THE COST OF DRIVING: CHOICES, POLICIES

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Energy Challenges for the Next Decade

The views expressed in this presentation are those of the presenter and not necessarily of the Agency, any of its Boards, or any NRA.

In this presentation

- **The model:**
  - **Main features**
  - **Variables**
  - **Constants**
  - **Sensitivity**
- **Results**
- **What could the results mean for policies?**

Levelized cost "Arm and Leg"© model

- **Total cost from consumer's viewpoint:**
  - CAPEX - full asset acquisition cost:
    - Taxes included (actual prices paid)
    - Financial charges (if any) included – ditto lease
    - Opportunity cost considered
  - OPEX:
    - Running cost
    - Repair cost (incl. overhauls)- car as a "consumer" item
    - Periodic payments (insurance, inspection, etc.)
    - End-of-life disposal cost or sale proceeds
- **Fixed ("arm" – depreciation!) and variable ("leg") cost**
- **Not considered: fashion and image, seller reputation / consumer reports re reliability, etc.**
- **Environmental cost: an externality (CO2 emissions – specific per km / mile and costed via price)**

Consumer choice variables

- **New or used?**
- **Financials:**
  - Price
  - Acquisition modality (outright, lease)
  - Cash or credit?
  - Opportunity cost
- **Asset features (model-specific):**
  - Propulsion (e.g. gas, Diesel, PI hybrid – gas or D, all E - BEV)
  - Specific fuel consumption (gas, Diesel, electricity)
- **Insurance (e.g. scope of coverage + associated cost)**
- **Miles / km driven per year**
- **Duration of intended use (years)**
- **"Bundled asset features":**
  - Depending on asset (e.g. oil change interval and expense)
  - Depending on pattern of use, preferences (e.g. frequency of tire change, brakes, etc.)

Variables over which consumer has no choice after vehicle acquisition

- **Fuel / electricity price**
- **Insurance cost**
- **Cost of consumables, repairs**
- **Mandatory charges (tax, inspection, etc.)**
- **Electricity generation fuel mix (hence CO2 emissions associated with electricity)**

- **BUT… some are associated with:**
  - Fixed cost (e.g. insurance, mandatory charges)
  - Variable cost (e.g. fuel / electricity cost)

- **And per unit externalities (CO2 per km driven) are totally beyond consumer control after acquisition**

Example 1: New / used gasoline powered car

Vehicle acquisition cost is	$	14,000.00
Arm (fixed operational cost over time of possession - payments not dependent on mileage driven	$	10,655.44
Leg (variable operational cost over time of possession - depends on mileage driven, e.g. fuel, tires)	$	13,362.10
Total cost over lifetime of vehicle in consumer hands, present day value	$	36,064.54
Of which fuel	*$*	*9,557.25*
Total cost per year owned , PV	$	3,606.45
Total levelized cost per km driven, cents/km	$	0.34
Ratio fixed cost / variable cost (proportion)		4/5
Ratio fuel cost / total cost (percent)		26.5%
Liters per 100 km consumption are equivalent to a mileage of this much miles per gallon:		33.6
This car emits this much grams of CO2 per km:		162.4

Vehicle acquisition cost is	$	7,000.00
Arm (fixed operational cost over time of possession - payments not dependent on mileage driven	$	5,110.41
Leg (variable operational cost over time of possession - depends on mileage driven, e.g. fuel, tires)	$	7,730.66
Total cost over lifetime of vehicle in consumer hands, present day value	$	17,631.43
Of which fuel	*$*	*5,073.24*
Total cost per year owned , PV	$	3,526.29
Total levelized cost per km driven, cents/km	$	0.32
Ratio fixed cost / variable cost (proportion)		2/3
Ratio fuel cost / total cost (percent)		28.8%
Liters per 100 km consumption are equivalent to a mileage of this much miles per gallon:		33.6
This car emits this much grams of CO2 per km:		162.4

This example based on:

- Lump sum payment - 12,000 km per year - 7 l/100 km - Fuel price $1.30 / liter
- Insurance $900 / year (3rd party, hull, comprehensive)
- Proceeds from sale at end of period – $2,500, etc.

Example 2: New / used Diesel powered car

Vehicle acquisition cost is	**$**	**16,000.00**
Arm (fixed operational cost over time of possession - payments not dependent on mileage driven)	**$**	**10,655.44**
Leg (variable operational cost over time of possession - depends on mileage driven)	**$**	**11,681.70**
Total cost over lifetime of vehicle in consumer hands, present day value	**$**	**35,993.55**
Of which fuel	***$***	***7,876.86***
Total cost per year owned , PV	**$**	**3,599.35**
Total levelized cost per km driven, cents/km	**$**	**0.34**
Ratio fixed cost / variable cost (proportion)		**1**
Ratio fuel cost / total cost (percent)		**21.9%**
Liters per 100 km consumption are equivalent to a mileage of this much miles per gallon:		**39.2**
This car emits this much grams of CO2 per km:		**157.2**

Vehicle acquisition cost is	**$**	**8,000.00**
Arm (fixed operational cost over time of possession - payments not dependent on mileage driven)	**$**	**5,110.41**
Leg (variable operational cost over time of possession - depends on mileage driven)	**$**	**6,838.66**
Total cost over lifetime of vehicle in consumer hands, present day value	**$**	**17,297.51**
Of which fuel	***$***	***4,181.25***
Total cost per year owned , PV	**$**	**3,459.50**
Total levelized cost per km driven, cents/km	**$**	**0.31**
Ratio fixed cost / variable cost (proportion)		**3/4**
Ratio fuel cost / total cost (percent)		**24.2%**
Liters per 100 km consumption are equivalent to a mileage of this much miles per gallon:		**39.2**
This car emits this much grams of CO2 per km:		**157.2**

This example based on:

- Lump sum payment - 12,000 km per year - 6 l/100 km - Fuel price $1.25 / liter
- Insurance $900 / year (3rd party, hull, comprehensive)
- Proceeds from sale at end of period – $3,000, etc.

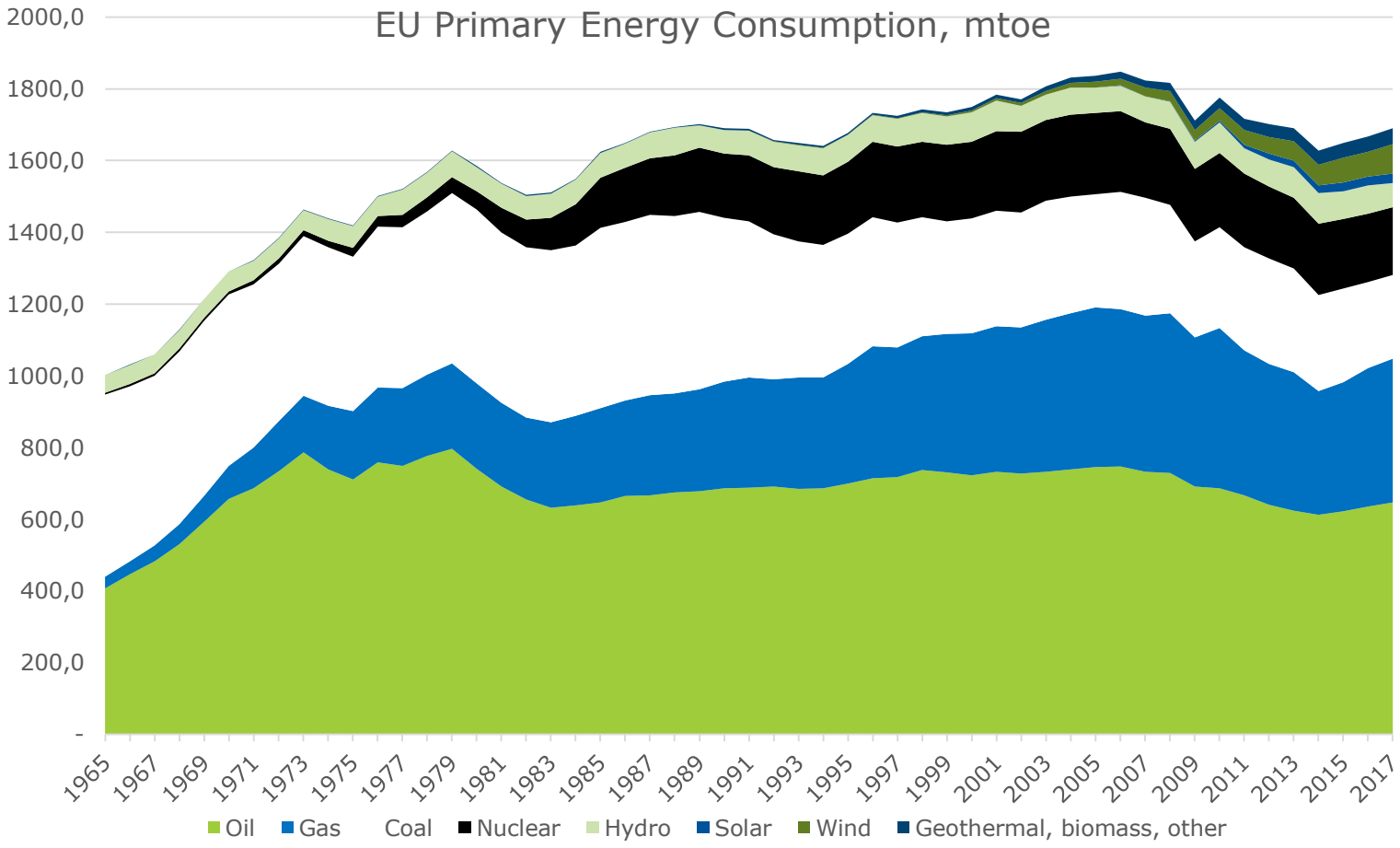
Example 3: New / used BEV

Vehicle acquisition cost is	$	36,000.00
Arm (fixed operational cost - payments not dependent on mileage driven)	$	10,655.44
Leg (variable operational cost over time of possession - depends on mileage driven)	$	7,165.64
Total cost over lifetime of vehicle in your hands, present day value	$	47,571.49
Of which fuel	*$*	*3,360.79*
Total cost per year owned	$	4,757.15
Total cost per km driven, cents/km	$	0.45
Ratio fixed cost / variable cost (proportion)		1 1/2
Ratio fuel cost / total cost (percent)		7.1%
CO2 emissions, per km driven, g/km, BEV		26.9

Vehicle acquisition cost is	$	18,000.00
Arm (fixed operational cost - payments not dependent on mileage driven)	$	5,110.41
Leg (variable operational cost over time of possession - depends on mileage driven)	$	4,441.41
Total cost over lifetime of vehicle in your hands, present day value	$	20,480.99
Of which fuel	*$*	*1,784.00*
Total cost per year owned	$	4,096.20
Total cost per km driven, cents/km	$	0.37
Ratio fixed cost / variable cost (proportion)		1 1/7
Ratio fuel cost / total cost (percent)		8.7%
CO2 emissions, per km driven, g/km, BEV		26.9

This example based on same assumptions as for gas/Diesel powered vehicles, plus the following power generation mix shares (w/o loss in transmission / conversion considered): hard coal 0.129, lignite 0.225, gas 0.129, oil 0.009, nuclear 0.118, RES 0.349, other 0.041.
Cost of power is $0.20 / kWh. Battery is 65 kWh and lasts 400 km.

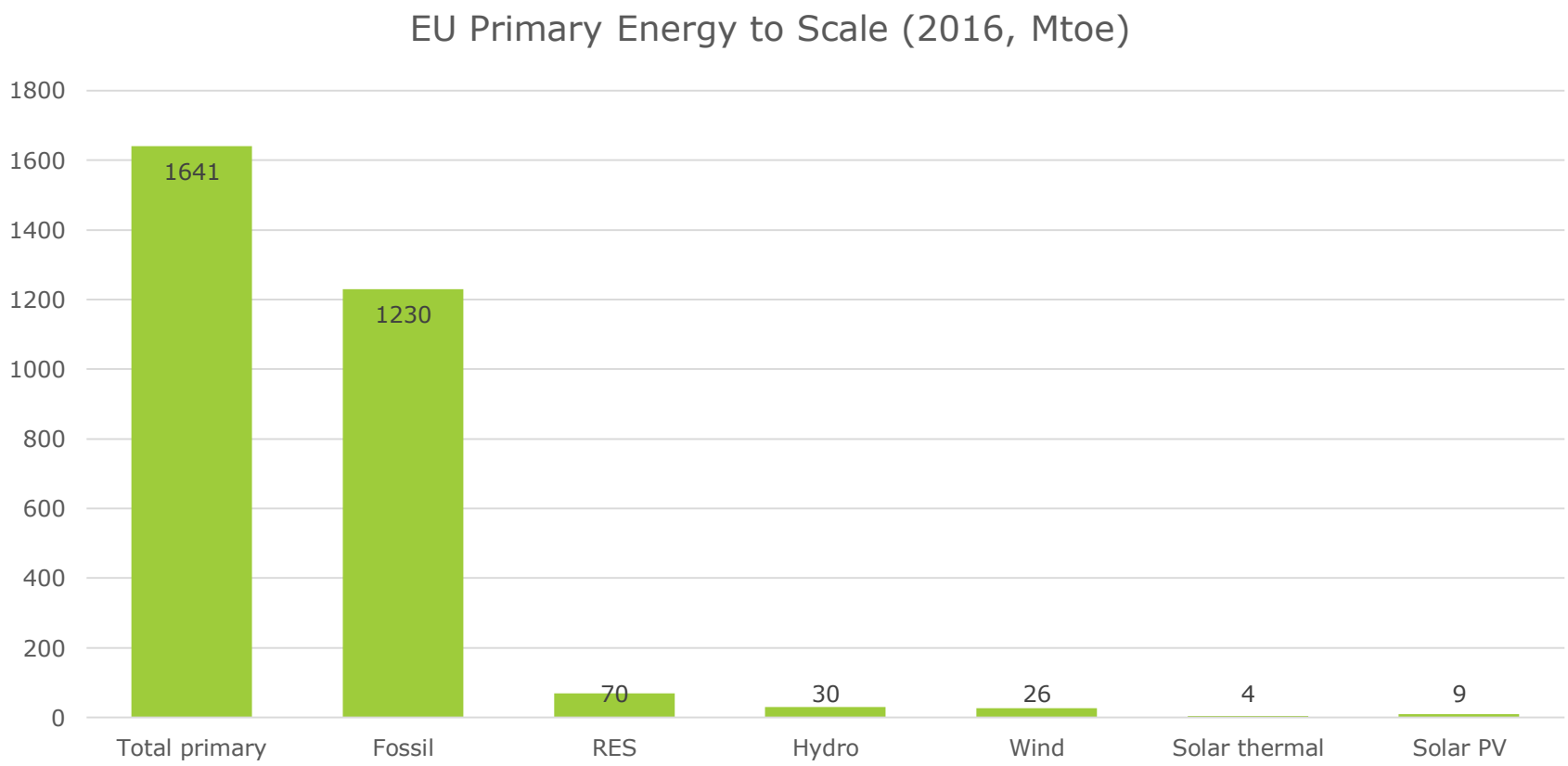
PtG, hydrogen, biogas are not primary – need primary resource input: resource available?



Source: BP. Illustrative example only.

Scale: Primary Energy

- To reduce CO2 emissions by 1%, about 12 Mtoe of fossil fuels have to be replaced by other energy (RES, nuclear) = approx. total solar in 2016
- Total available electricity (all sources) is about 220 Mtoe, including about 40 Mtoe wind and solar (of which only 9 Mtoe solar PV)
- End use pattern for oil (mostly transportation) is very different from those of electricity and natural gas (appliances, heat) – next slide



Source: Eurostat

Demand-side: then, now, in the future?

What can be substituted for what, where?

	Residential			Commerc.		Industr.		Trans.
	L	H	Appl	H	L	Boil	Proc	
O-NG	-	Y	0	Y	-	Y	S	L
O-E	0	Y	0	Y	0	Y	S	L
O-C	-	Y	0	-	-	Y	0	-
NG-E	0	Y	Y	Y	0	Y	S	-
NG-C	-	Y	0	-	-	Y	0	-
E-C	0	Y	0	-	0	Y	0	-

1989

2019

2049?

O – oil; NG – natural gas; E - electricity; C - coal

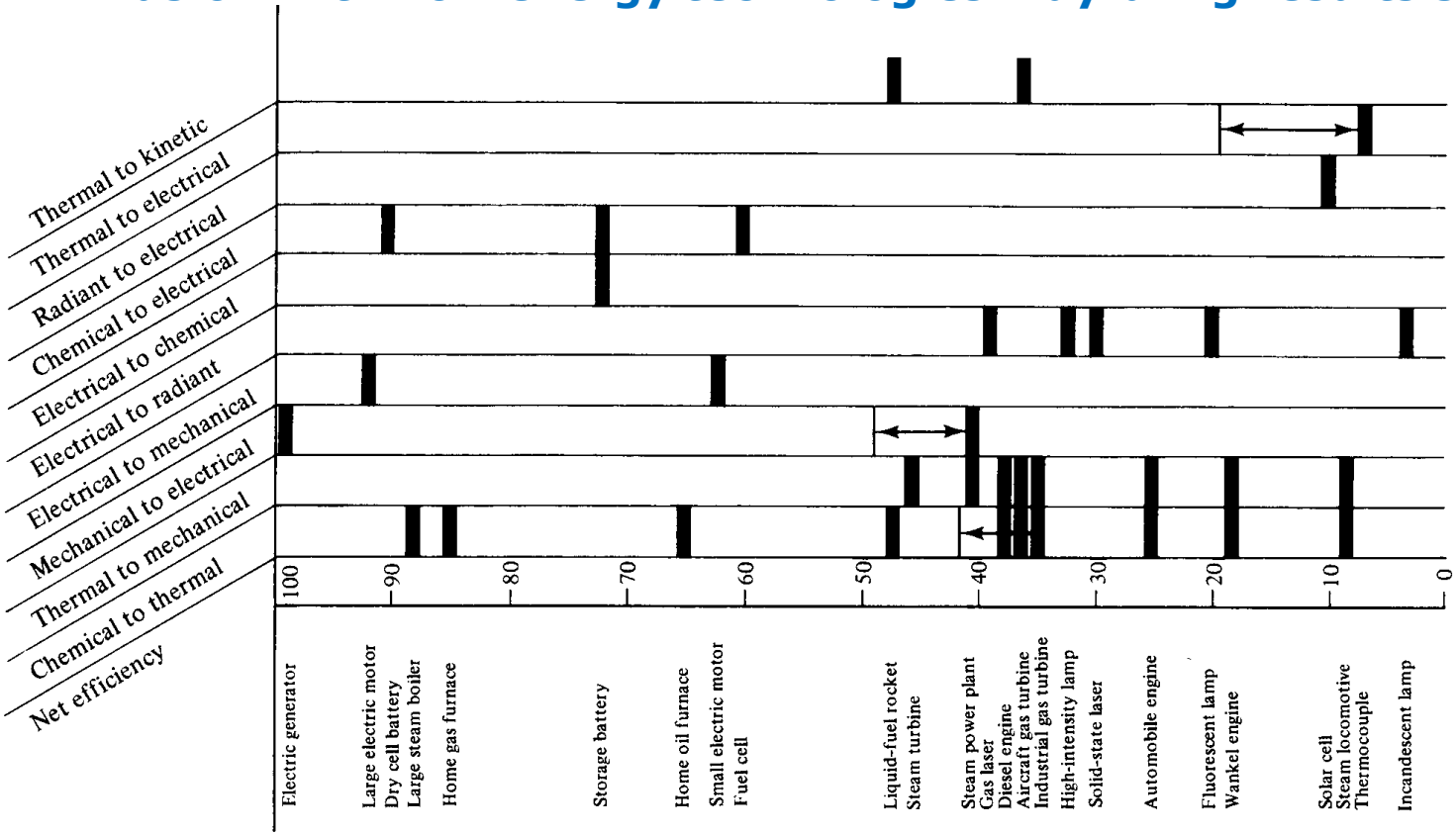
L - lighting; H - heating; Appl – appliances; Boil- boiler heat; Proc – process heat

Y- easy substitution; S - some substitution; L – low substitution; 0 – very low substitution; dash (-) not applicable

Source: Considine (1989)

Energy efficiency: Technology-specific, dispersed

- **Energy efficiency ≠ prevention of energy waste**
- **Use, energy type, niche-specific**
- **Progress across the board = one giant leap impossible**
- **Fusion with non-energy technologies may bring results sooner**



Source: Eden at al.

All-electric is the solution in transportation?

- MAJOR scale-up of RES, esp. wind and solar E, is needed if de-C transportation, PtG, H are to take hold any time soon. Ditto primary resources for biogas.
- Historically, many decades pass before a new primary energy source becomes the dominant one. Time is of the essence!
- PtG, H, biogas are manufactured resources: there is energy loss in conversion. To displace a unit of fossil energy by RES, more than one unit of RES is needed: rate of RES growth (esp. wind, solar) must > the rate of fossil energy displacement in final energy demand. Current RES growth rate is lower than the one needed to be fossil-free by 2050.
- Primary energy consumption is unlikely to go down in absolute terms. So energy handling infrastructure will still be needed. Just maybe not where that infrastructure is now and not of the "classic" kind.
- Energy is not "consumed", but mostly productively used – it is an input to making GDP, a "factor of production". There could be unintended consequences when one kind of energy is displaced by another one.
- For BEV to become the "natural choice", cost must go down and externalities internalized to consumers.
- Non-fossil fuel vehicles will help to clean air in cities. To really do that in absolute terms everywhere, E must be RES or nuclear… and the road will be a long one.


Thank you for your attention