Electric vehicles and urban transport externalities – is OSLO a good example?

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Motivation

- Norway is leader in penetration of EV (30% ? In Oslo) - has close to 100% renewable electricity (hydro)
- Thanks to strong incentives for purchase and use of EV's
- What have been the effects on urban transport equilibrium? – in particular congestion?
- Is there a better mix of instruments?

Outline

- Norwegian objectives and policies
- What is to be expected from these policies
- Numerical model description for Oslo
- Effects of present policy
- Alternative policies
- Conclusions and further work

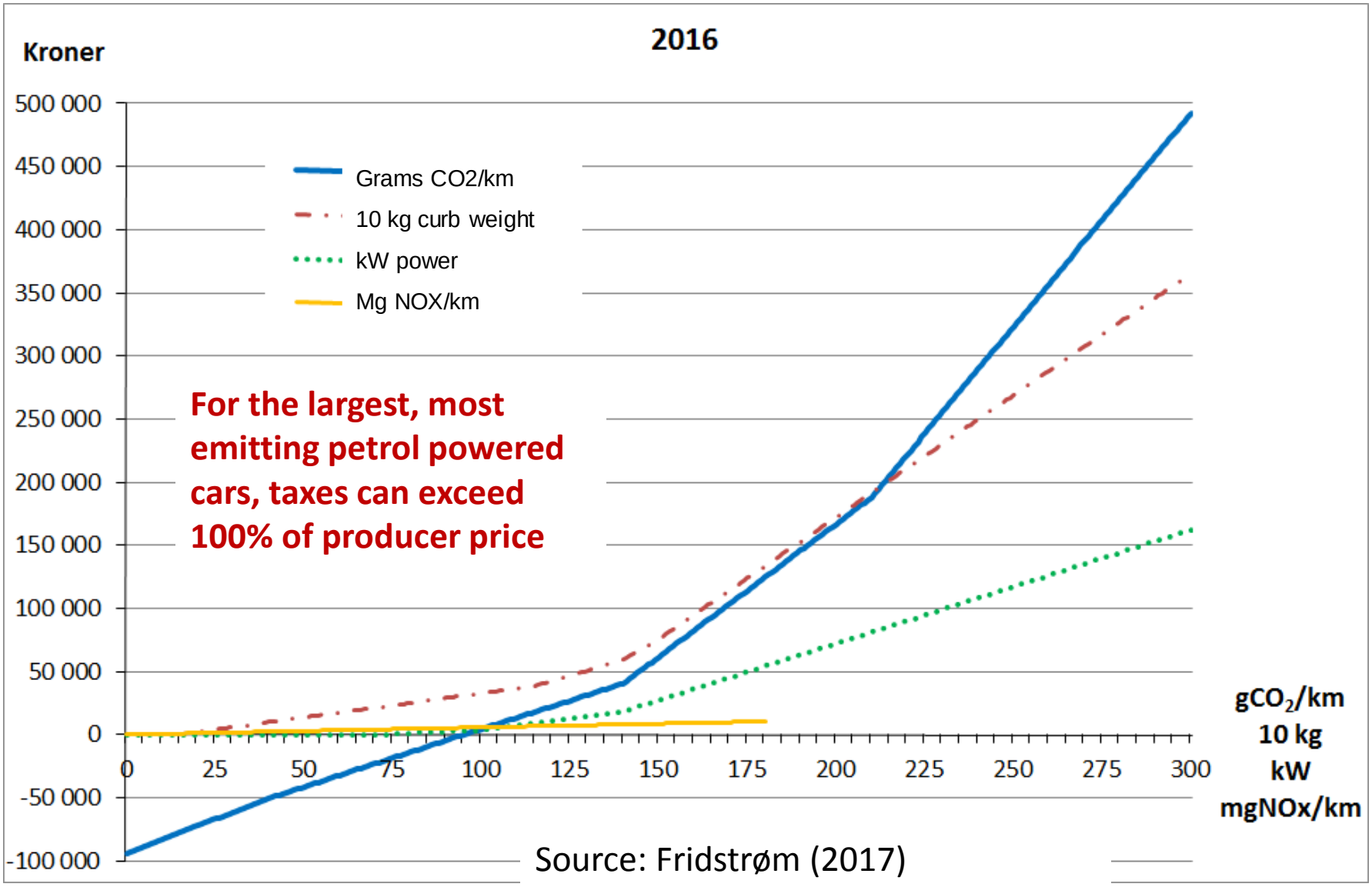
Norwegian EV & Transport policies 1

- National transport plan:
  - All new light vehicles and busses are 0 carbon emission by 2025
  - Zero growth of passenger car transport in urban areas, facilitated by walking, cycling and public transport
- Principles for promotion of low and zero emission vehicles:
  - Purchase costs of EV competitive with fossil fuel cars
  - User costs of EV should be lower than of fossil cars
  - Prioritize EV when road capacity or parking is scarce
  - Power charging facilities should be available everywhere

Norwegian EV & Transport policies 2 -implementation-

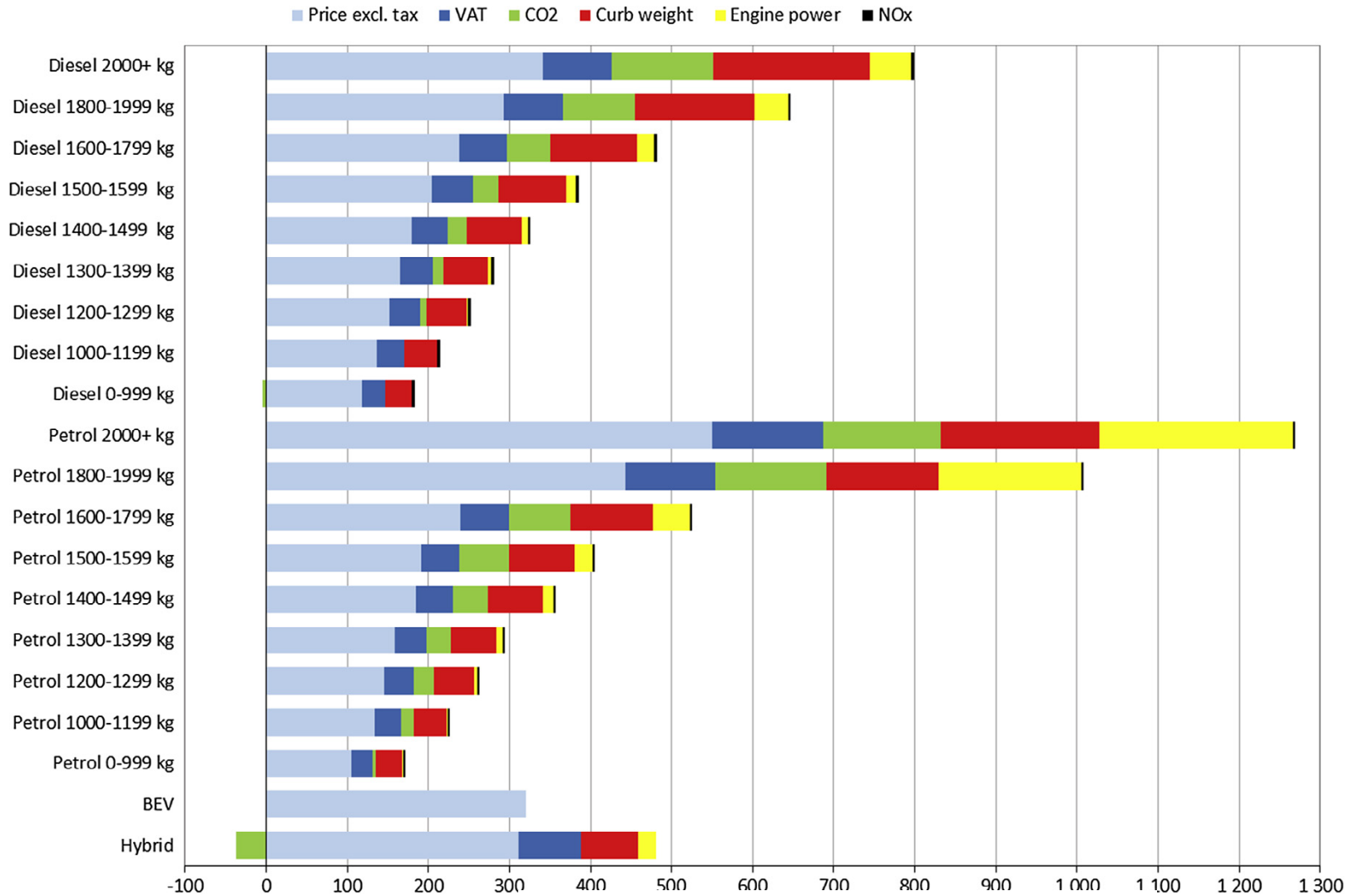
- Purchase taxes on fossil cars: 25% VAT+ progressive purchase tax on CO2, NOX, weight and engine power
- No purchase taxes on EV's
- EV's have lower user costs:
  - No tolls
  - Free municipal parking (most places)
  - Almost free use of the bus lane (but becoming problematic)
- Gasoline costs ca 1,75 $/liter, of which 0,9 $/liter is tax
- Extensive Public Tansport supply and low prices
  - Prices uniform over the day
  - Revenues cover some 50% of operation costs in Oslo area

Progressive purchase taxation



Source: Fridstrøm (2017)

Estimated average automobile prices and tax components, by fuel type and curb weight (2014)



Source: Fridstrøm & Østli (2017)

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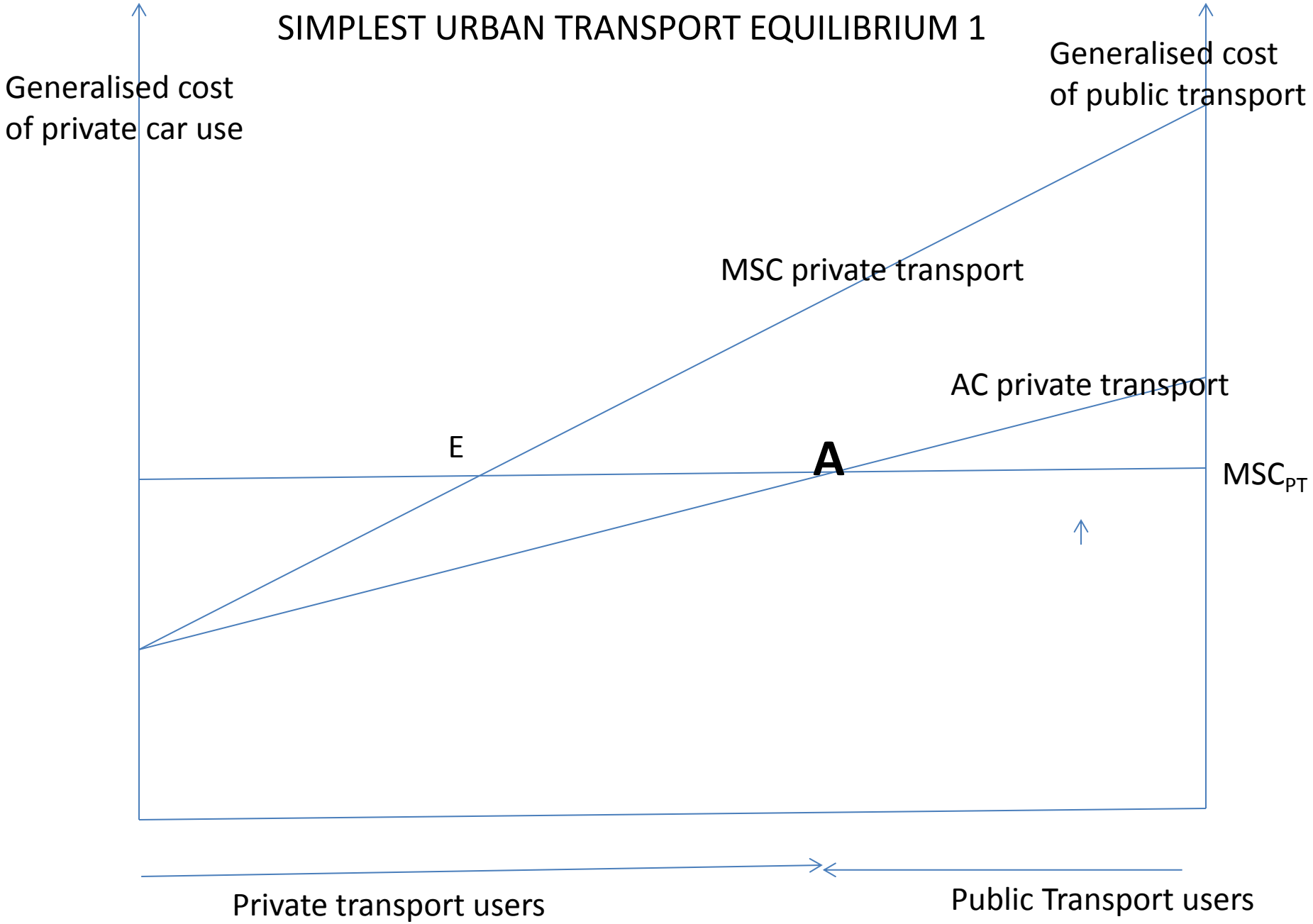
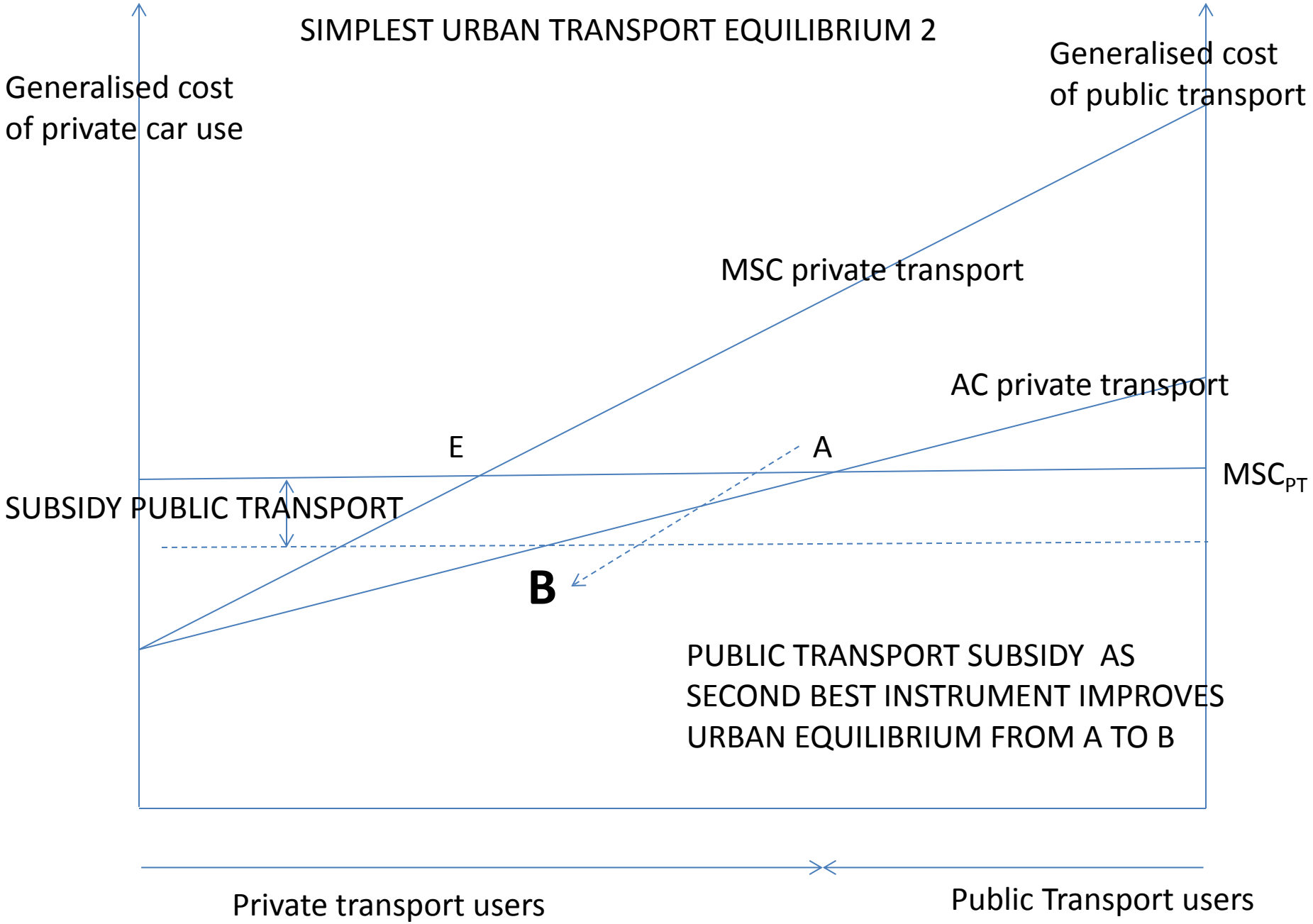
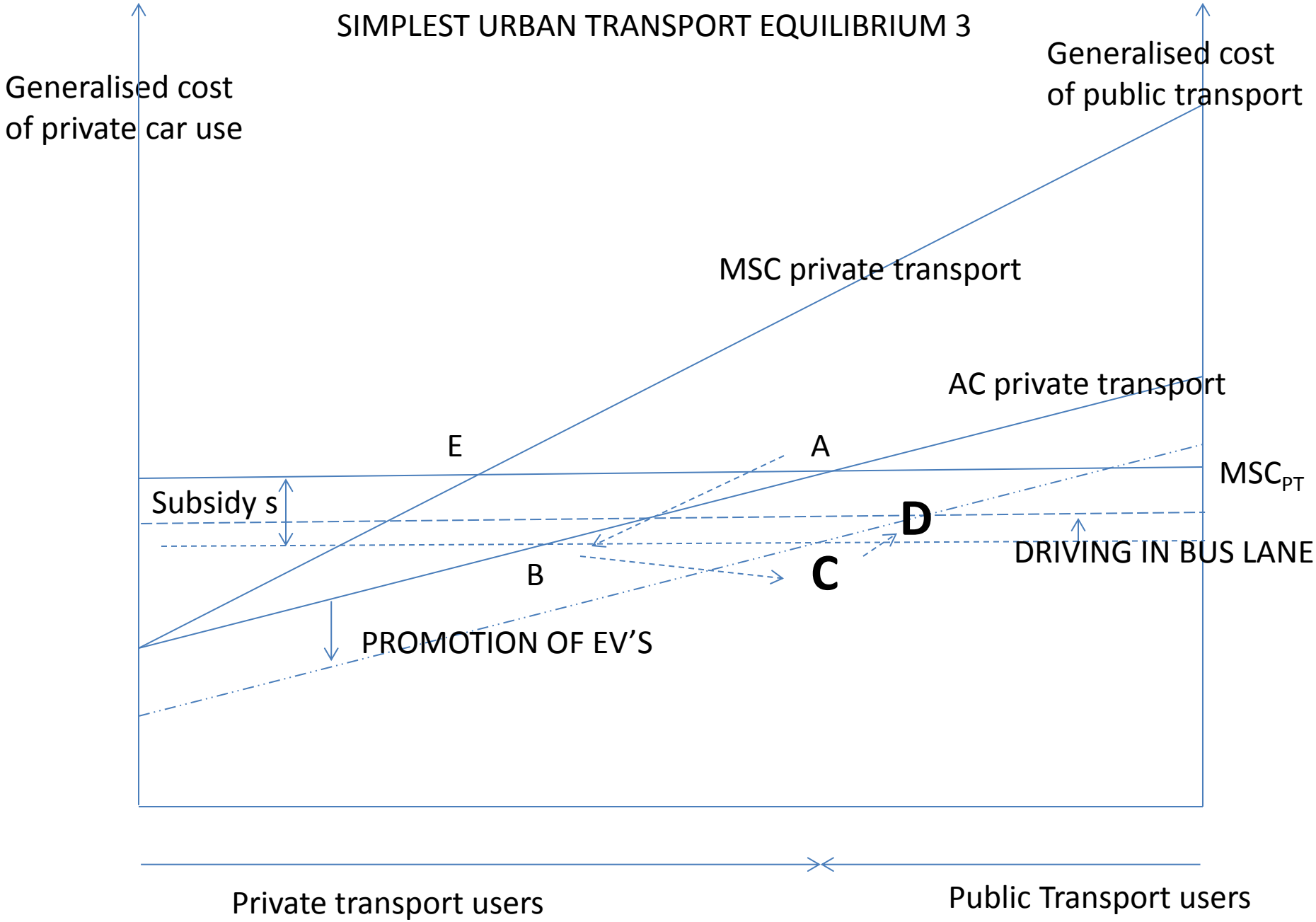
Focus on urban transport equilibrium

- Given land use
- Major externalities (other than Climate):
  - Congestion
  - Accidents
  - Air pollution
- Focus on congestion as air pollution is improving and relation between accidents and total volume of car use is not clear
- **Current policies may deteriorate urban equilibrium**


SIMPLEST URBAN TRANSPORT EQUILIBRIUM 1
Generalised cost of private car use
Generalised cost of public transport
MSC private transport
AC private transport
E
A
MSC$_{PT}$
Private transport users
Public Transport users


SIMPLEST URBAN TRANSPORT EQUILIBRIUM 2
Generalised cost of private car use
Generalised cost of public transport
MSC private transport
AC private transport
E
A
MSC$_{PT}$
SUBSIDY PUBLIC TRANSPORT
B
PUBLIC TRANSPORT SUBSIDY AS SECOND BEST INSTRUMENT IMPROVES URBAN EQUILIBRIUM FROM A TO B
Private transport users
Public Transport users


SIMPLEST URBAN TRANSPORT EQUILIBRIUM 3
Generalised cost of private car use
Generalised cost of public transport
MSC private transport
AC private transport
E
A
MSC$_{PT}$
Subsidy s
D
DRIVING IN BUS LANE
B
C
PROMOTION OF EV'S
Private transport users
Public Transport users

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Model objective

- Build a model for decarbonisation policies in Norway modelling transport and electricity supply policies (part of ELECTRANS project)
- Here: focus on passenger transport in OSLO urban area for given electricity prices
- Later:
  - Interaction with electricity sector, charging of EV
  - Non-urban transport (rail, domestic aviation, freight..)

Urban transport model

- Oslo is modelled as a homogeneous zone with
  - 2 periods (urban peak and off-peak)
  - one congested urban road link that has car lanes and a bus lane
  - Utility of Short trips (within Oslo) and Long trips (out of Oslo, no congestion)
  - Public transport supply with endogenous frequency adaptation
  - N (now 2, later 20) different types of user groups that select
    - Type of car (ICEV, PHEV, EV short, EV long)-now 4, later more
    - Number of trips in peak or off peak, and type of mode (car, public transport)
  - Model calibrated to year 2014 using travel survey distingushing between short and long trips, public transport and car trips and what type of car was used (mainly fossil)
  - Price and cross price elasticities from literature and from other Norwegian transport models

Calibration & Simulation procedure

- Calibrate for each user group (2 to 20) a quadratic utility function that represents transport behaviour(mode and peak/off peak) and for 2 types of trips (long, short) for the type of car they have – using travel survey+ price elasticities
- Estimate speed flow function + Value Of Times gives observed generalised prices (“full cost of a trip”)
- Estimate cost function for peak and off peak public transport trips and calibrate crowding factors for public transport (VOTx2 if standing)

– Change policy parameters
  - For each possible car choice (4 types) – simulate travel behaviour, and select car choice that generates the highest utility for 1st group in population
  - Redo the car selection for the next group, taking into account the car choices and behaviour of the first group,
  - If necessary redo the car choice selection + user behaviour for the 1st group
  - RESULT: joint optimisation of car choice and user behaviour for each consumer group

2 typical individuals and 4 types of cars

- Group A makes many long car trips, PT has share 26%
- Group B only makes short trips, PT has share 42%

– 4 types of cars:

	ICEV	PHEV	EV short range (190 km)	EV long range (528 km)
Consumer Price	388 237	456 036	263 049	720 468
Purchase tax	109 056	44 143	0	0
VAT	55 836	82 379	0	0

All prices are in NOK (1 NOK = 0.11 EUR)

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Current advantages for EV's

- No taxes on EV's
- No tolls
- Free parking
- Drive in bus lane

Policies in baseline (11 NOK = 1Euro)

Policy	Value
Peak toll ICEV	0.45 NOK per v-km
Off-peak toll ICEV	0.45 NOK per v-km
Toll on long trips (far from cities) ICEV	0.11 NOK per v-km
Peak toll EV	0 NOK per v-km
Off-peak toll EV	0 NOK per v-km
Toll on long trips (far from cities) EV	0 NOK per v-km
VAT ICEV/Hybrid	25 %
VAT EV	0 %
Purchase tax average ICEV	109 056 NOK
Purchase tax average PHEV	44 143 NOK
Purchase tax EVs	0 NOK
Fare cost peak	5.5 NOK + 0.55 NOK/pkm
Fare cost off peak	5.5 NOK + 0.55 NOK/pkm
Average parking cost per day ICEV	20 NOK
Average parking cost per day EV	0 NOK

Provisional results for 2 population groups

- 3 “Reference equilibria”
  - Current equilibrium 2014
  - Long term equilibrium with current policies
  - Long term equilibrium without favouring EV

Reference equilibrium 2014

Scenarios	Car choice group A	Car choice group B	Road use (bn vkm)	PT use (bn pkm)	Carbon emissions (1000 tons)	Gross transport utility group A	Gross transport utility group B	Transport externality costs	Net governme nt surplus (bn NOK)	Welfare W (bn NOK)
Reference case 2014 («Observed»)	ICEV	ICEV	4.95	2.14	792	52.63	58.16	3.11	2.96	339.60

- In 2014 we observe that “everyone” (98%) drives an ICEV

Business As Usual Equlibrium

Scenarios	Car choice group A	Car choice group B	Road use (bn vkm)	PT use (bn pkm)	Carbon emissions (1000 tons)	Gross transport utility group A	Gross transport utility group B	Transport externality costs	Net governme nt surplus (bn NOK)	Welfare W (bn NOK)
Reference case 2014 («Observed»)	ICEV	ICEV	4.95	2.14	792	52.63	58.16	3.11	2.96	339.60
BAU scenario	EV long	EV short	5.47	1.97	0	54.05	58.20	1.67	- 6.70	338.12

- Continued EV promotion policies are expected to lead to high penetration of Evs
  - People drive more and use less public transport

No EV-favoritism Equlibrium

Scenarios	Car choice group A	Car choice group B	Road use (bn vkm)	PT use (bn pkm)	Carbon emissions (1000 tons)	Gross transport utility group A	Gross transport utility group B	Transport externality costs	Net governme nt surplus (bn NOK)	Welfare W (bn NOK)
Reference case 2014 («Observed»)	ICEV	ICEV	4.95	2.14	792	52.63	58.16	3.11	2.96	339.60
BAU scenario	EV long	EV short	5.47	1.97	0	54.05	58.20	1.67	- 6.70	338.12
No EV-favoritism scenario	PHEV	No car	3.05	3.63	117	53.49	35.87	0.86	-3.50	331.53

- No EV-favoritism expected to lead to much lower EV penetration,
- lower overall car ownership and massive Public Transport

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What is wrong with current policy?

instruments not targeted

	Car tax fossil	Car tax EV	Gas tax	Car regulation	Toll Free EV	Peak Toll cars	Peak Fare PT
Climate	+		++		+		
Air poll				+			
Congestion					-		
Crowding PT							
Parking					-		

What is wrong with current policy?

instruments not targeted

	Car tax fossil	Car tax EV	Gas tax	Car regulation	Toll Free EV	Peak Toll cars	Peak Fare PT
Climate	+		++		+		
Air poll				+			
Congestion					-	++	
Crowding PT							++
Parking					-		

Provisional results for 2 population groups

- We show the results from welfare-maximizing policies (pricing of car use, PT use, parking) for given vehicle combinations
- Assuming MCPF = 1, the combination with highest welfare when optimized, can be achieved

Best off with group A driving a PHEV and group B driving short range EVs

BEST

Welfare Rank	Group A (longtripper)	Group B (shorttripper)
1	PHEV	EV short range
2	ICEV	EV short range
3	PHEV	ICEV

WORST

Welfare Rank	Group A (longtripper)	Group B (shorttripper)
10	EV high range	PHEV
11	EV low range	ICEV
12	EV low range	PHEV

Welfare maximizing policies for best combinaton (A:PHEV and B:EV Low)

Policy variable	Change from reference (NOK)
Peak toll ICEV	Up from 0.45 to 2.85
Off-peak toll ICEV	Down from 0.45 to 0.35
Toll on long trips (far from cities) ICEV	Up from 0.11 to 0.14
Peak toll EV	Up from 0 to 2.60
Off-peak toll EV	Up from 0 to 0.35
Toll on long trips (far from cities) EV	Up from 0 to 0.1
Fare cost peak	Up 9% on average
Fare cost off peak	Down 41 % on average
Average parking cost per day ICEV	Unchanged
Average parking cost per day EV	Up from 0 to 20, same as for conventional cars

Result variable	Change from reference
Road use	0.2 %
PT use	7.5 %
Carbon emissions	-85.3 %
Gross transport utility group A	0.8 %
Gross transport utility group B	-0.3 %
Transport externality costs	-50.2 %
Net government surplus	-136.6 %
Welfare	1.3 %

Key takeaways I

- Important to understand both the choice of car ownership and transport patterns for different population groups
- There is a conflict between reducing CO2-emissions by promoting EVs via low user costs and curbing congestion

Key takeaways II

- Never forget that there are MANY market failures and policy parameters (probably ALL of them are sub-optimally assigned in Norway)
- The distribution of longtrippers and shortrippers matter!

Avenues for further work

Adding to the model:

- More groups of agents
- More types of cars
- Issues of charging (capacity, network externalities)
- Public transport (Electric busses, ..)
- Distributional aspects of high car taxes

THANK YOU FOR YOUR ATTENTION!