BMU-Datenbank

Monitoring impacts of policies and measures

Training on Quantifying Urban Transport GHG Emissions
Leipzig, 18-19 May 2014

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Contents

GHG mitigation potentials in the transport sector

Mechanisms of GHG reduction in the transport sector

Avoid
Reduce number of trips and/or distances

Shift
Choice of transport mode (Modal Split)

Improve
Vehicle efficiency (technology, usage)

Fuel
GHG intensity of energy carriers

GHG emissions of a transport activity = **Transport activity** (veh.km, pass.km, ton.km) x **GHG emission factor**

GHG emission factor: Specific final energy demand x Energy-specific GHG emissions

VKT
(vehicle kilometres travelled)

*Transport performance (e.g. **Pass.km, Ton-km**)*

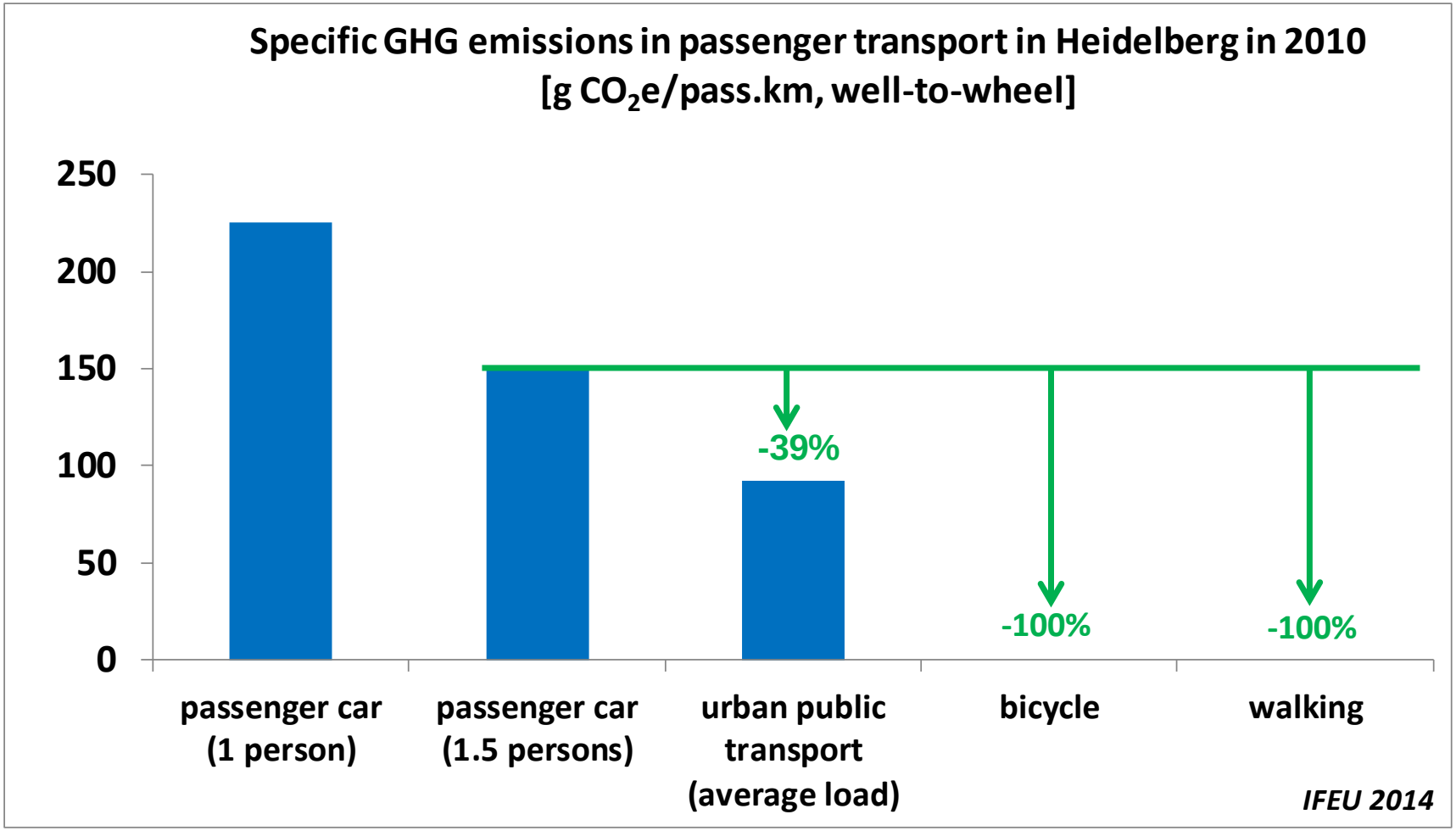
Depends on

- *Vehicle efficiency*
- *Vehicle load*
- *Traffic conditions*
- *Driving behaviour*

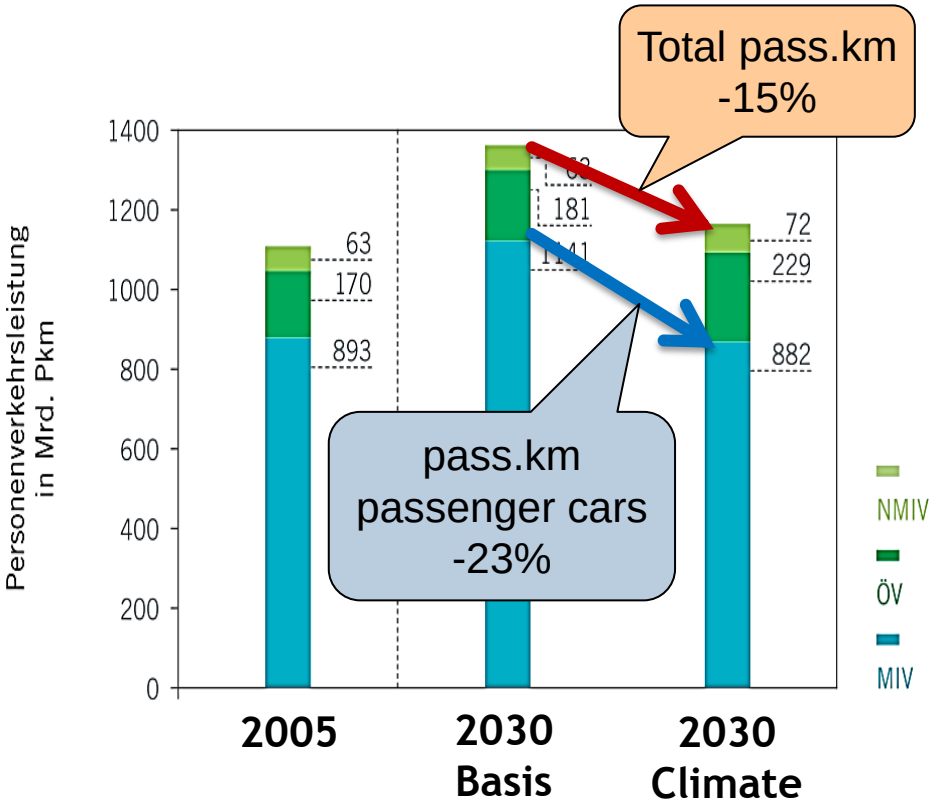
Depends on

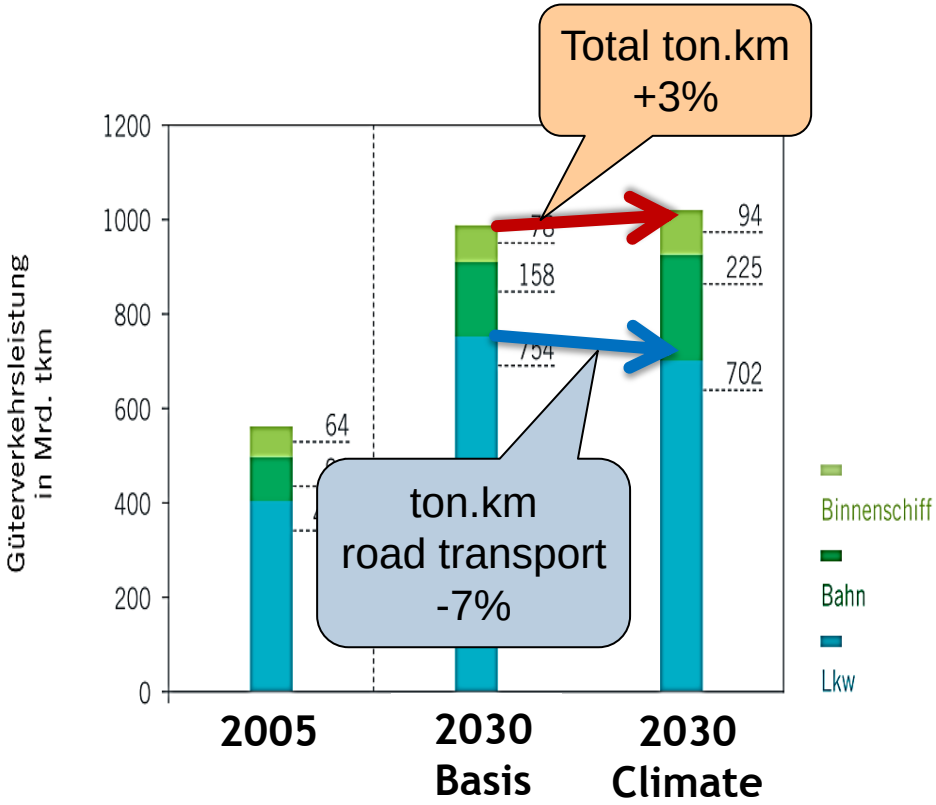
- *Final energy carrier*
- *greenhouse gases (CO_2, CH_4, N_2O)*
- *Consideration of upstream emissions*

GHG mitigation potentials – Avoid and Shift
Specific GHG emissions of passenger transport in Heidelberg



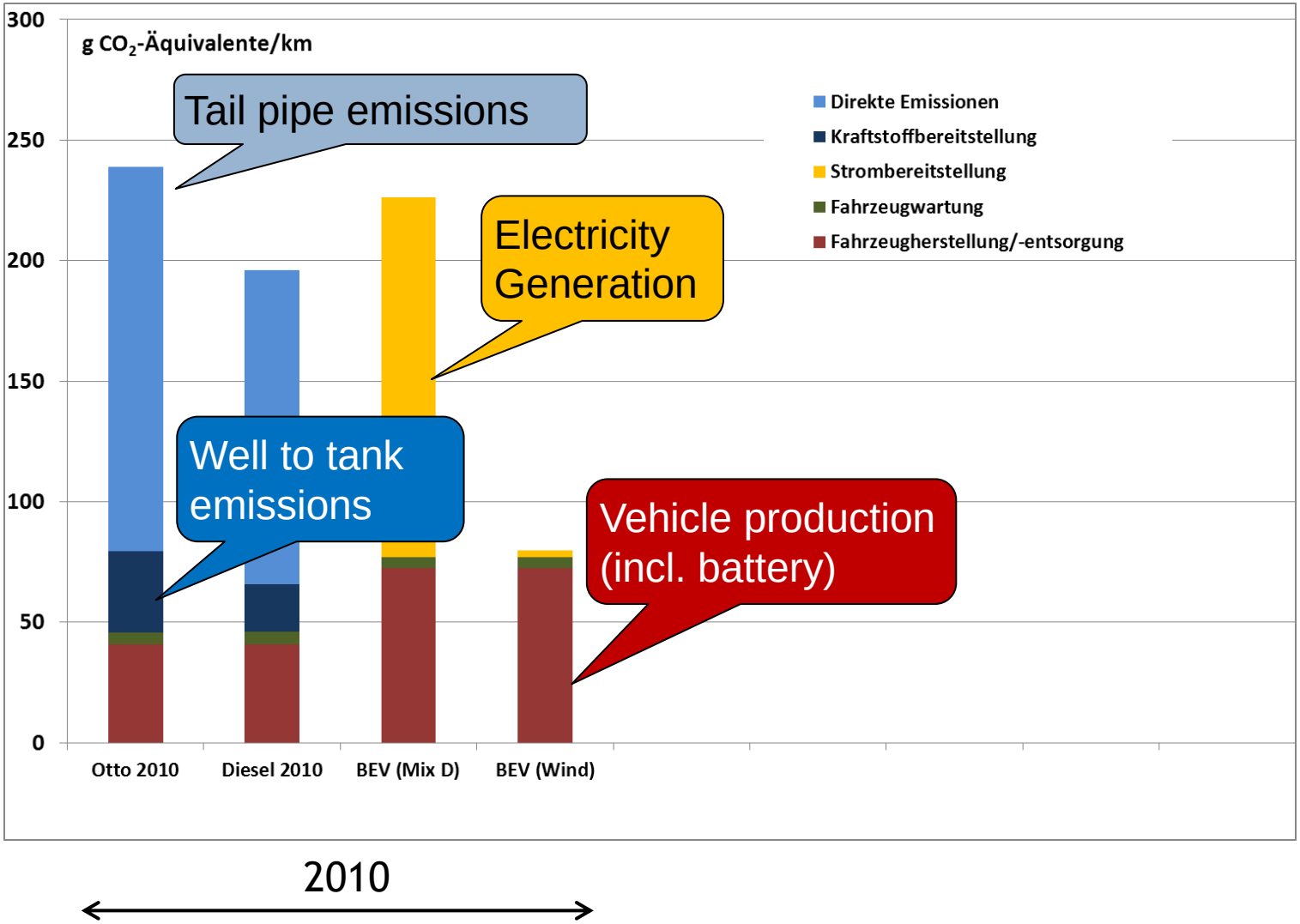
GHG mitigation potentials – Avoid and Shift Renewbility scenarios for Germany



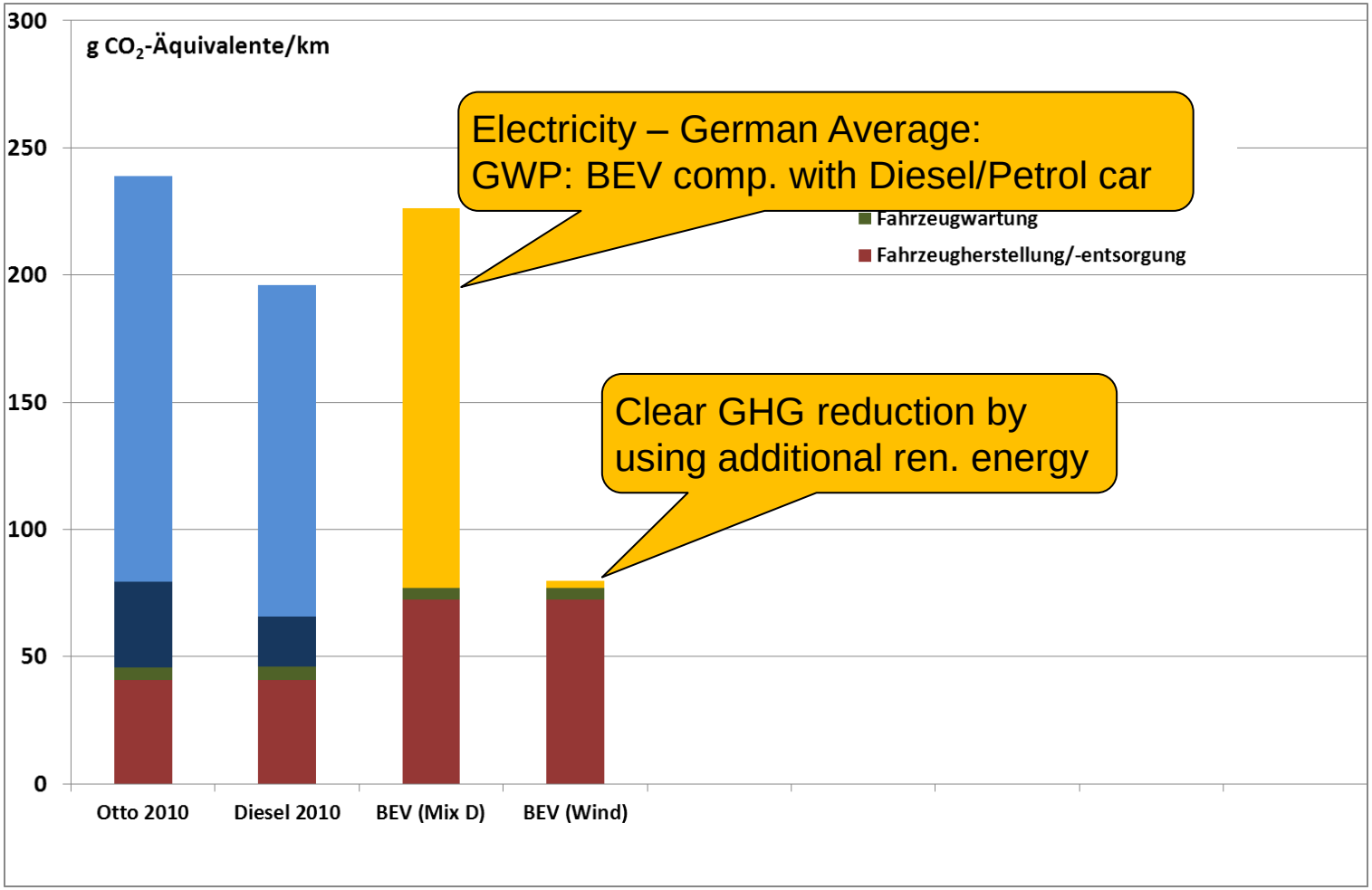


- Passenger transport: Avoid and Shift to public transport and non-motorized transport modes
- Freight transport: Shift from road transport to rail and inland navigation

GHG mitigation potentials - Improve and fuel

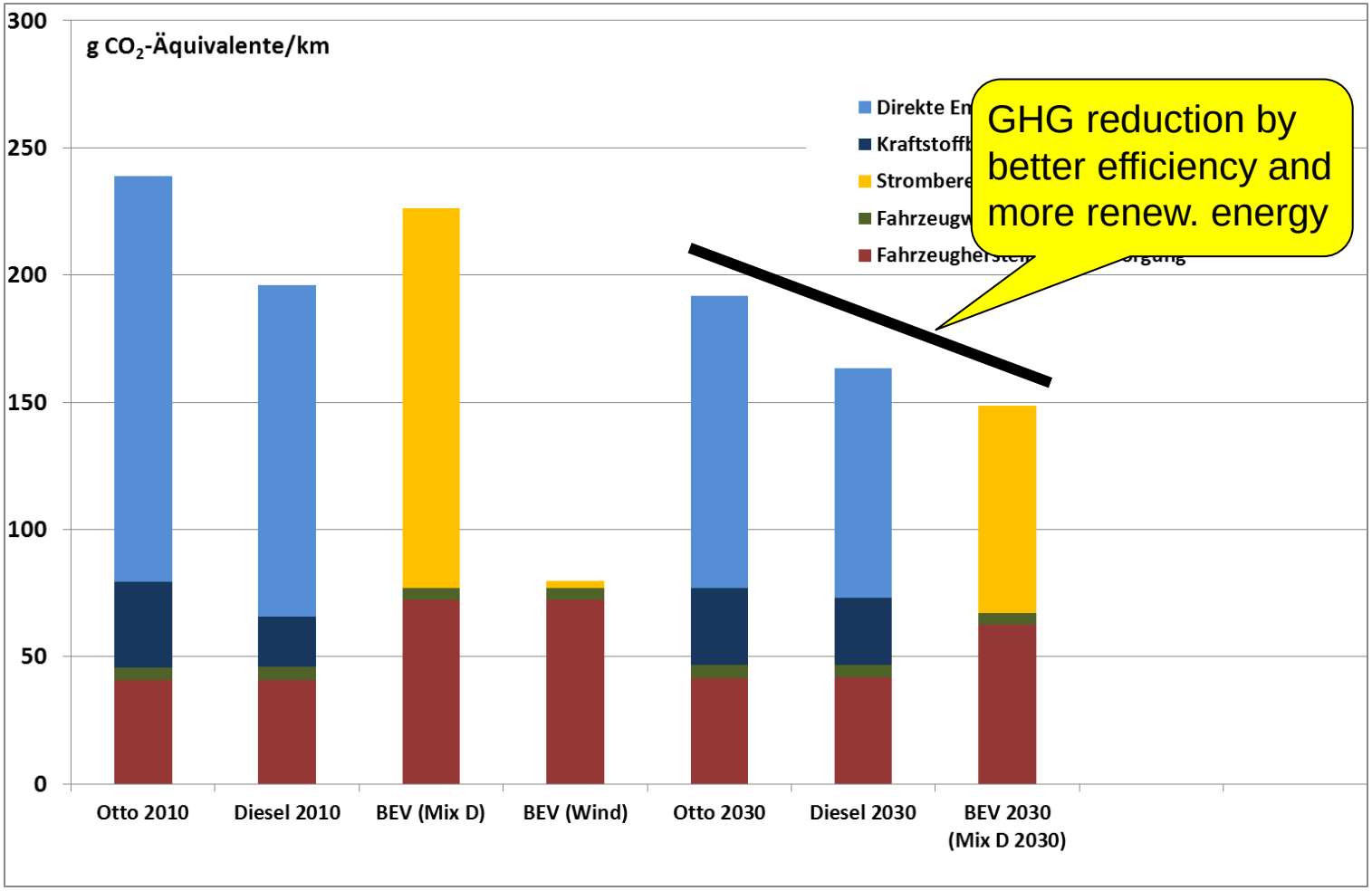


GHG mitigation potentials - Improve and fuel



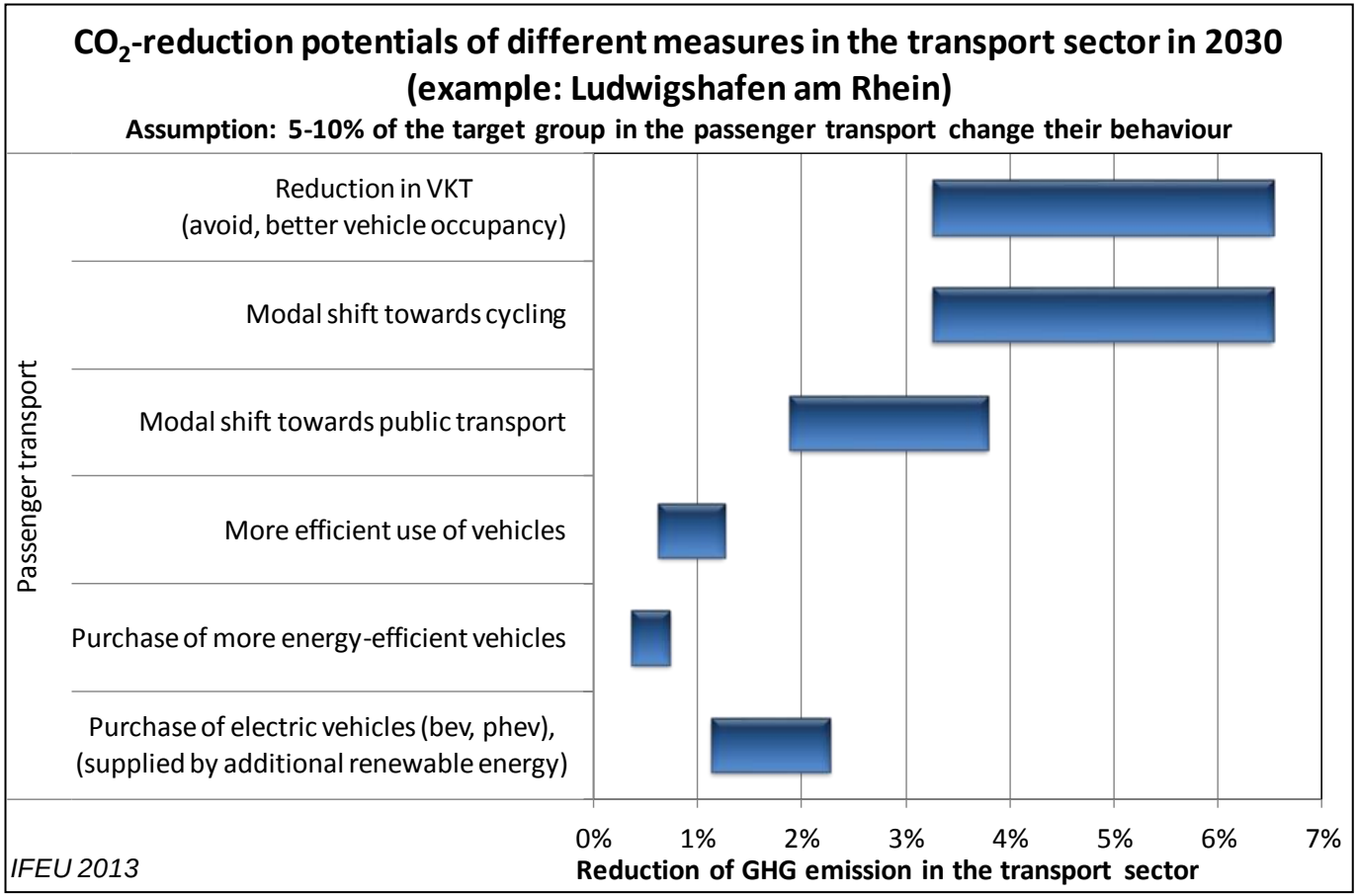
2010

GHG mitigation potentials - Improve and fuel



2010 ⟷ 2030

GHG mitigation potentials
Potential analysis for municipal measures in Ludwigshafen



➔ **Mitigation potentials in municipalites mainly with avoid & shift measures**

Basic steps for starting a GHG monitoring process

Objectives of Monitoring impacts of policies and measures

- Monitoring GHG emission reductions over time
  - for a municipality
  - for individually defined monitoring boundaries
- Comparison of real GHG emissions developments with a reduction path towards existing reduction goals
- Basis for analysing actual GHG emission effectiveness of measures within ex-post evaluations
- Assessment of further impacts of realised measures (other environmental and sustainability topics)

➔ **Controlling the success of GHG mitigation efforts**

Basic steps for starting a GHG monitoring process

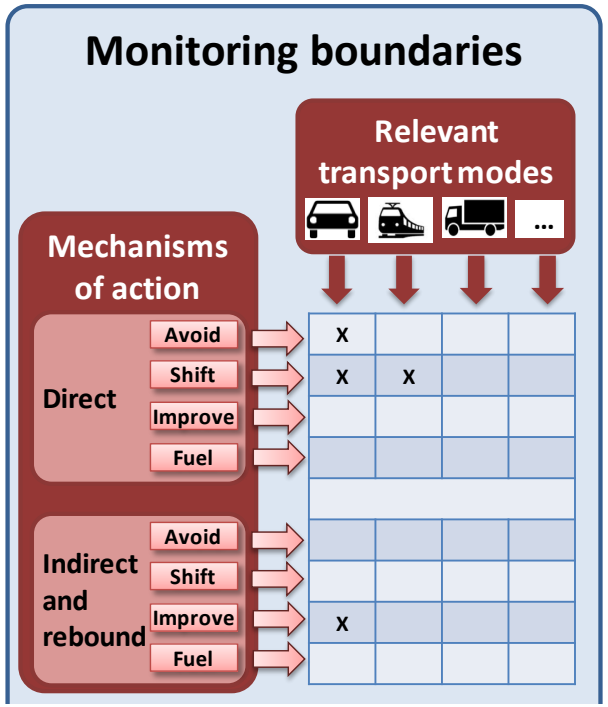
1. Characterization of the measures or policies to be monitored
2. Identification of main GHG relevant effects and definition of monitoring boundaries
3. Determination of relevant GHG calculation parameters
4. Determination of regularly available data sources
   a) Transport activities
   b) Emission factors
5. Adaption of a GHG monitoring tool

Basic steps for starting a GHG monitoring process
1) Characterization of the measures or policies

- Main objectives
  e.g. Climate protection, Congestion reduction, Generate financial resources for public transport improvements
- Type of measure and mode of action
  e.g. taxes, access limitations, information, limit values, public transport operation quality, infrastructure improvements
- Target groups
  e.g. inhabitants, commuters, companies, freight carriers
- Scope of the measures
  - Regional scope: e.g. Selected city districts, Complete city, City and surrounding region, County or national level
  - Temporal scope: all-the-year, certain weekdays or hours of the day

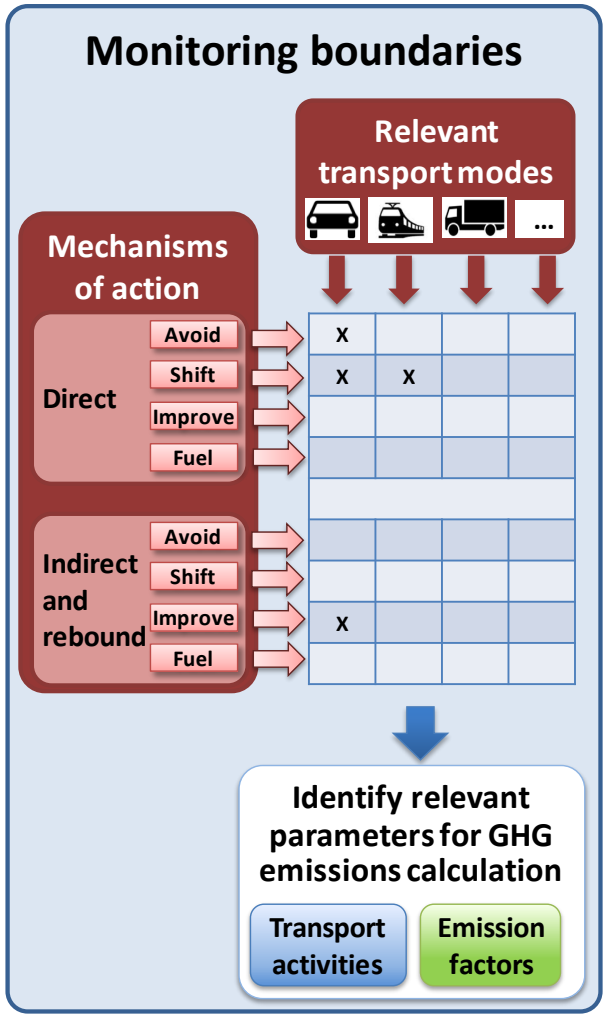
Basic steps for starting a GHG monitoring process
2) Definition of monitoring boundaries

- Which transport modes are affected by the measures
  - Direct effects within the measure scope
  - Indirect effects outside the measure scope
  - Rebound effects
- How are the transport modes affected
  - Avoid
  - Shift
  - Improve
  - Fuel
- Informative value of monitoring results increases with more measure-specific definition of monitoring boundaries



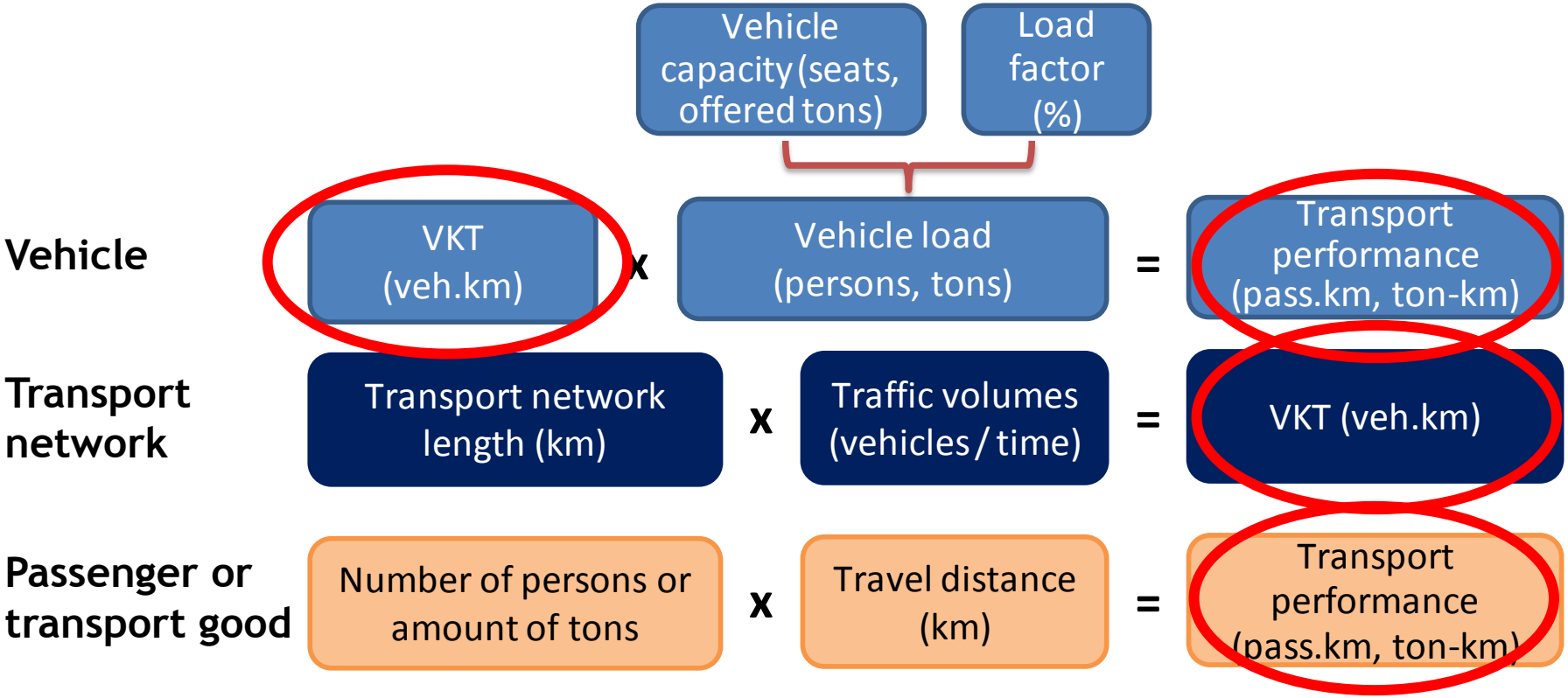
Basic steps for starting a GHG monitoring process
3) Determination of relevant GHG calculation parameters

- Individual GHG calculation parameters are required for each emission source.
- Which parameters are measure-influenced?
  - Not influenced: Regular data sources and statistics suitable
  - Influenced: Measure-specific monitoring data
- Transport activities: VKT, pass.km, ton.km
- Emission factors per transport mode, depending on:
  - Fleet composition: Shares of vehicles with individuel energy efficiency and fuel type
  - Shares of different traffic situations



Basic steps for starting a GHG monitoring process
4) Determination of regularly available data sources
a) Transport activities

- Alternative approaches to determine transport activities



Data sources for transport activities

➔ **Periodic data availability in the future is crucial for the monitoring.**

Typical data sources for transport activities

Regular data sources and statistics

- Urban transportation planning models
- National or regional models (with top-down or bottom-up regionalisation)
- Periodic household or driver surveys
- Local vehicle statistics
- Operating data of public transport operators and transport associations
- Freight transport statistics (tons, ton.km, origin-destination relation)
- Statistics on commuting traffic

Measure-specific monitoring data

- Starting permanent (automatic) or periodic (manual) traffic counts
- development of a local traffic model
- Starting periodic household or driver surveys

Data sources for transport activities
Example: Data availability for Baden-Wuerttemberg

	Means of transportation	Kind of data	Data sources
Passenger transport modes	Passenger cars and two-wheelers	Vehicle-km by road type and municipality	Statistisches Landesamt Baden-Württemberg
	Urban bus, tram & light-rail	Vehicle-km, seat-km, pass.-km by municipality	Public transport operators, regional transport associations
	Regional trains	train-km by municipality	Regional transport associations, German Railways (Regio section)
	Long-distance trains	train-km, seat-km by propulsion (diesel, electro) and municipality	German Railways
Freight transport modes	Light and heavy duty trucks	Vehicle-km by road type and municipality	Statistisches Landesamt Baden-Württemberg
	Rail freight transport	train-km by propulsion (diesel, electro) and municipality	German Railways
	Inland navigation	ton.km by waterway section	Federal statistical office

Basic steps for starting a GHG monitoring process
4) Determination of regularly available data sources
b) Emission factors

Avoid+shift measures

- Average emission factors per transport mode can be used in most cases, considering weighted fleet compositions and traffic situations.
- It can be suitable to aggregate different transport modes to one single emission source and use weighted average emission factors, e.g.
  → Cars + two-wheelers = private transport
  → bus, subway, lightrail, regional train = public transport

Improve+fuel measures

- Local-specific fleet compositions and/or traffic characteristics are required for a refinement of emission factors.
- Important: Only the use of well-to-wheel emission factors ensures comprehensive monitoring of GHG effects resulting from shifts to alternative energy carriers (electricity, biofuels).

Data sources for emission factors

➔ **Periodic data availability in the future is crucial for the monitoring.**

Typical data sources for emission factors

<u>Regular data sources and statistics</u>

- Emission factor database, including
  - default emission factors for typical fleet compositions traffic situations
  - detailed emission factors for more in-depth analyses

  Source(s): e.g. (inter)national inventory model
- Local, federal or national vehicle fleet compositions
  (VKT shares of different drive concepts, vehicle size, age etc.)
  Source(s): e.g. local emissions inventory
- Local-specific traffic flow characteristics
  Source(s): e.g. local traffic model

<u>Measure-specific monitoring data</u>

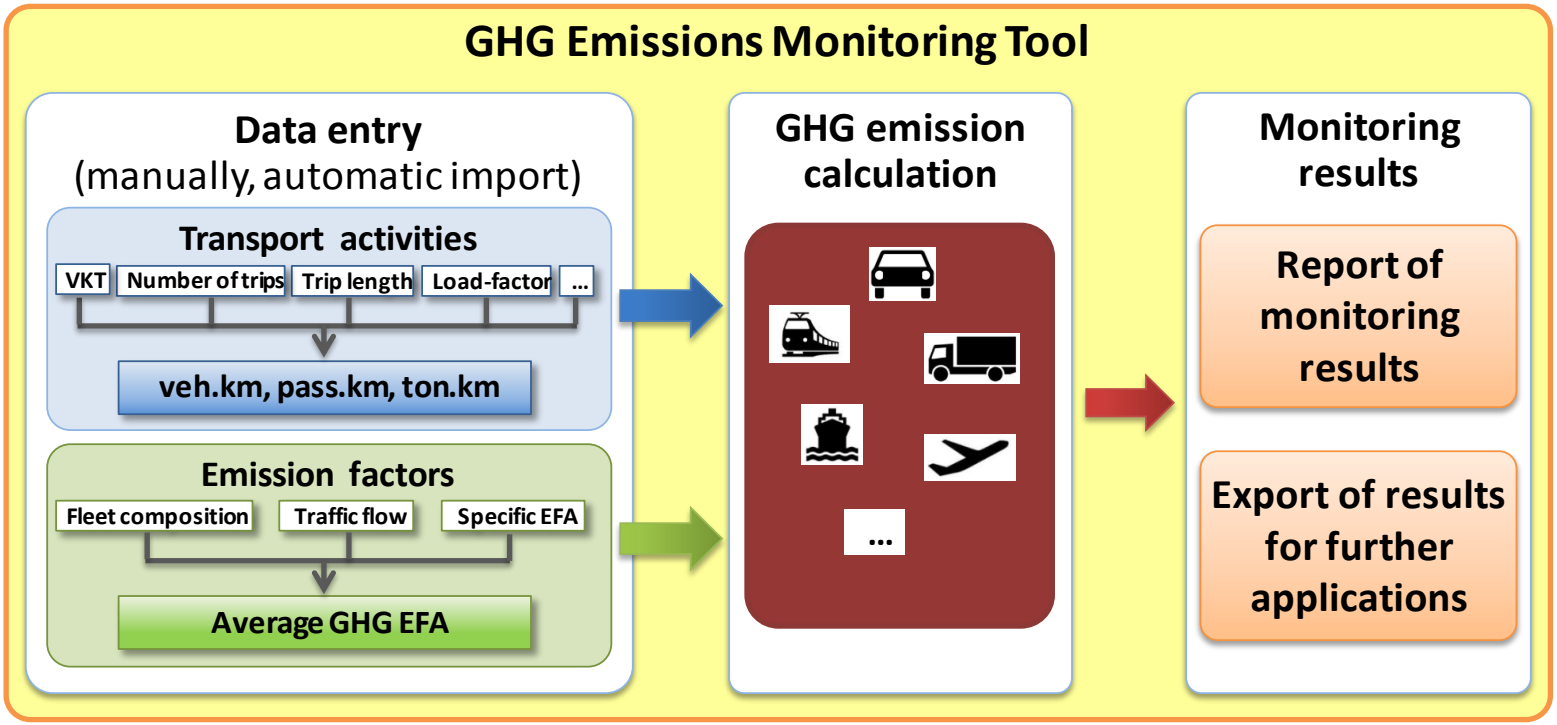
- Licence plate surveys (for derivation of fleet compositions)
- Road-specific measurement and modelling of velocity and traffic flow
  Emission measurements (e.g. remote sensing)

International emission factors data bases for transport

	HBEFA	TREMOD	COPERT	TREMOVE	MOVES
Latest version	HBEFA 3.1 (2010)	TREMOD 5.2 (2012)	COPERT 4, v. 9.1 (2012)	TREMOVE 3.3.2 (2010)	MOVES 2010b
Developer	INFRAS AG	IFEU Heidelberg	EMISIA	TML, KU Leuven	US EPA
Commissioner	Several federal environmental authorities in Europe	Federal Environmental Agency of Germany (UBA)	European Environment Agency (EEA)	European Commission, DG Environment	EPA (United States Environmental Protection Agency)
Purpose	Database for emission factors Emission Inventory and Scenario Calculation (Exp. Version)	Emission Inventory and Scenario Calculation Database for emission factors and transport activity data	Emission Inventory Database for emission factors and transport activity data	Emission Inventory and Scenario Calculation	Emission Inventory and Scenario Calculation Database for emission factors and transport activity data
Transport Modes	Road	Road, Rail, Inland Water and Aircraft	Road	Road, Rail, Inland Water, Maritime	Road
Timeline	1990-2030	1960-2030	1970-2030	1995-2030	1990, 1999-2050
Resolution (Road)	Vehicle, road and fuel type Tank to wheel	Vehicle, road and fuel type Well to wheel	Vehicle, road and fuel type Tank to wheel	Vehicle, road and fuel type Well to wheel	Vehicle, road and fuel/powertrain type Tank to wheel
Software requirements	MS ACCESS	MS ACCESS	MS ACCESS	MS ACCES and EXCEL, WINZIP, GAMS	MySQL and JAVA
Software Availability	Order by registration, fee: 250 € www.hbefa.net Expert version for ERMES-members	Available for several public authorities and cooperation partners	Order by registration, fee for country data (300 € each) http://www.emisia.com/copert/General.html#	Free download http://www.tremove.org	Free download (GNU license) http://www.epa.gov/otaq/models/moves/index.htm
Data availability	Europe- individual purposes	Germany- national level	Europe- national level	Europe- national level	USA- national and county level
Typical application	Micro to macro scale inventories (street, city, national level) for EU emission standards	National inventory and scenarios for Germany	Macro (country level) scale inventories for EU emission standards	Macro scale (country/ EU level) inventories and scenarios for EU emission standards	Micro to macro scale (federal, state, county, city) inventories with US emission standards

Basic steps for starting a GHG monitoring process
5) Adaption of a GHG monitoring tool

- Adaption of an easily operated monitoring tool considering
  - kind and format of regularly available input data and
  - requirements on presentation of results and their further use



Example for a GHG Monitoring tool: BICO$_2$ model

BICO2

- Excelbased calculation tool for GHG inventories of municipalities
- Final energy consumption & GHG emissions calculation for all energy sectors
- Nationally harmonized emission factors (for transport from TREMOD)
- Required input parameters and presentation of results are adjusted individually for each municipality for different data availability and intended further use.

Jahresfahrleistung Straßenverkehr im Gemeindegebiet

Kfz-Kategorie	Einheit	Innerorts	Außerorts	Autobahn
Motorisierte Zweiräder ("Kräder")	*Mio. Fz-km*			
Pkw	*Mio. Fz-km*			
Leichte Nutzfahrzeuge (LNF)				
Lkw >3,5t				
Busse (Reise- + Linienbus)				
Gesamtfahrleistung	***Mio. Fz-km***	-	-	-

Input screen (example)

Betriebsleistungen ÖPNV & Schienenpersonennahverkehr im Gemeindegebiet

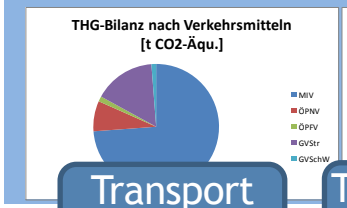
	Einheit	Wert	Datenquellen
Linienbus			
Fahrleistung	*Mio. Fz-km*		Lokale(s) Verkehrsunternehm
Verkehrsleistung	*Mio. Pkm*		
Auslastungsgrad der Busse	*%*		
Stadt-/Straßenbahn			
Angebotene Verkehrsleistung	*Mio. Platz-km*		Lokale(s) Verkehrsunternehm
Verkehrsleistung	*Mio. Pkm*		
Betriebs-/Fahrplanleistung	*Mio. Zug-km*		
Betriebs-/Fahrplanleistung	*Mio. Wagen-km*		
Auslastungsgrad der Fahrzeuge	*%*		

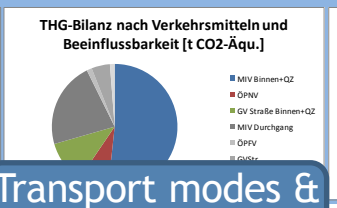
Results screen (example)

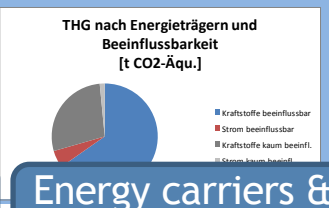
THG-Bilanz nach Verkehrsmitteln	t CO2-Äqu.
MIV	255483
ÖPNV	27007
ÖPFV	4621
GVStr	54695
GVSchW	4206

THG-Bilanz nach Verkehrsmitteln und Beeinflu	t CO2-Äqu.
MIV Binnen+QZ	178838
GVSchW	4206

THG nach Energieträgern	t CO2-Äqu.
Kraftstoffe beeinflussbar	225874







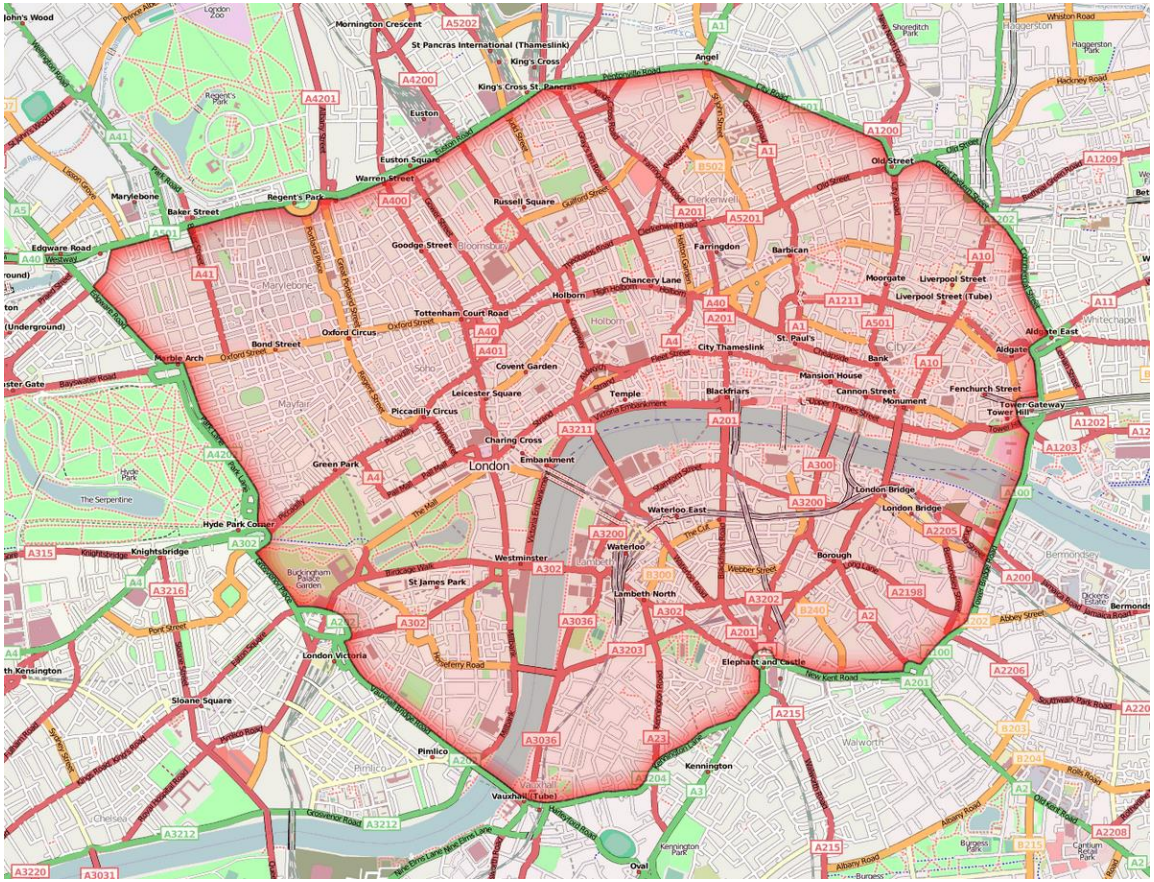
Transport modes

Transport modes & local action field

Energy carriers & local action field

Case study: Impact monitoring for the London Congestion Charge

Case-Study: London Congestion Charge
Characterization of the measure



General

- Introduced in 2003 in Central London
- Mo-Fr; 07:00-18:00
- 21 sq.km; 200‘000 inh.
- £10/day (fiscal measure)
- Exemptions für cars with <75 g CO_2/km

Main objective

- reduction of congestion

Target group

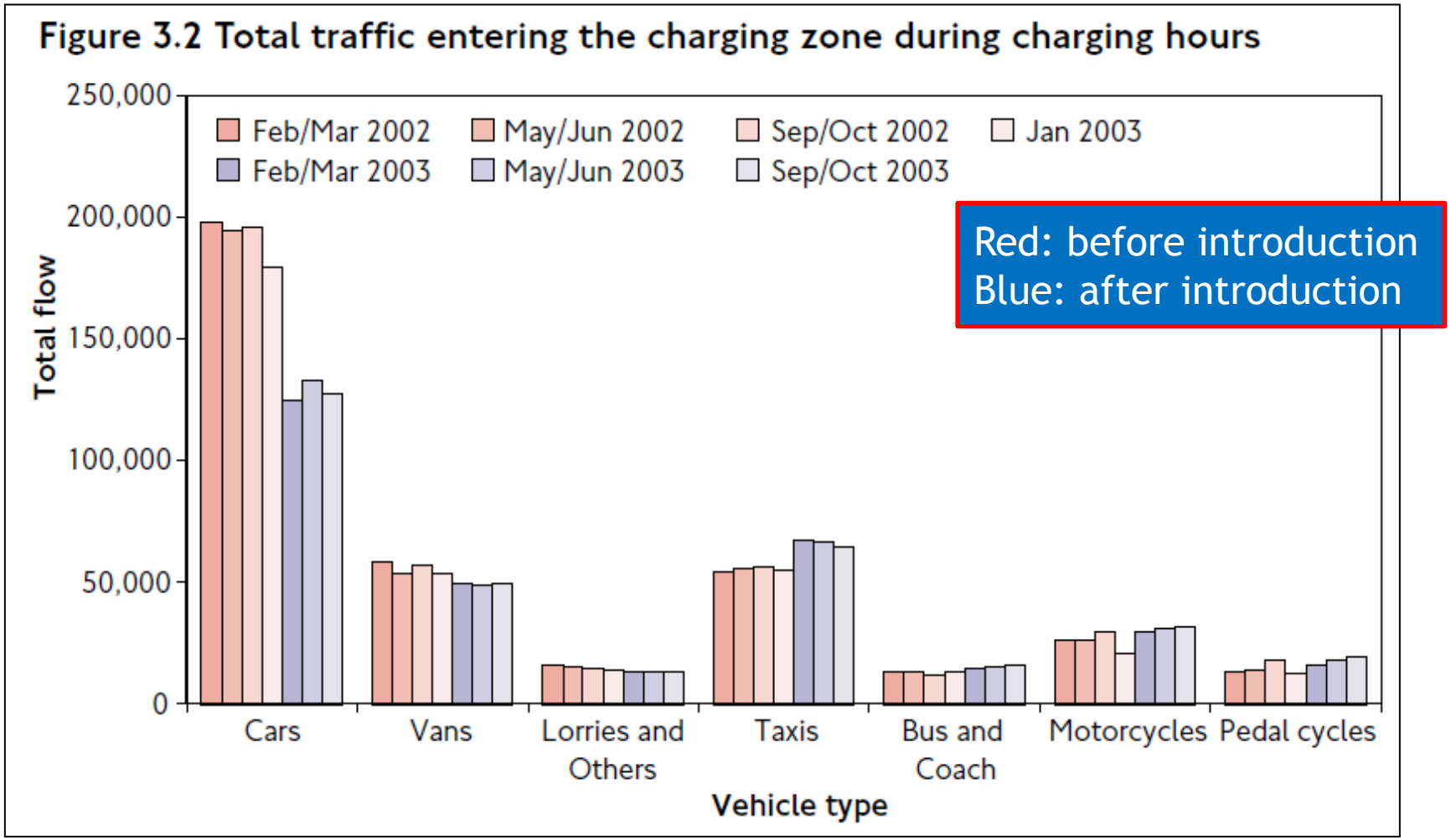
- Road vehicle drivers
- Focus: commuter

Case-Study: London Congestion Charge
GHG-relevant measure effects

		Avoid	Shift	Improve	Fuel
In CCZ	**passenger cars**	omitted trips; higher vehicle loads	shift to other transport modes	Change in traffic flow and average speed	Exemptions for fuel-saving cars (for electric vehicles: upstream emissions relevant)
	motorcycles	addtional trips (shift from cars)			-
	taxis	addtional trips (shift from cars)			-
	public transport	Extended PT offer (for shift from cars)			-
	Vans, lorries	omitted trips; higher vehicle loads	-		-
Outside CCZ	**passenger cars**	additional trips (diverted traffic)	shift to other transport modes (e.g. commuter traffic entering the CCZ)	Change in traffic flow and average speed	Exemptions for fuel-saving cars (for electric vehicles: upstream emissions relevant)
	motorcycles	-	-		-
	taxis	-	-		-
	public transport	Extended PT offer (for shift from commuting car traffic)			-
	Vans, lorries	additional trips (diverted traffic)	-		-

CCZ: Congestion Charging Zone

Case-Study: London Congestion Charge
Transport activity data → Number of vehicles



Case-Study: London Congestion Charge
Transport activity data → VKT

Table 3.3 Key changes in vehicle-kilometres driven within the charging zone during charging hours. Annualised weekday 2002 compared with 2003 (post-charging)

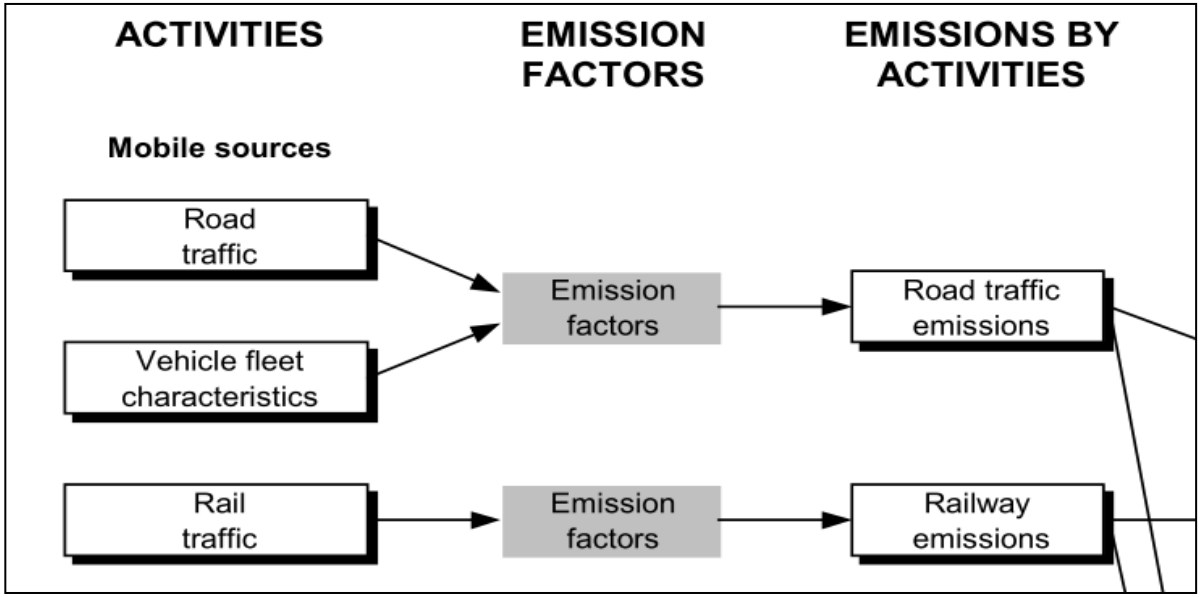
Vehicle type	2002 vkm (millions)		2003 vkm (millions)		percentage change
All vehicles	1.64	(100%)	1.45	(100%)	**-12%**
Four or more wheels	1.44	(88%)	1.23	(85%)	**-15%**
Potentially chargeable	1.13	(69%)	0.85	(58%)	**-25%**
Cars	0.77	(47%)	0.51	(35%)	**-34%**
Vans	0.29	(18%)	0.27	(19%)	-5%
Lorries and other	0.07	(4%)	0.07	(5%)	-7%
Licensed taxis	0.26	(16%)	0.31	(21%)	**+22%**
Buses and coaches	0.05	(3%)	0.07	(5%)	**+21%**
Two wheeled vehicles	0.20	(12%)	0.23	(16%)	**+14%**

Note: Changes given in bold are statistically significant at the 95 percent confidence level.
The percentage contribution to total charging zone traffic is also shown for each of 2002 and 2003.

Case-Study: London Congestion Charge
Emission factors

Emission factors adopted from **London Atmospheric Emissions Inventory (LAEI)**

- Local fleet composition: Yes
- Traffic flow characteristics: Yes
- CO_2 equivalents and upstream emissions: No



Source: Detail of the LAEI compilation procedure illustrated in (GLA 2004)

Case-Study: London Congestion Charge
Monitoring results

Direct effects

Indirect effects

Table 6.3 Principal changes to emissions [illegible] d PM_{10}. Percentage c[illegible] 2003 compared with 2002.

Change	Charging zone NO_x	Charging zone PM_{10}	Charging zone CO_2	Inner Ring Road NO_x	Inner Ring Road PM_{10}	Inner Ring Road CO_2
Flow change - motorcycles	-	0.4	0.2	0.2	2.4	1.0
Flow change - taxis	2.3	3.8	2.4	2.0	3.6	2.1
Flow change - car	-4.5	-4.6	-11.2	-1.6	-1.8	-3.9
Flow change - bus and coach	2.9	1.0	1.2	3.2	1.1	1.4
Flow change - light goods	-0.1	-0.1	-0.1	1.7	3.2	2.3
Flow change - rigid goods	-1.6	-1.0	-0.7	1.6	1.0	0.7
Flow change - articulated heavy goods	-0.4	-0.2	-0.2	0.4	0.2	0.2
Traffic volume change	-1.4	-0.8	-8.4	7.4	9.7	3.8
Speed change	-6.5	-5.5	-7.3	-7.7	-6.9	-8.5
Traffic volume and speed change	-7.9	-6.3	-15.7	-0.2	2.8	-4.7
Vehicle stock change	-5.5	-9.2	-0.7	-6.7	-9.6	-0.7
Overall traffic emissions change 2003 versus 2002	-13.4	-15.5	-16.4	-6.9	-6.8	-5.4
Overall traffic emissions change 2004 versus 2003	-5.2	-6.9	-0.9	-5.6	-6.3	-0.8

Emission factors

Transport activities

Emission factors

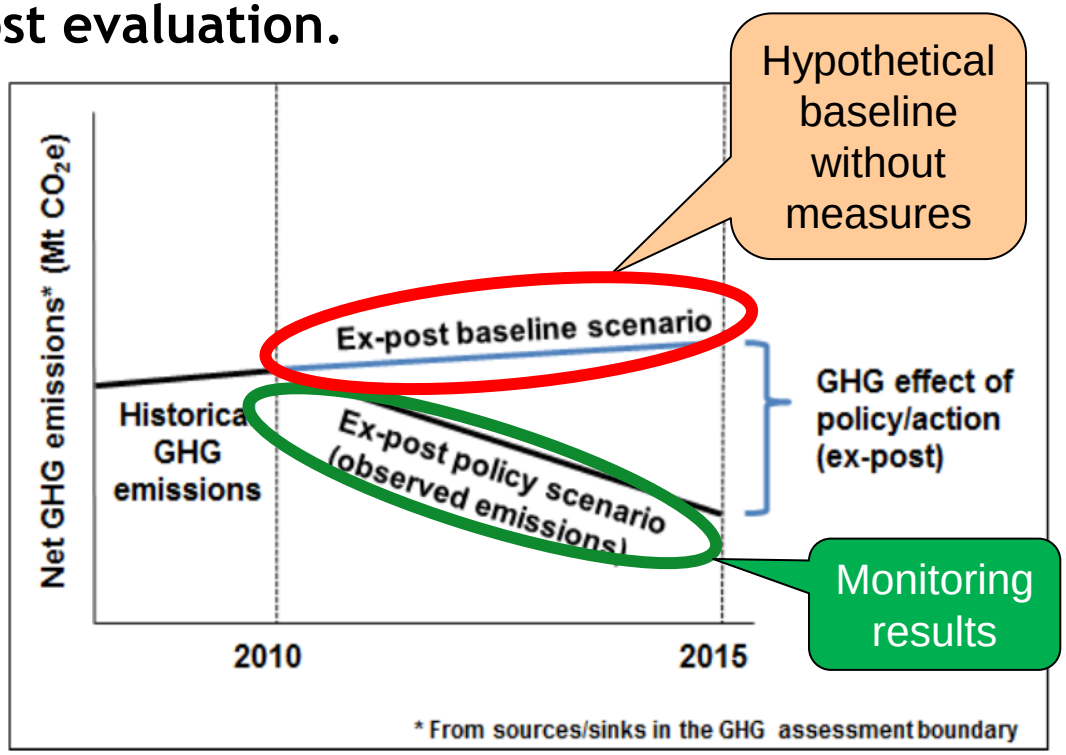
Alternative and complementary monitoring issues

Ex-post evaluation of impacts from measures

- GHG monitoring documents the real development of GHG emissions.
- This real development is caused by the analysed measures, but also influenced by general trend and other measures.

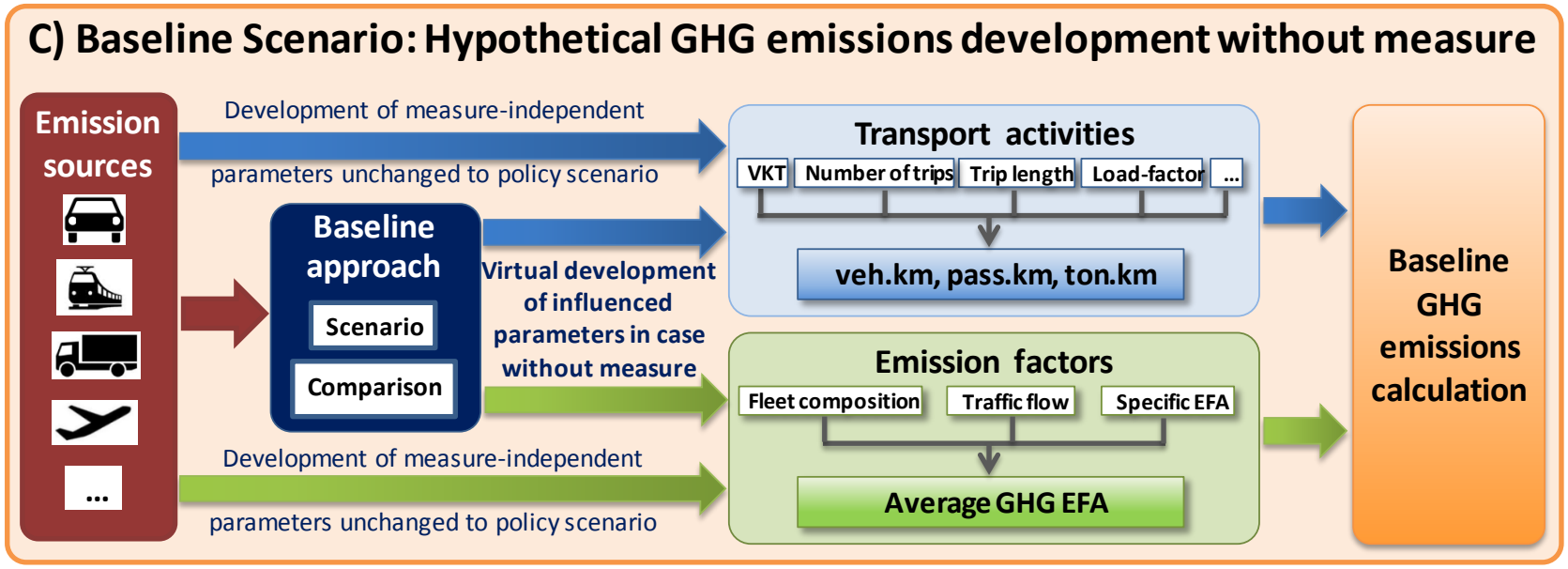
→ **Assessment of actual GHG mitigation effectiveness of specific measures requires an ex-post evaluation.**

Ex-post evaluations estimate the net GHG mitigation effect of a measure by comparing the real GHG emissions development (= monitoring results) with a reliable and plausible estimate of developments without measure (= hypothetical baseline).

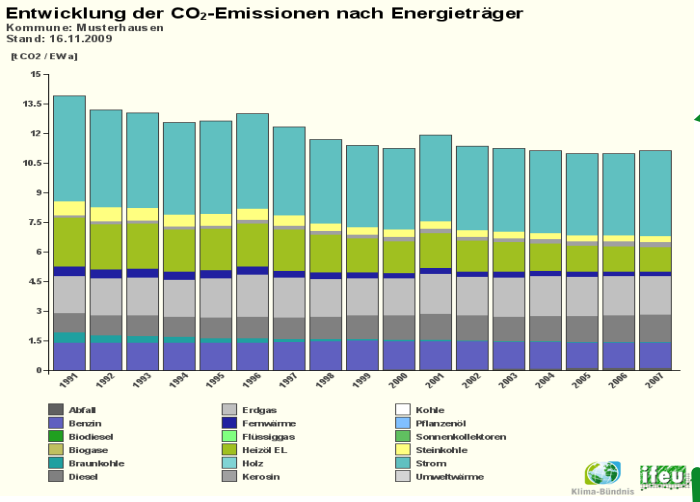


Ex-post evaluation: Baseline scenario

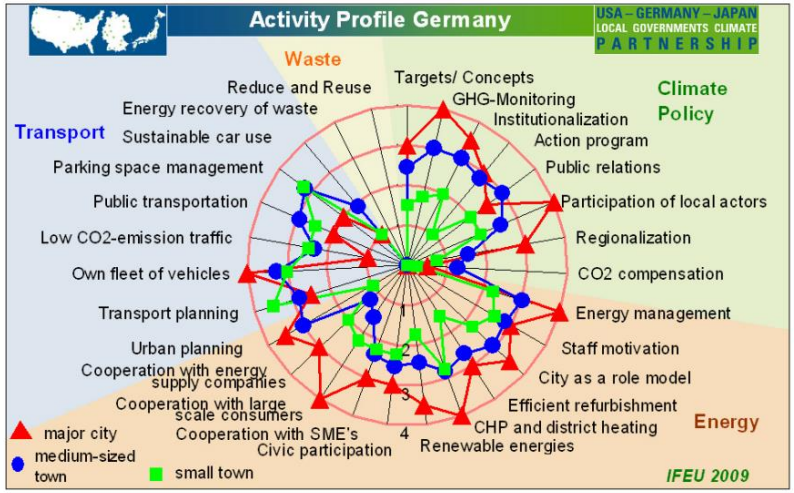
- Calculation of a hypothetical GHG emissions development trying to factor out all effects of the evaluated measure
  - Same assessment boundaries as in the real GHG emissions development.
  - Parameters, not affected by the measure: Adoption of real developments from the policy scenario
  - Parameters, affected by the measure: Estimation of hypothetical, but plausible developments without implementation of the measure

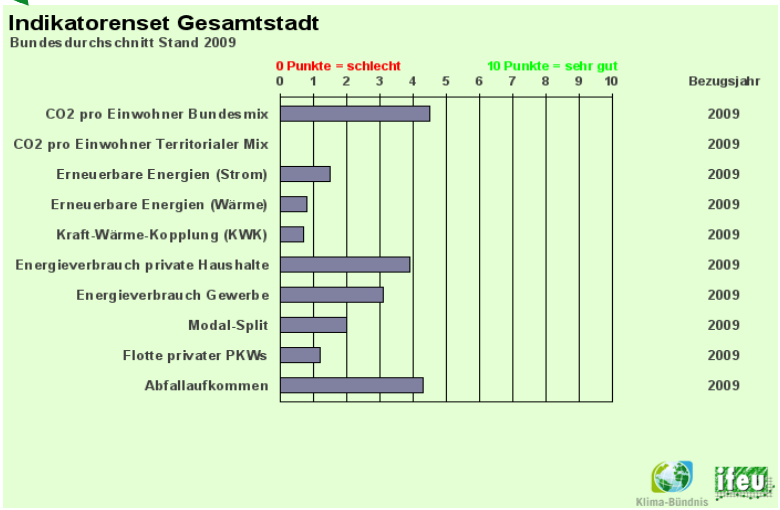


Monitoring implies more than GHG emissions calculation
Example: Climate protection Benchmark



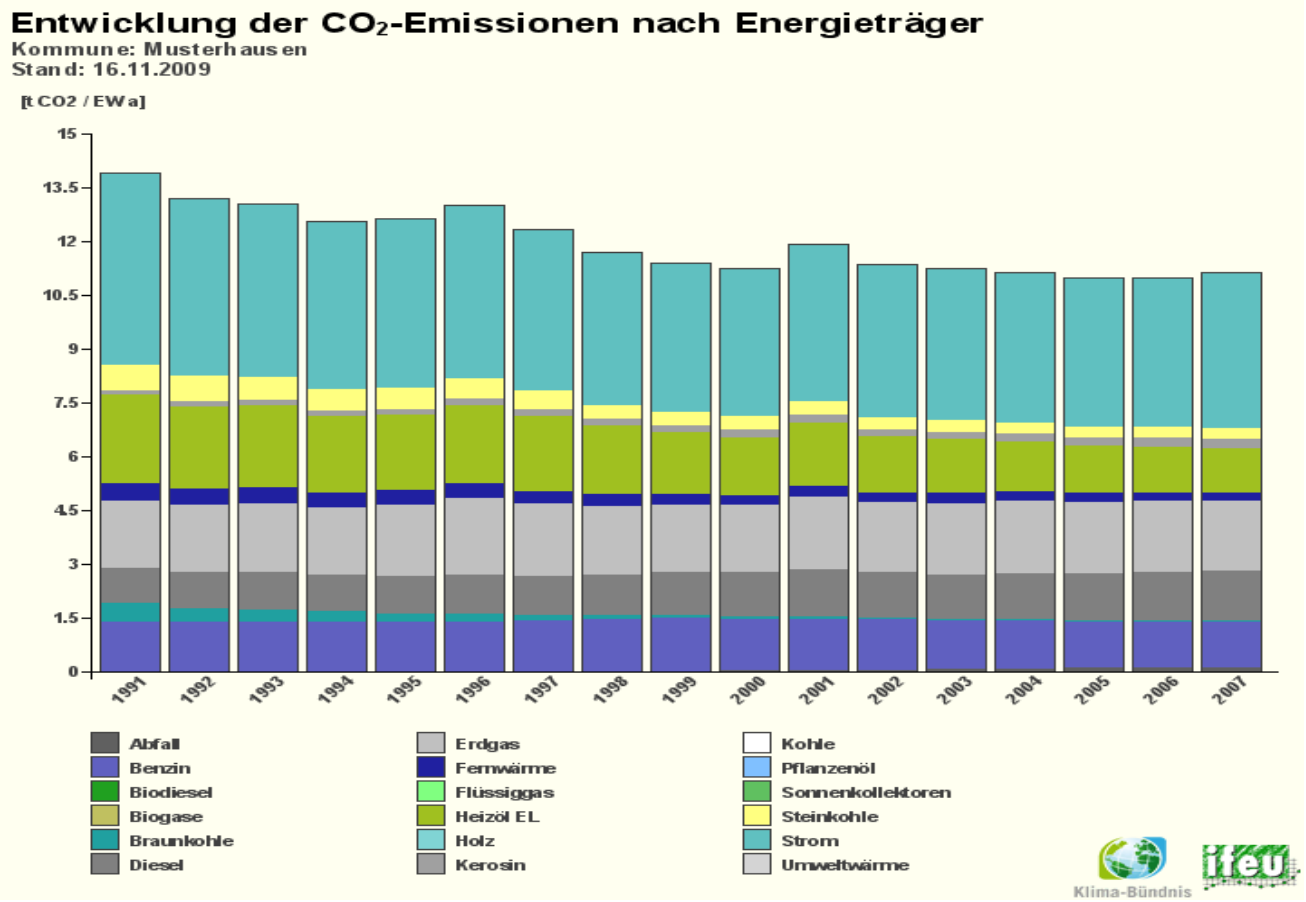
- Step 1: Monitoring GHG emissions
- Step 2: Activity profile
- Step 3: Set of indicators





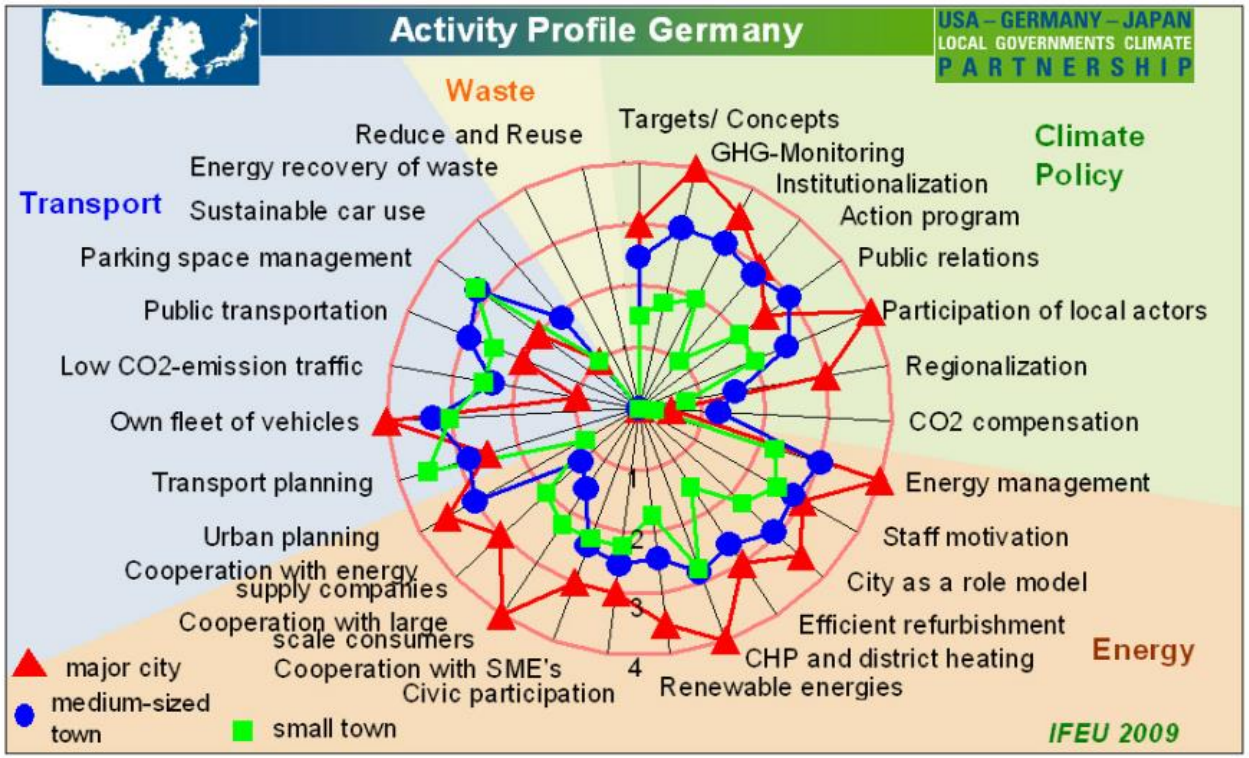
Climate protection Benchmark: GHG inventory

- Development of GHG emissions of the city differentiated by energy sector and energy carrier



Climate protection Benchmark: Activity Profile

- Illustrates present state and implementation of a city's climate protection activities
  - in four categories: climate policy, Energy, Traffic, Waste
  - in steps from 0 (slightly active) to 4 (exceedingly active)

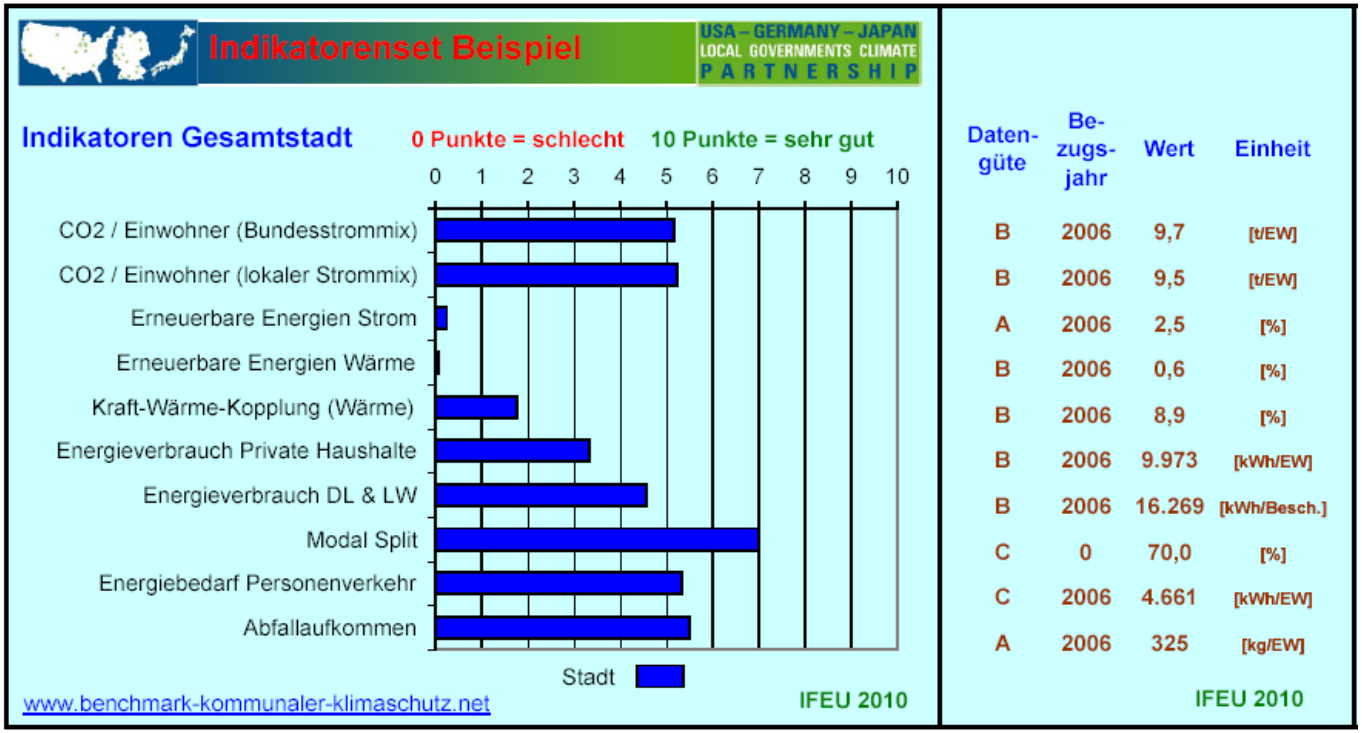


Climate protection Benchmark: Activity Profile - Mobility

	Mobility	1: getting started		2: moving forward		3:forging ahead		4: taking the lead	
M1	**Involve your staff in your sustainable mobility plans**	inform your employees about the environmental impact of their travel to and from work and about the alternatives	☐	set up a mobility plan for the local administration	☐	adapt the number and type of your vehicles to the specific needs (including car-sharing possibilities)	☐	purchase fuel efficient, alternative fueled and electric vehicles	☐
M2	**Reduce transport demand by sustainable land use planning**	investigate sustainable transport solutions (low surface area, mix of functions) when (re)designing residential areas or for housing projects	☐	introduce criteria for urban planning that aim at reducing transport demand, and promoting public transportation	☐	plan in favor of pedestrians and cyclists, traffic calming as well as energy efficient and responsible car use	☐	implement innovative models of urban design regarding transport (car free residential areas etc.)	☐
M3	**Increase the share of zero carbon transport modes**	set targets to increase the rate of cycling and walking modes	☐	work on the progressive enlargement and improvement of your cycling and pedestrian network	☐	consider cyclists and pedestrians as main actors when reorganizing the distribution of roadways	☐	become a cycling city exempt of cars!	☐
M4	**Provide convenient public transport**	increase insights in the possibilities of existing public transport	☐	improve public transport facilities and services	☐	develop and implement action plans on the priority and expansion of public transport	☐	achieve a best practice public transport system (broad choice of public transport, simple and cheap access to tickets, regional alliance)	☐
M5	**Restrict traffic flows by managing parking space**	increase compliance with existing parking regulations (diminish wild parking)	☐	start in the city centre to use parking and access restrictions to tempt users back to sustainable modes of transport	☐	set up and implement step-by-step an integrated parking programme	☐	introduce regulations to limit parking space in new developments	☐
M6	**Promote responsible car use of citizens**	consider the applicable legal framework and analyze potential users of efficient schemes (car-sharing, energy-efficient vehicles)	☐	promote eco-driving, car-sharing and car pooling	☐	promote the purchase of energy-efficient vehicles	☐	develop a local low energy infrastructure (smaller and more efficient vehicles, interconnect users, eco-driving)	☐

Climate protection Benchmark: Set of indicators

- Transparent overview over the effects of climate protection activities with significant indicators
- Identification of areas with need for action
- Description of data quality for each indicator



Daten-güte	Be-zugs-jahr	Wert	Einheit
B	2006	9,7	[t/EW]
B	2006	9,5	[t/EW]
A	2006	2,5	[%]
B	2006	0,6	[%]
B	2006	8,9	[%]
B	2006	9.973	[kWh/EW]
B	2006	16.269	[kWh/Besch.]
C	0	70,0	[%]
C	2006	4.661	[kWh/EW]
A	2006	325	[kg/EW]

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Measure-specific indicators – Example
Indicators for improving a regional network of cycling routes

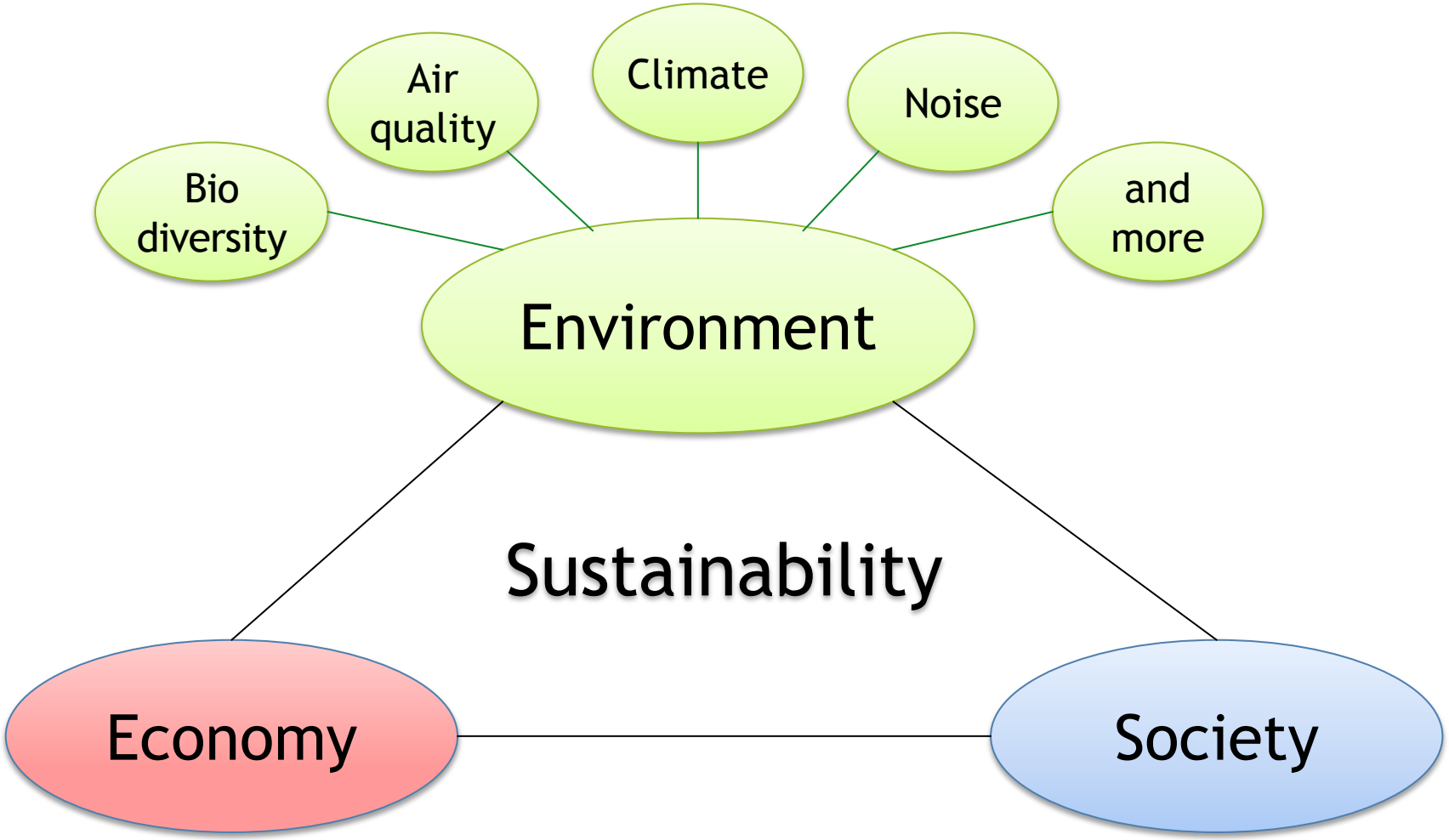
Indicators for direct effects

- Length of the cycling network
- Number of cyclists, e.g. from
  - periodic counts at selected main routes of the cycling network,
  - surveys in households, companies, public institutions
  - frequency of use of bicycle parking facilities
- Quality of cycle traffic, e.g.
  - number of accidents per cycling activity (from policy statistics)

Indicators for indirect effects

- Mobility surveys (modal shift from passenger cars)
- Traffic counts for passenger cars at selected roads with parallel cycling route (from regular traffic monitorings or own counts)
- Total VKT of passenger cars in the region (e.g. from statistical office)

Monitoring implies more than GHG emissions calculation



Thank you for your attention!

Questions and remarks?

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