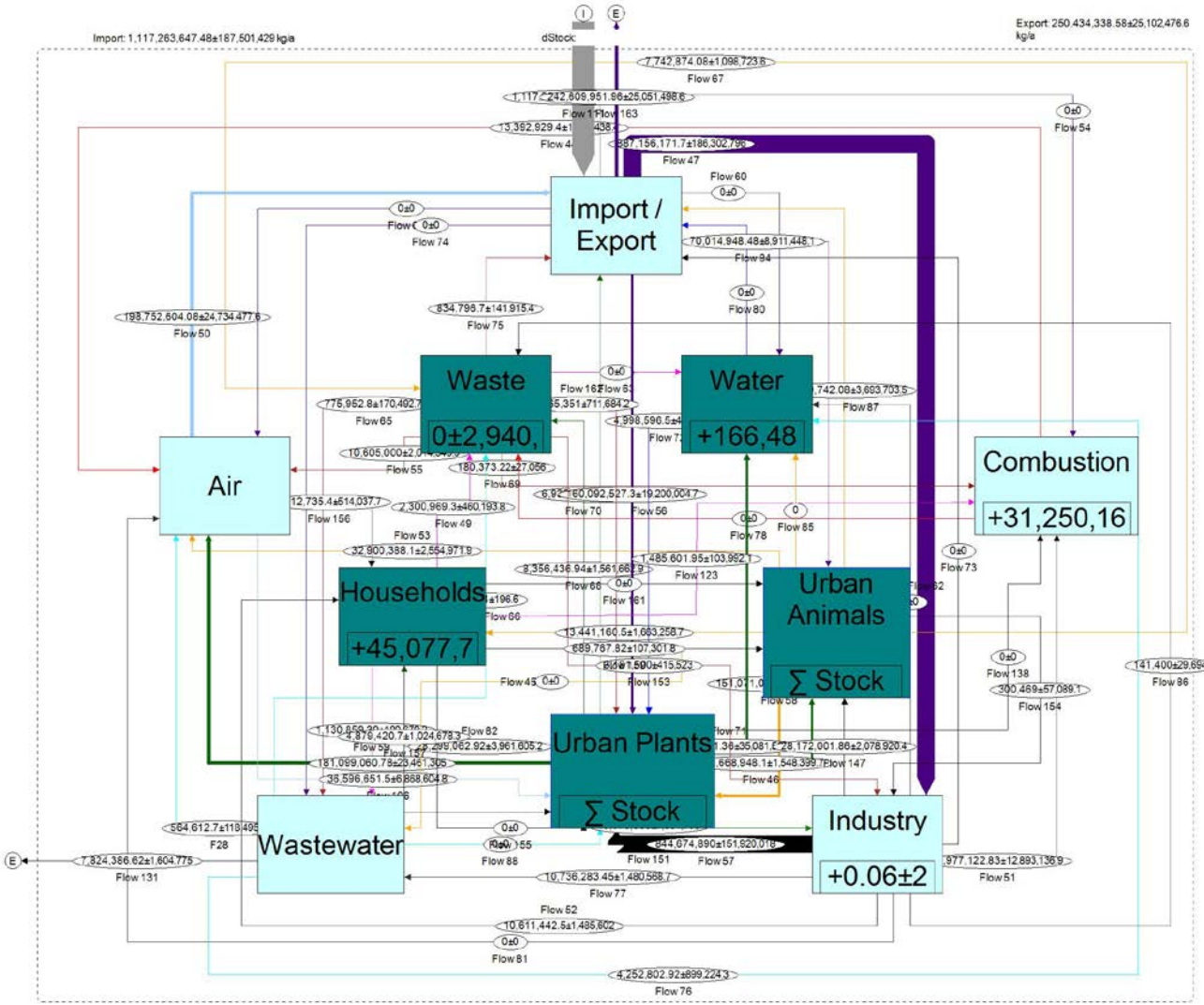
Beijing Surrounding



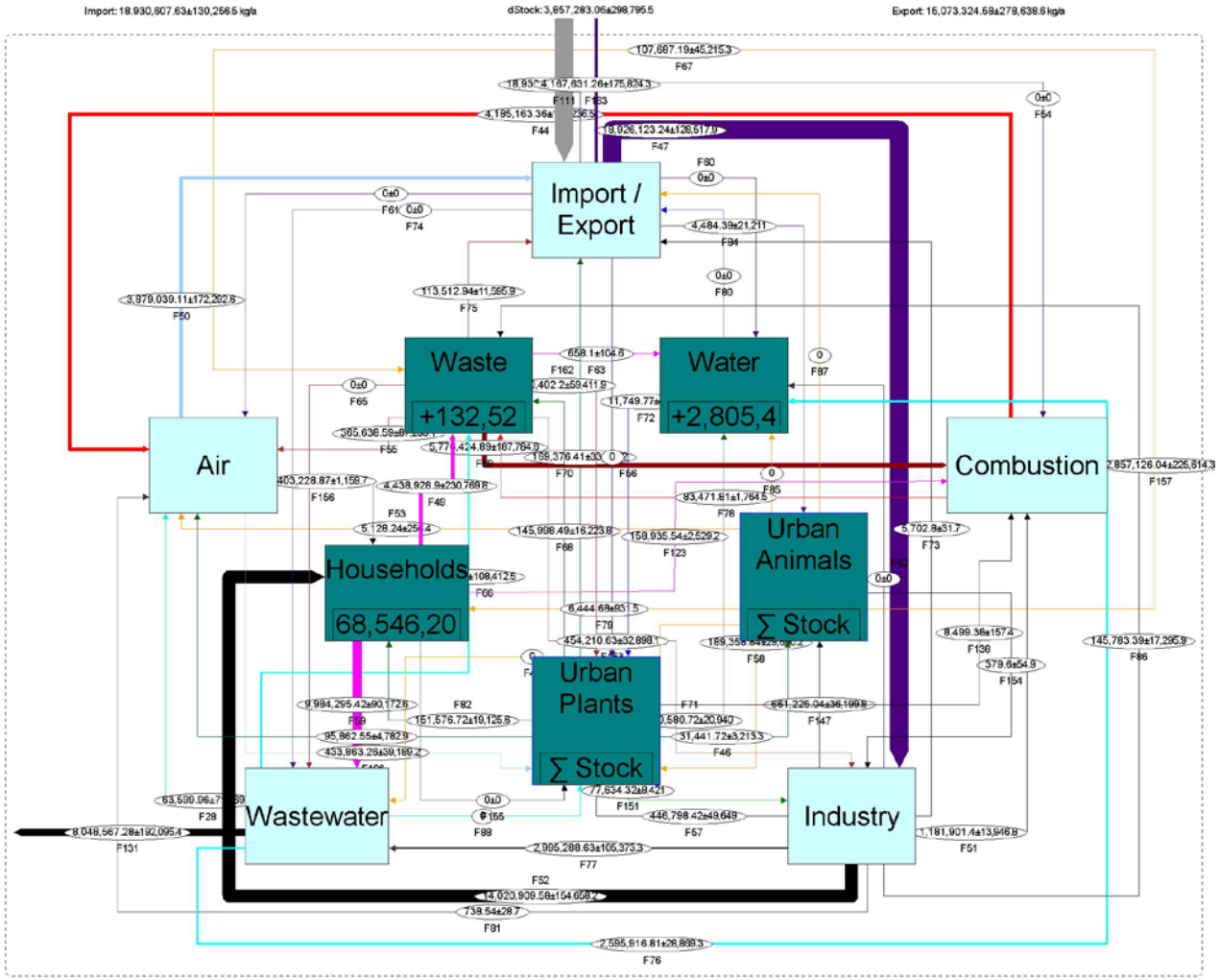
Shijiazhuang Core



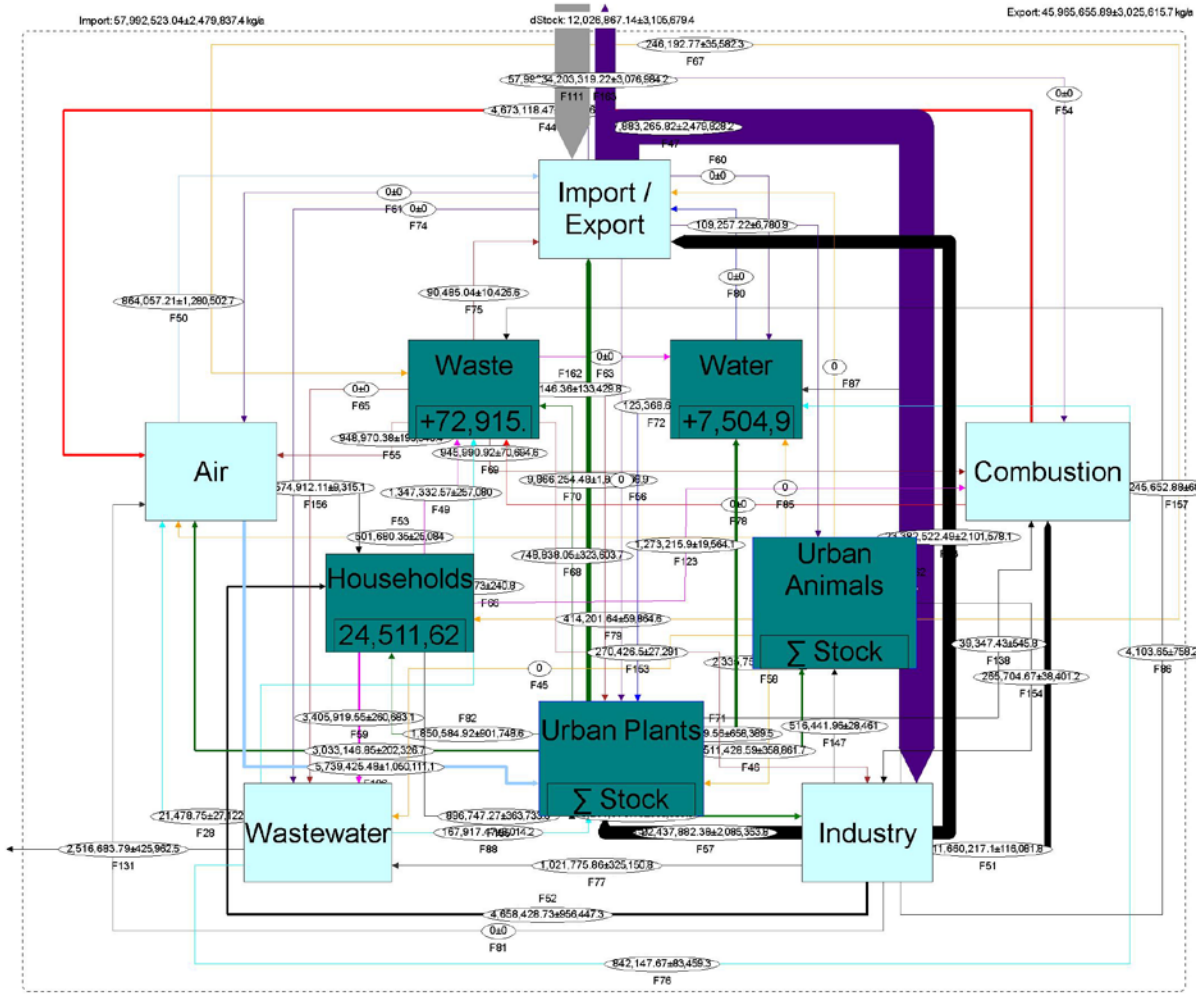
Shijiazhuang Surrounding

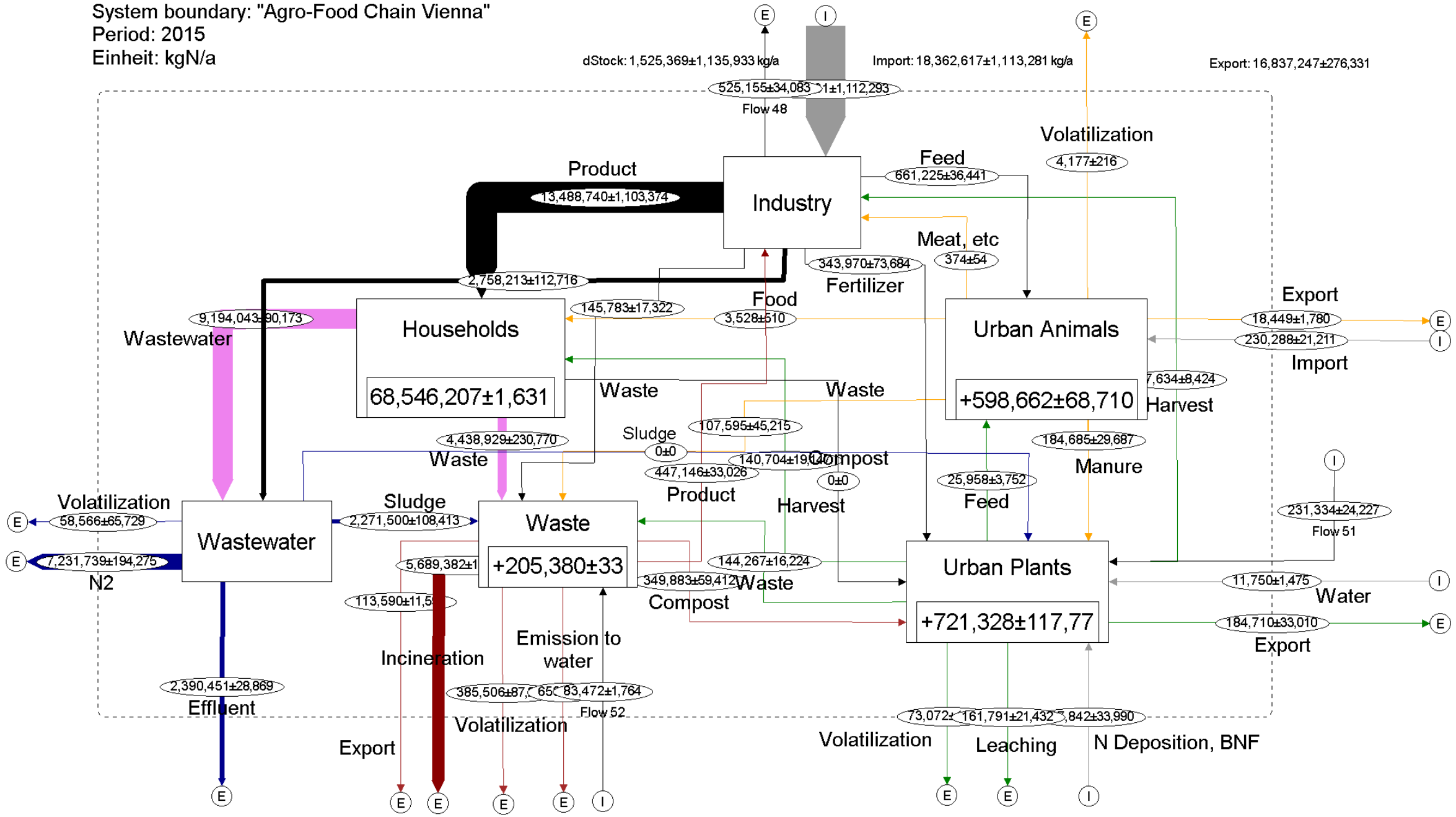


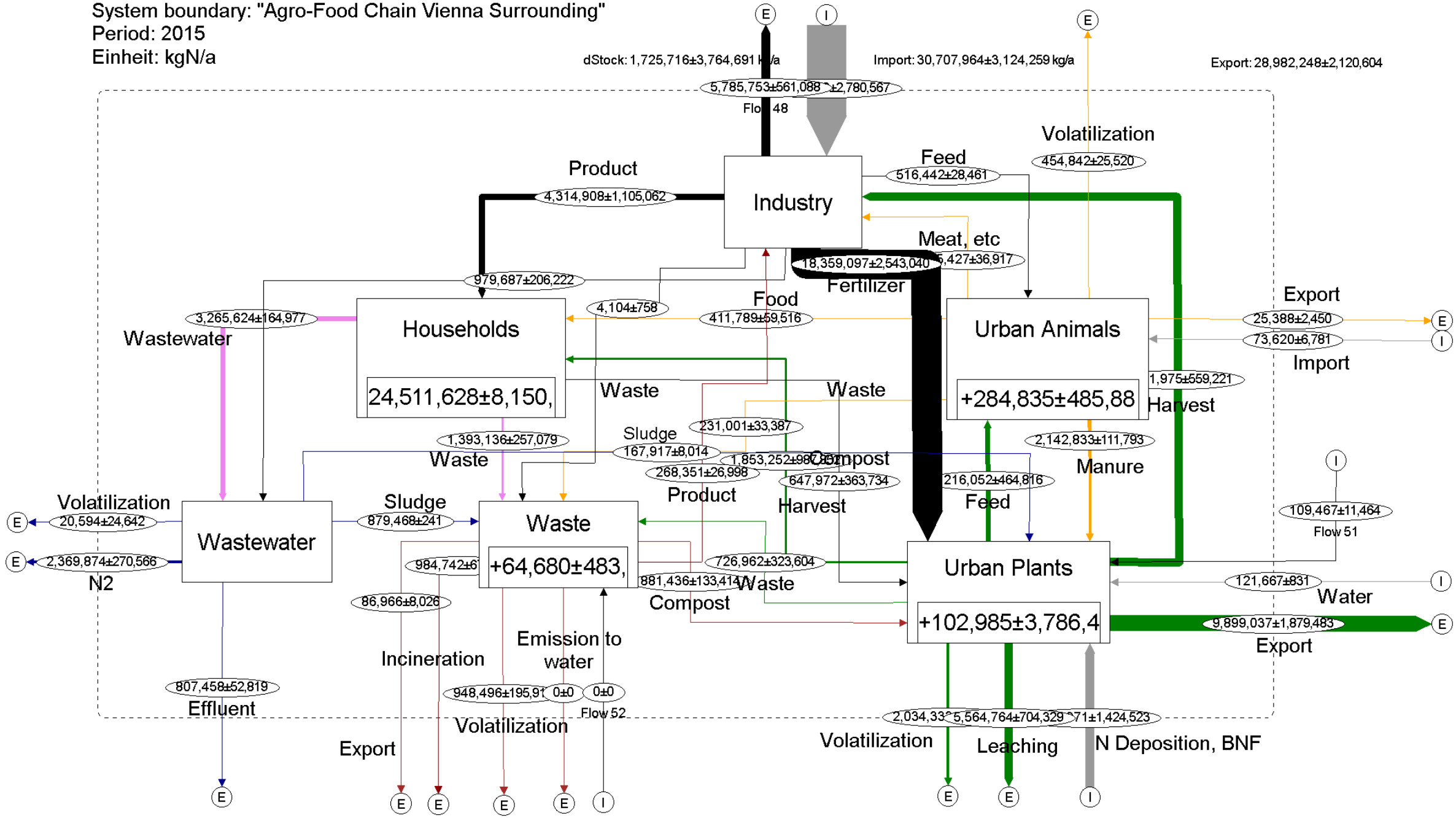
Vienna Core

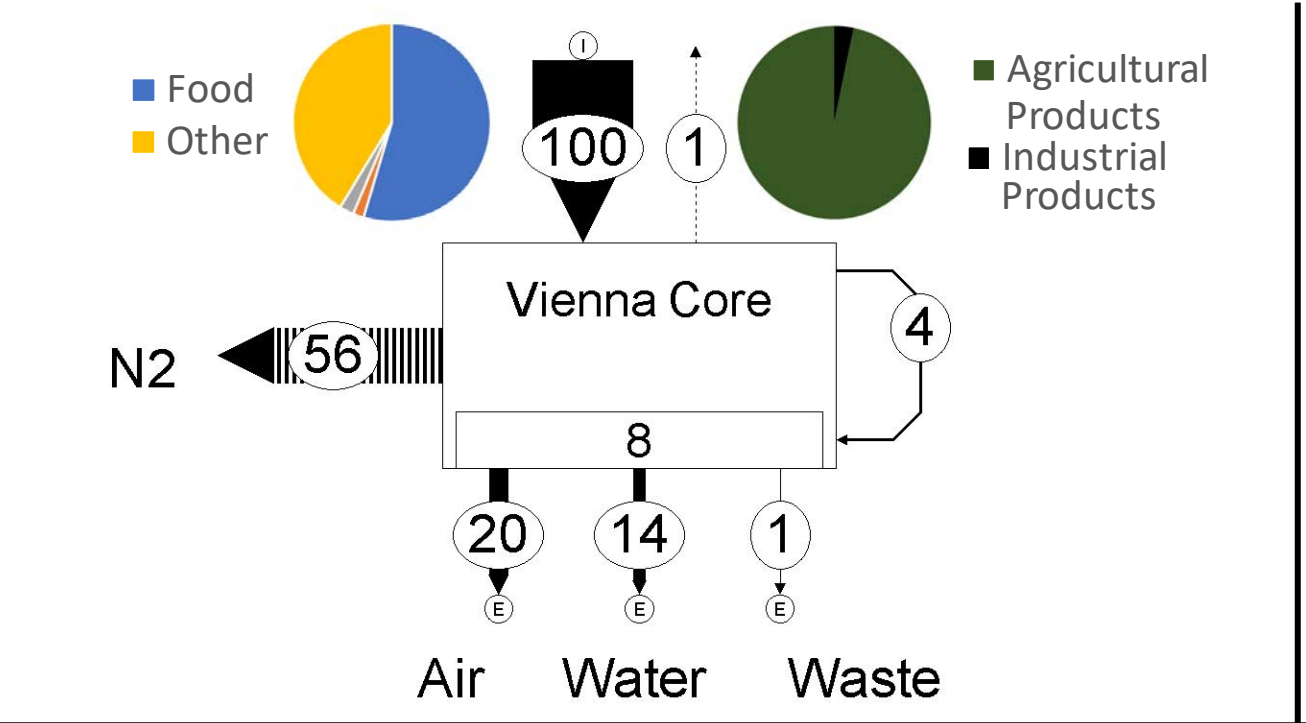


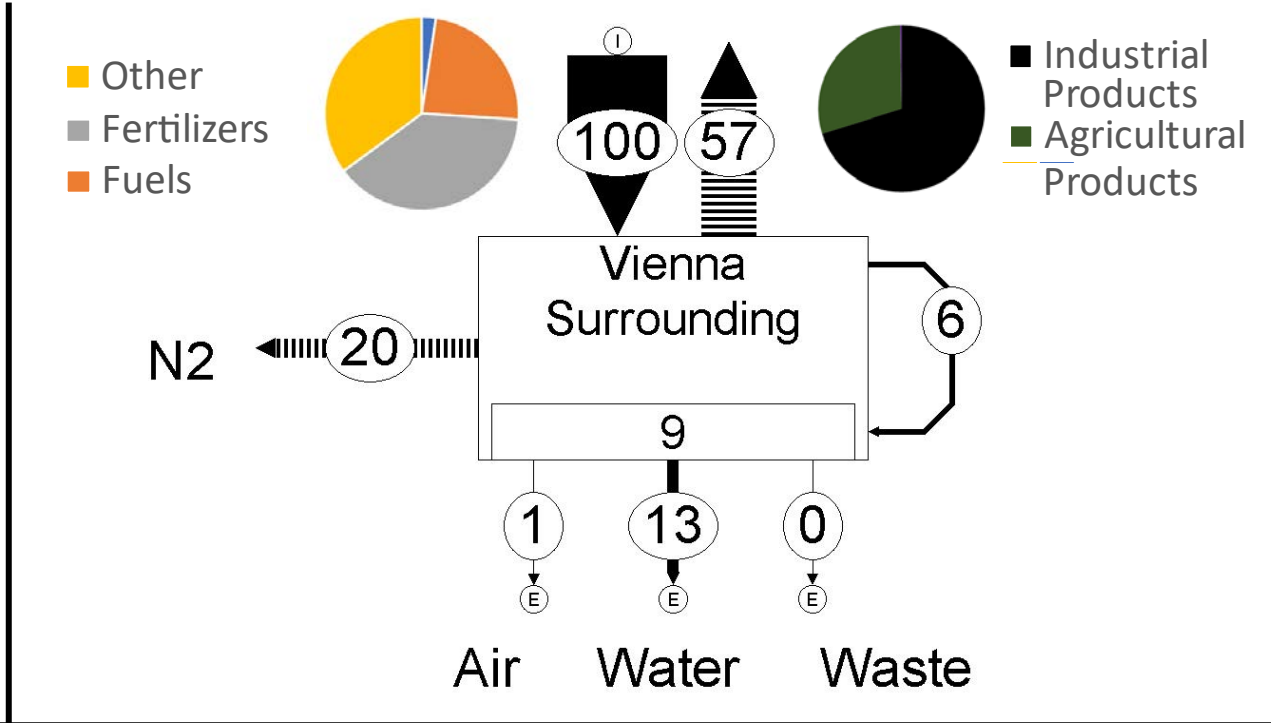
Vienna Surrounding

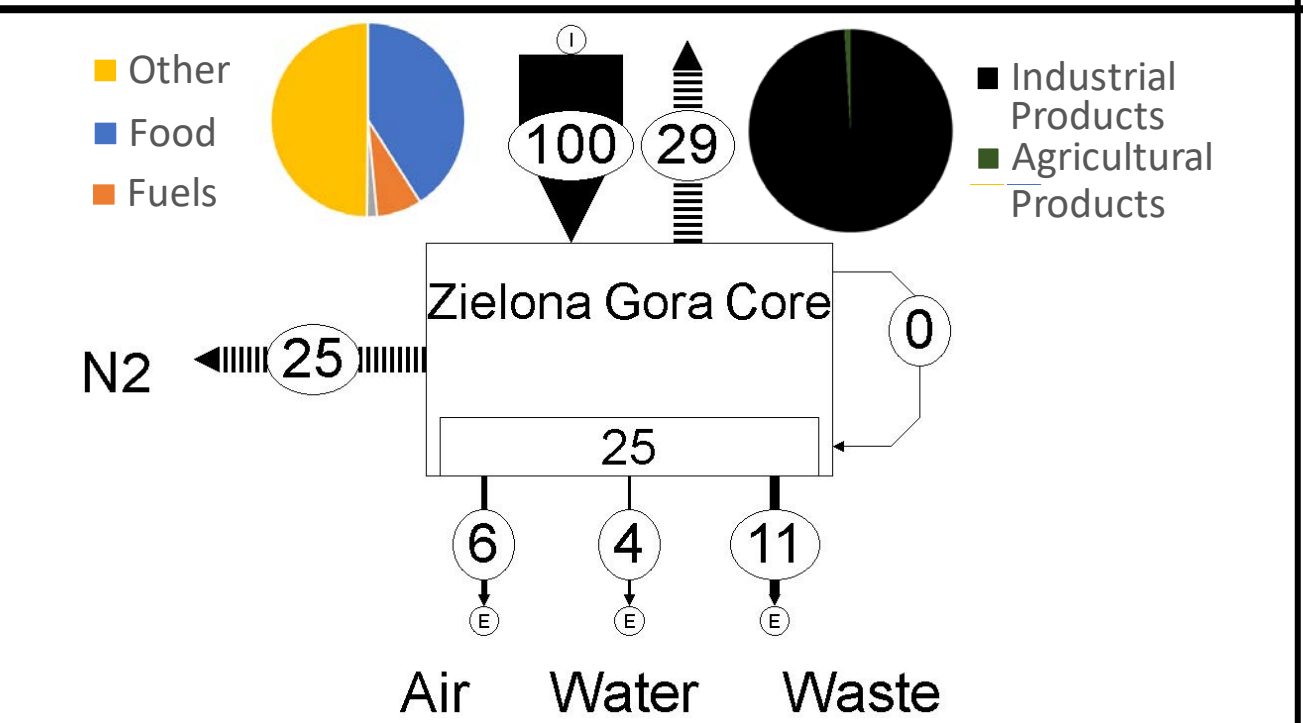


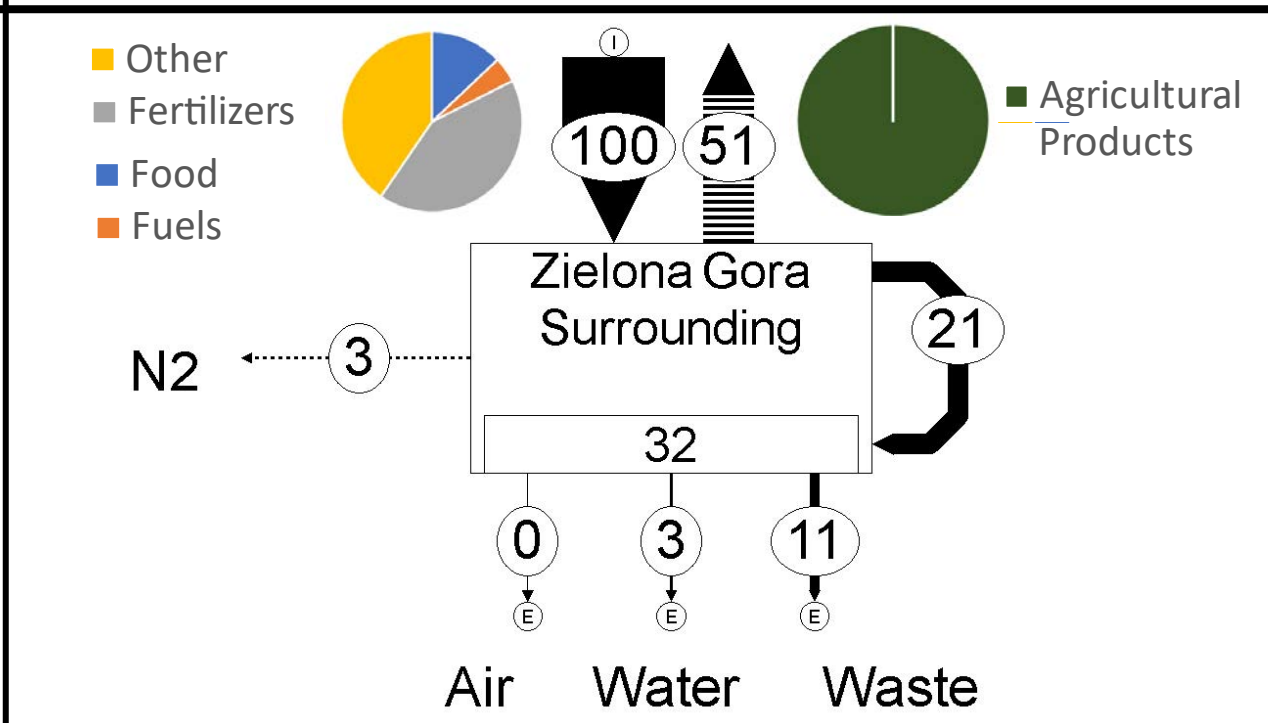

System boundary: "Agro-Food Chain Vienna"
Period: 2015
Einheit: kgN/a
dStock: 1,525,369±1,135,933 kg/a
Import: 18,362,617±1,113,281 kg/a
Export: 16,837,247±276,331
525,155±34,083
1±1,112,293
Flow 48
Volatilization
4,177±216
Product
13,488,740±1,103,374
Industry
Feed
661,225±36,441
Meat, etc
374±54
343,970±73,684
Fertilizer
2,758,213±112,716
Food
3,528±510
145,783±17,322
9,194,043±90,173
Wastewater
Households
68,546,207±1,631
Waste
Waste
Urban Animals
+598,662±68,710
Export
18,449±1,780
230,288±21,211
Import
7,634±8,424
Harvest
4,438,929±230,770
Waste
Sludge
0±0
107,595±45,215
140,704±19,040
447,146±33,026
Product
Compost
0±0
Harvest
184,685±29,687
Manure
25,958±3,752
Feed
Volatilization
58,566±65,729
7,231,739±194,275
N2
Wastewater
Sludge
2,271,500±108,413
Waste
+205,380±33
5,689,382±1
113,590±11,5
144,267±16,224
349,883±59,412
Waste
Compost
Urban Plants
+721,328±117,77
231,334±24,227
Flow 51
11,750±1,475
Water
184,710±33,010
Export
2,390,451±28,869
Effluent
Incineration
Emission to water
385,506±87,
65
83,472±1,764
Flow 52
Volatilization
Export
73,072±
161,791±21,432
842±33,990
Volatilization
Leaching
N Deposition, BNF

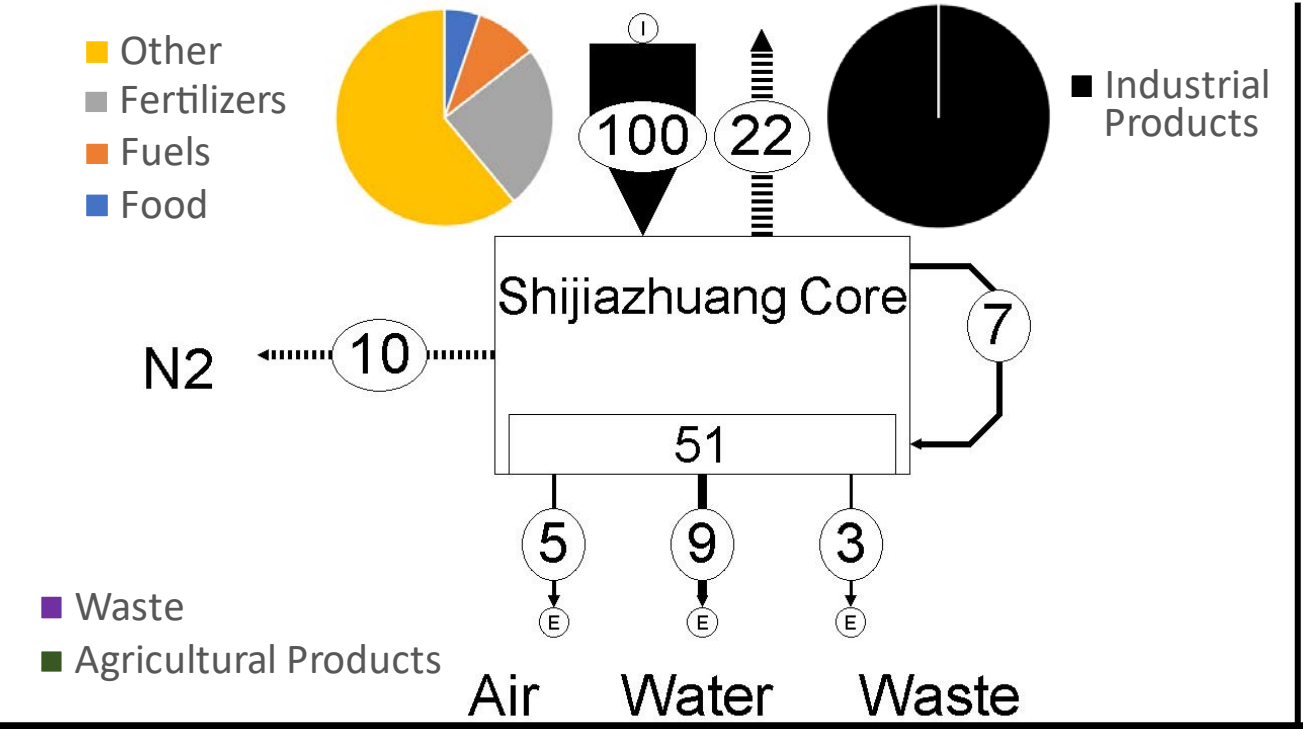

System boundary: "Agro-Food Chain Vienna Surrounding"
Period: 2015
Einheit: kgN/a
dStock: 1,725,716±3,764,691 kg/a
Import: 30,707,964±3,124,259 kg/a
Export: 28,982,248±2,120,604
5,785,753±561,088
±2,780,567
Flow 48
Industry
Product
4,314,908±1,105,062
Feed
516,442±28,461
Volatilization
454,842±25,520
Meat, etc
18,359,097±2,543,040
5,427±36,917
Fertilizer
979,687±206,222
Households
24,511,628±8,150,
3,265,624±164,977
Wastewater
4,104±758
Food
411,789±59,516
Urban Animals
+284,835±485,88
Export
25,388±2,450
73,620±6,781
Import
1,975±559,221
Harvest
Waste
Waste
231,001±33,387
1,393,136±257,079
Waste
Sludge
167,917±8,014
1,853,252±987,861
Compost
268,351±26,998
Product
647,972±363,734
Harvest
216,052±464,816
Feed
2,142,833±111,793
Manure
Volatilization
20,594±24,642
Wastewater
Sludge
879,468±241
Waste
+64,680±483,
984,742±6
881,436±133,414
Waste
726,962±323,604
Compost
109,467±11,464
Flow 51
Urban Plants
+102,985±3,786,4
121,667±831
Water
9,899,037±1,879,483
Export
2,369,874±270,566
N2
86,966±8,026
Incineration
Emission to water
807,458±52,819
Effluent
948,496±195,91
0±0
0±0
Flow 52
Volatilization
Export
2,034,33
5,564,764±704,329
71±1,424,523
Volatilization
Leaching
N Deposition, BNF

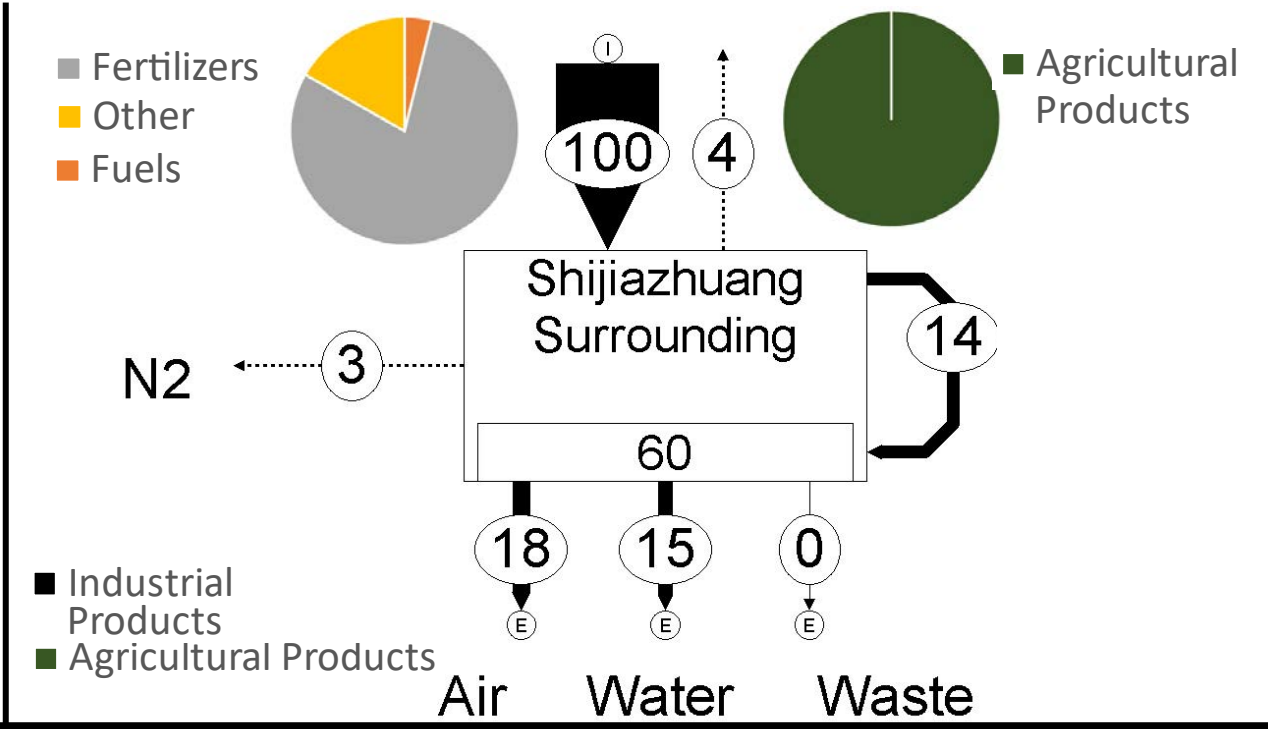

Food
Other
Agricultural Products
Industrial Products
100
1
Vienna Core
N2
56
4
8
20
14
1
E
Air
Water
Waste

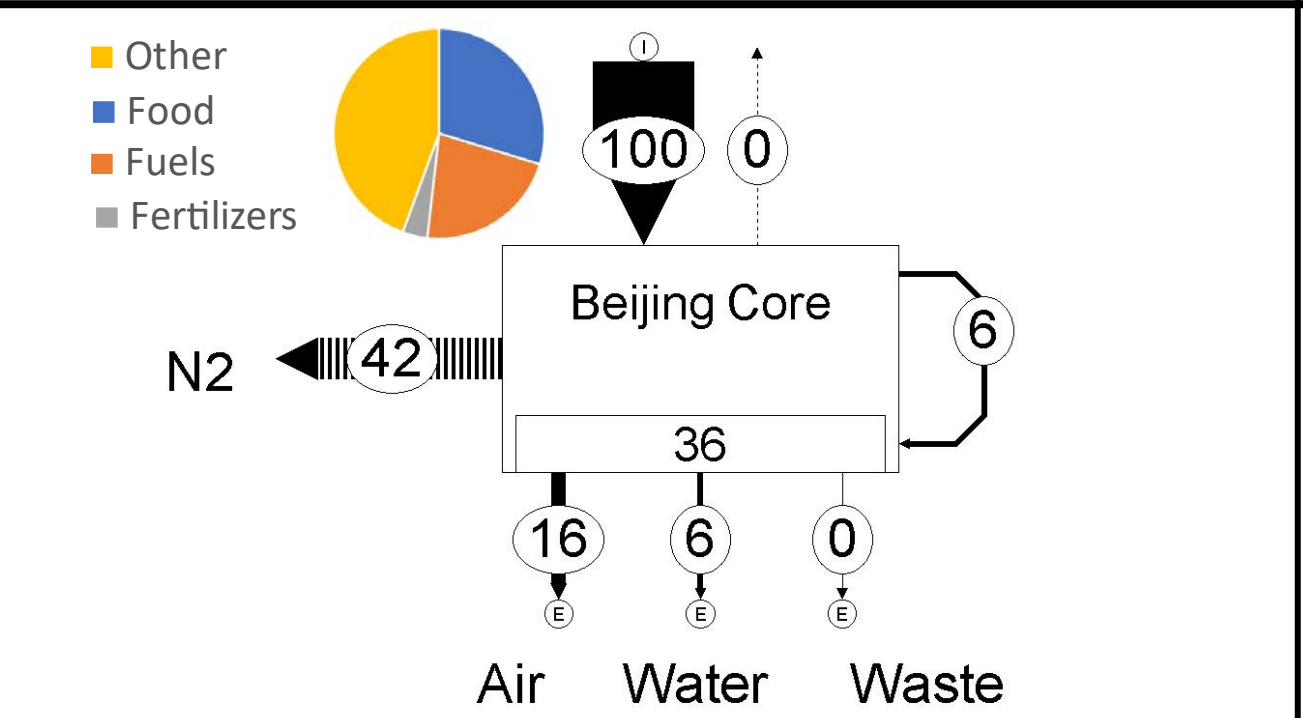

Other
Fertilizers
Fuels
Industrial Products
Agricultural Products
100
57
Vienna Surrounding
N2
20
6
9
1
13
0
E
Air
Water
Waste

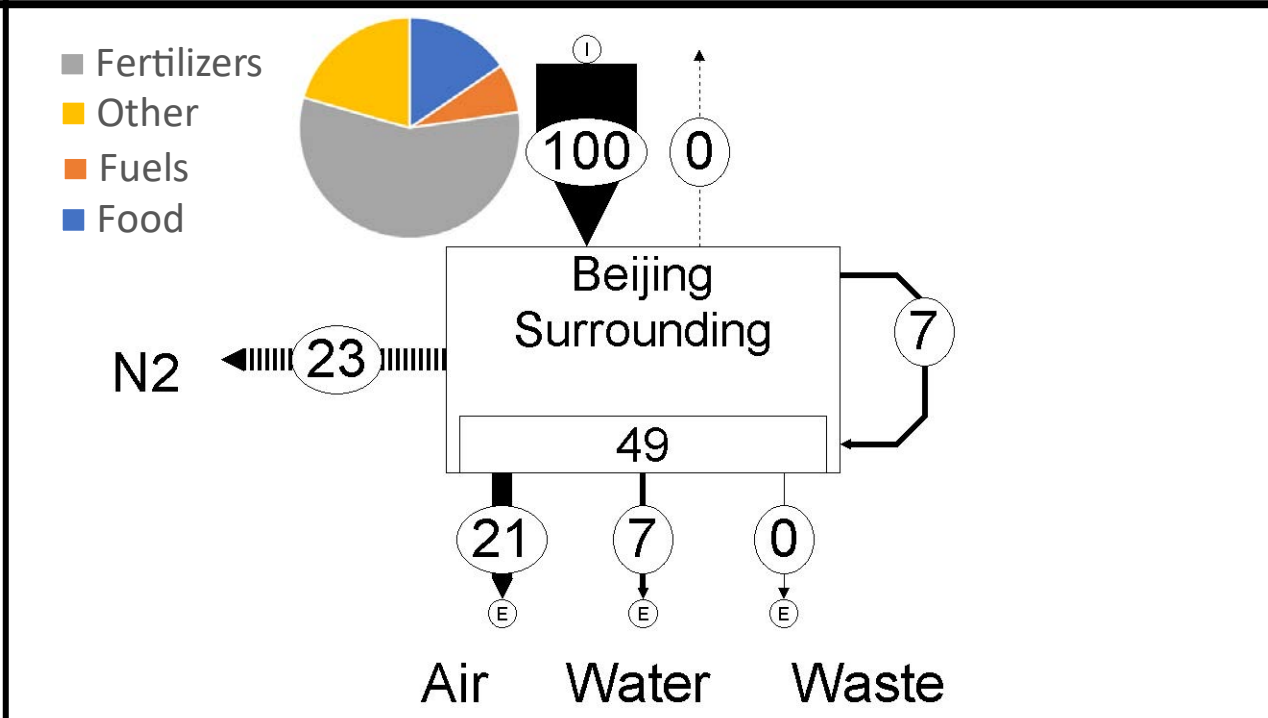

Other
Food
Fuels
Industrial Products
Agricultural Products
100
29
Zielona Gora Core
N2
25
0
25
6
4
11
E
Air
Water
Waste


Other
Fertilizers
Food
Fuels
Agricultural Products
100
51
Zielona Gora Surrounding
N2
3
21
32
0
3
11
E
Air
Water
Waste


Other
Fertilizers
Fuels
Food
Industrial Products
100
22
Shijiazhuang Core
N2
10
7
51
5
9
3
Waste
Agricultural Products
Air
Water
Waste


Fertilizers
Other
Fuels
Agricultural Products
100
4
Shijiazhuang Surrounding
N2
3
14
60
18
15
0
Industrial Products
Agricultural Products
Air
Water
Waste

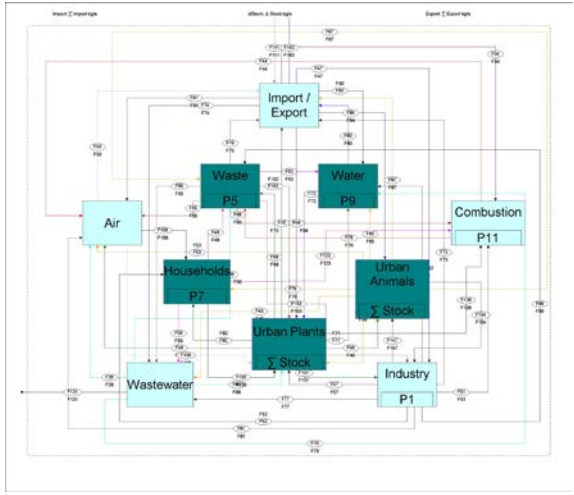

Other
Food
Fuels
Fertilizers
100
0
Beijing Core
N2
42
6
36
16
6
0
Air
Water
Waste


Fertilizers
Other
Fuels
Food
100
0
Beijing Surrounding
N2
23
7
49
21
7
0
Air
Water
Waste

Analysis and Indicators

	Vienna Core	Vienna Surrounding	Zielona Gora Core	Zielona Gora Surrounding	Shijiazhuang Core	Shijiazhuang surrounding	Beijing Core	Beijing surrounding
General								
Products Out (% of import) - NUE?	1%	57%	29%	51%	22%	4%	0%	0%
Recycling (% of import)	4%	6%	0%	21%	7%	14%	6%	7%
Agri-Food Chain Indicators								
Self-sufficiency Plant Food	3%	317%	6%	20%	59%	69%	9%	66%
Self-sufficiency Livestock Products	0%	38%	0%	20%	41%	84%	0%	65%
Self-sufficiency Feed	728%	276%	0%	49%	48%	88%	0%	49%
NUE on agricultural land	55%	68%	76%	85%	27%	19%	2%	11%
N surplus [kgN/ha]	62	46	19	16	684	991	446	853
Emission and Deposition								
N deposition per hectare [kgN/ha]	17	13	16	17	37	37	21	45
Emission per hectare [kgN/ha]	110	16	35	2	80	18	132	14

Pathway through the urban area



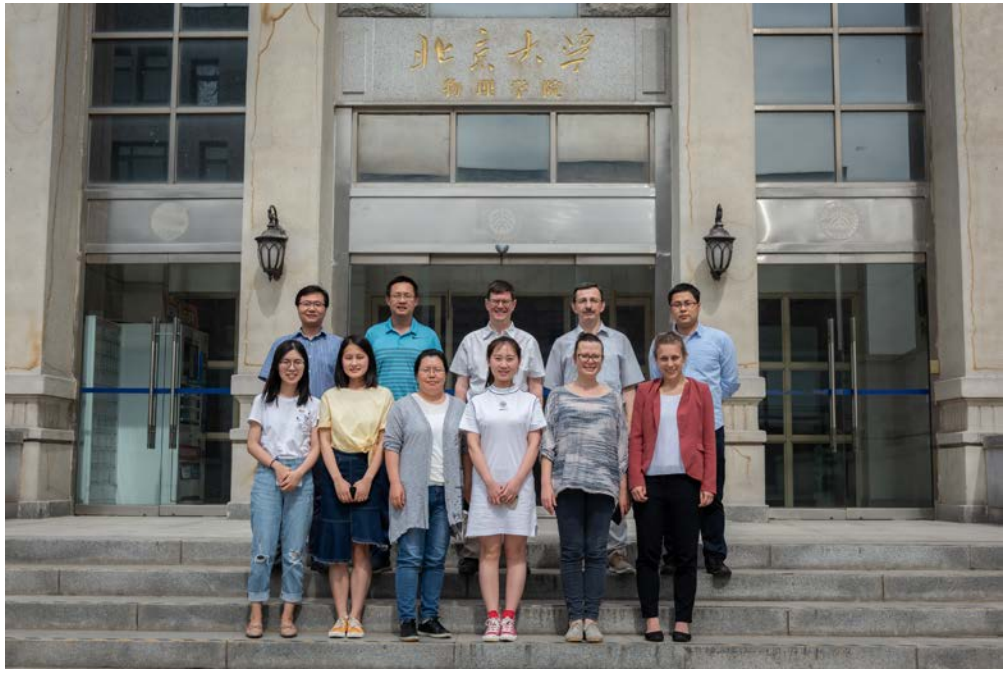
- Distinct pattern between urban and peri-urban area
  - Agricultural emissions dominate in peri-urban area
- Nr recycling is low
- Nr accumulates in soil or in water
  - Local differences in effect
- Wastewater (treatment) offers a great potential to increase Nr recycling
- Higher uncertainties related to the household pool

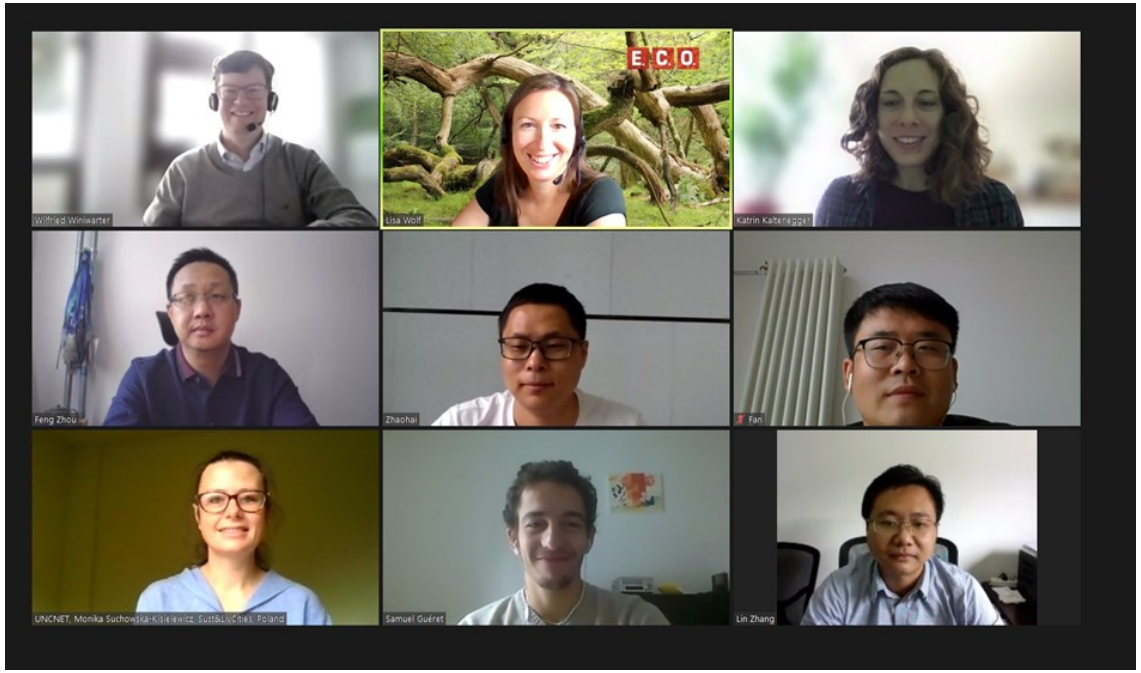
Conclusion

Developed a framework close to EPNB concept and open source

Learn from each other through comparisons

Identify challenges, potentials and solutions for urban N





Thank you!

Contact/Information:
kalteneg@iiasa.ac.at
uncnet.org

UNCNET - Urban nitrogen cycles:

new economy thinking to master the challenges of climate change

Europe – China joint call on Sustainable Urbanisation in the Context of Economic Transformation and Climate Change: Sustainable and Liveable Cities and Urban Areas

Funded by

NCN (Poland), project UMO-2018/29 / Z / ST10 / 02986

NSFC (China), project 71961137011

FFG (Austria), project 870234

References

Svirejeva-Hopkins, A., & Reis, S. (2011). Nitrogen flows and fate in urban landscapes BT - The European Nitrogen Assessment. *The European Nitrogen Assessment*, *12*, 1–22. papers2://publication/uuid/D54990A1-3B35-46EB-BED1-FFCBB28B06A5

UN. 2018. World urbanization prospects: the 2018 revision. New York: United Nations, Department of Economic and Social Affairs, Population Division.

Winiwarter, W., Amon, B., Bai, Z., Greinert, A., Kaltenegger, K., Ma, L., Myszograj, S., Schneidergruber, M., Suchowski-Kisielewicz, M., Wolf, L., Zhang, L., & Zhou, F. (2020). Urban nitrogen budgets: flows and stock changes of potentially polluting nitrogen compounds in cities and their surroundings–a review. *Journal of Integrative Environmental Sciences*, *17*(1), 57–71. https://doi.org/10.1080/1943815X.2020.1841241