The Fugitive Gas Emissions Team

Summary presentation of scientific and socio-political perspectives submitted in the 2018 Dragon's Den Competition

Not peer-reviewed and not intended for public distribution or citation

The ReDeveLoP Challenge
Calgary, Alberta
Apr.30 – May 4, 2018

Fugitive Gas Emissions

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The ReDeveLoP Challenge
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Research Questions

(1) Reliability and accuracy of methane emission estimates

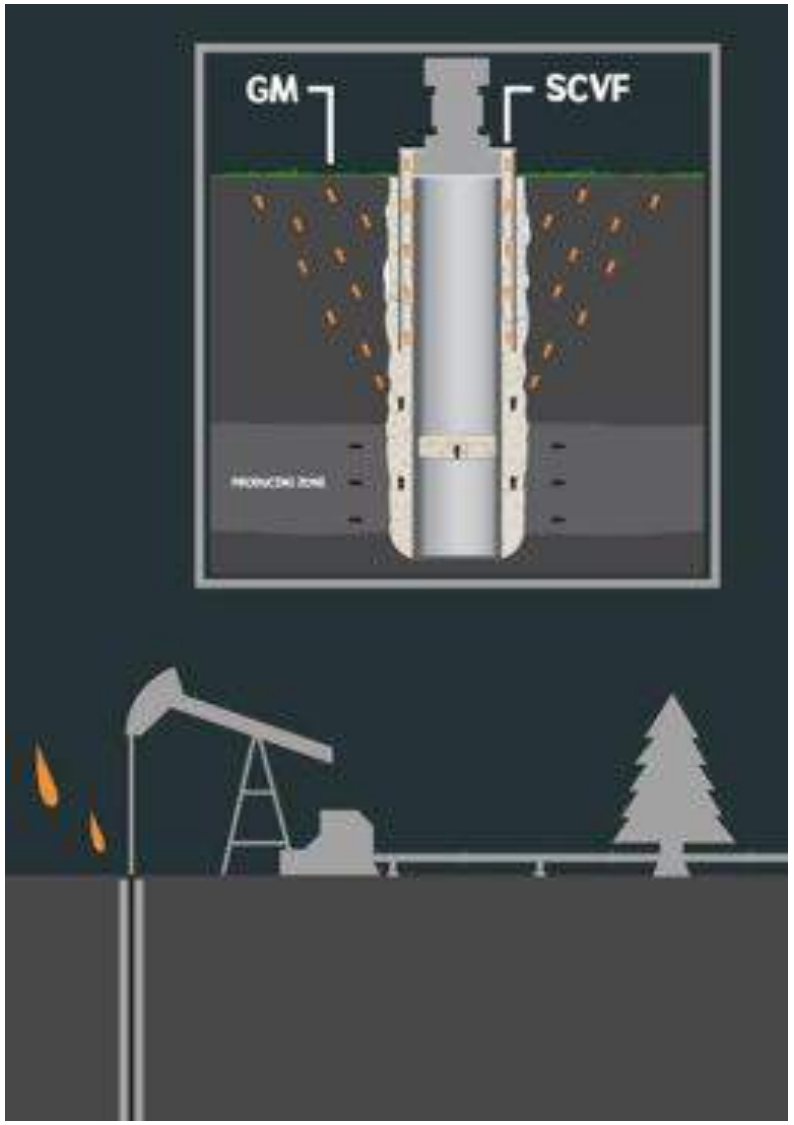
(2) Major sources of methane emissions

(3) Costs & benefits of better measurement techniques

(4) Costs & benefits of more stringent emissions regulations

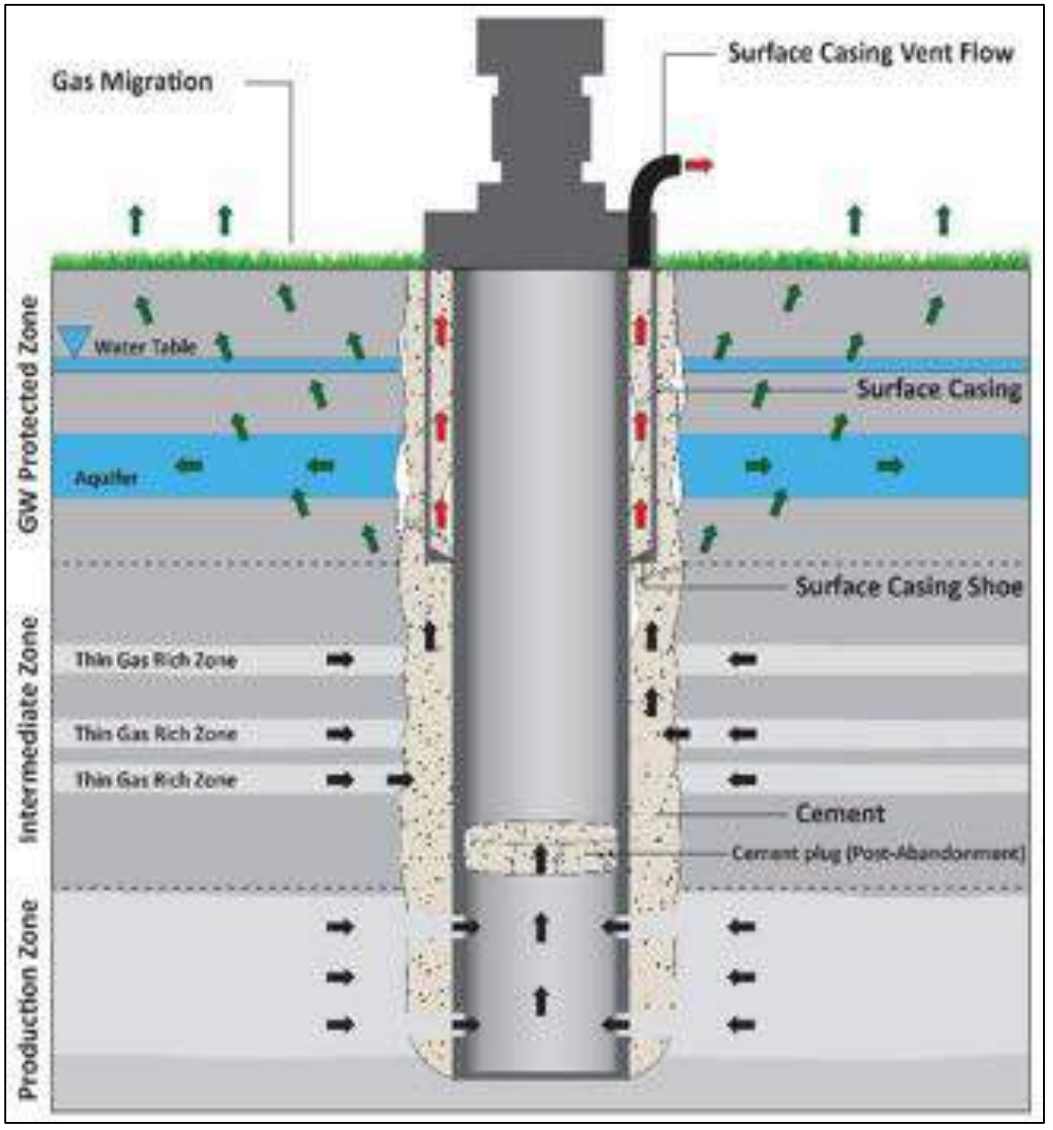
What are Fugitive Gas Emissions?

- Unintentional releases of gas to atmosphere
- Gas migration
- Surface casing vent flow



Gas Migration & Surface Casing Vent Flow

- Originates in borehole
- GM moves from borehole to rock, aquifer, soil
  - To atmosphere
- SCVF moves up inside casing to atmosphere



➡ Natural Gas

➡ Gas Migration

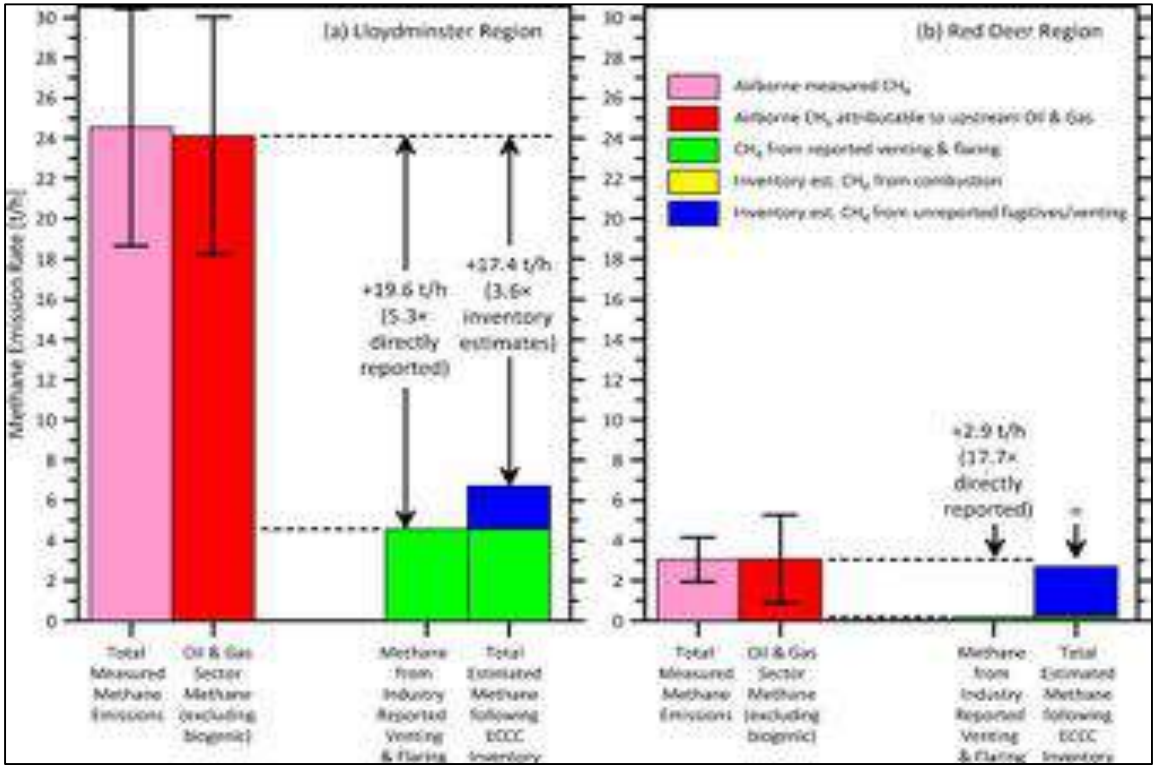
➡ SCVF

Methane Fluxes in Alberta

- Lloydminster
  60 x 60km (3600 km^2)
  - 5.3x Industry self reports
  - 3.6x Environment and Climate Change Canada (ECCC) estimates

- Red Deer
  50 x 50 km (2500 km^2)
  - 17.7x Industry self reports
  - Roughly = ECCC estimates

- Difference: Red Deer outside Required Testing Area (RTA)



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Measurement Methods

Bottom-Up

- On lease, ⩽ 10 m of well head
  - AER's Directive-20 style survey
- Directly measures concentrations at exact location or in soil around specific probe
  - values can vary within only a few meters depending on permeability
- Good: obtains accurate data for precise location
- Bad: not areally or linearly continuous

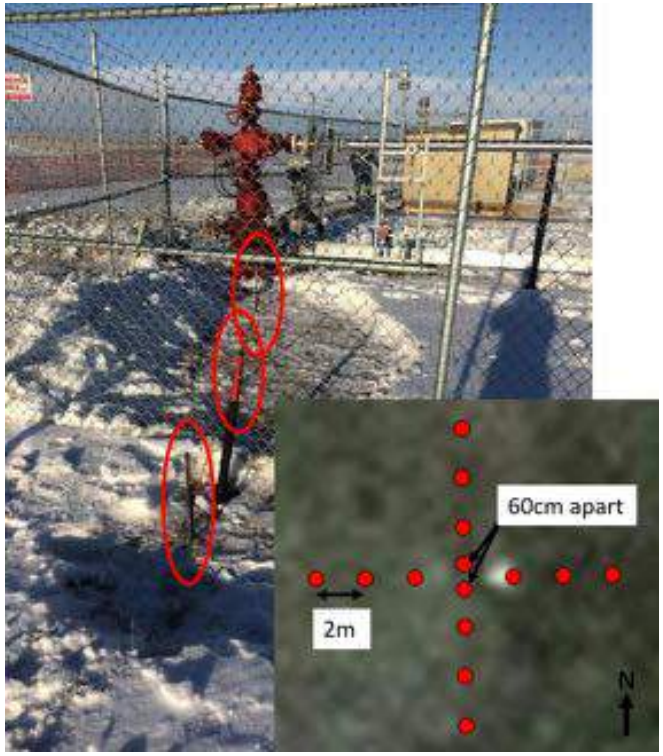
Top-Down

- Off lease or remote
  - Aircraft mounted portable spectroscopy
- Directly measures concentrations away from source/well head
- Good: obtains accurate data from area
- Bad: difficult to identify point sources

Measurement Methods

Bottom-Up

- Directive-20 recommended survey



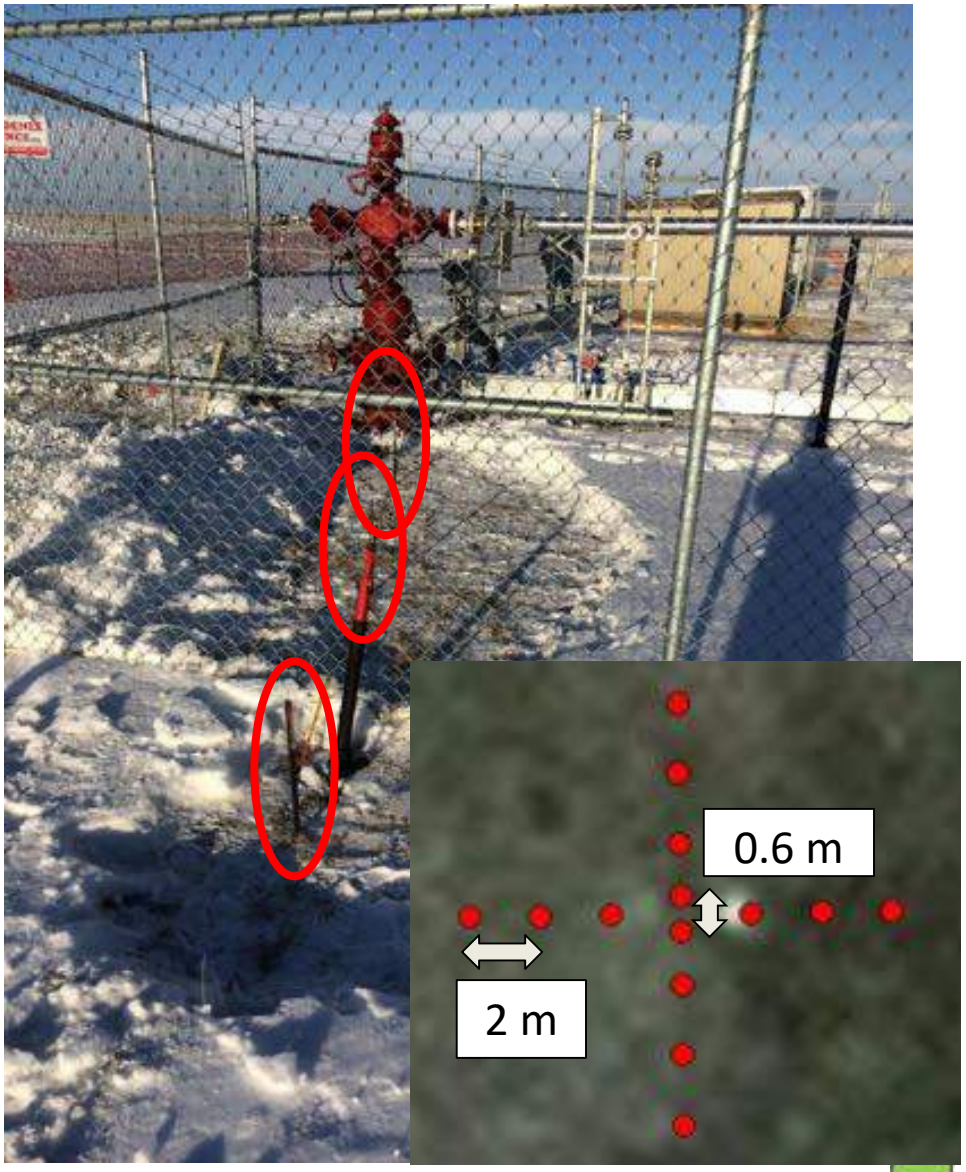
Top-Down

- Aircraft mounted portable spectroscopy survey

Desjardins, R., Worth, D., Pattey, E., Vanderzaag, A., Srinivasan, R., Mauder, M., . . . Metzger, S. (2018). The challenge of reconciling bottom-up agricultural methane emissions inventories with top-down measurements. *Agricultural and Forest Meteorology, 248*, 48-59. doi:10.1016/j.agrformet.2017.09.003

Vadose/Soil Gas Survey

- Follows AER Directive-20 recommendation
- Probes driven to sample depth of 50 cm
- Probes form cross pattern
- 2 samples 30 cm from well head opposite to each other
- Samples taken at 2 m, 4 m, 6 m from well head



“Serious” SCVF: AER Definition

- Flow rate > 300 m^3 (1000 ft^3) per day
  - Must be remediated within 90 days
- Why 300 m^3?
  - arbitrary
  - may change: new AER Directive 060 and 017 Drafts
  - Feedback can be given until May 28, 2018:

http://aer.ca/about-aer/spotlight-on/methane-reduction

https://upload.wikimedia.org/wikipedia/commons/2/26/Abandoned_gas_well_in_high_grass.jpg

https://commons.wikimedia.org/wiki/Category:Traffic_congestion#/media/File:2008-08-01_Peremohy_Avenue,_Kiev.jpg

“Serious” SCVF: AER Definition

- Ideal gas law: PV = nRT

- At STP conditions (25°C and 101.325 kPa) flow is **71.8 tCH_4/year**

  = **1795 tCO_2/year** or **974 cars/year**

https://upload.wikimedia.org/wikipedia/commons/2/26/Abandoned_gas_well_in_high_grass.jpg

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Policy Issue

- Additional social costs associated with fossil fuel production (negative externalities)
- There are fugitive gas emissions and their associated methane emissions
- The benefits of using natural gas as the bridge fuel towards a future less dependent on hydrocarbons are at risk

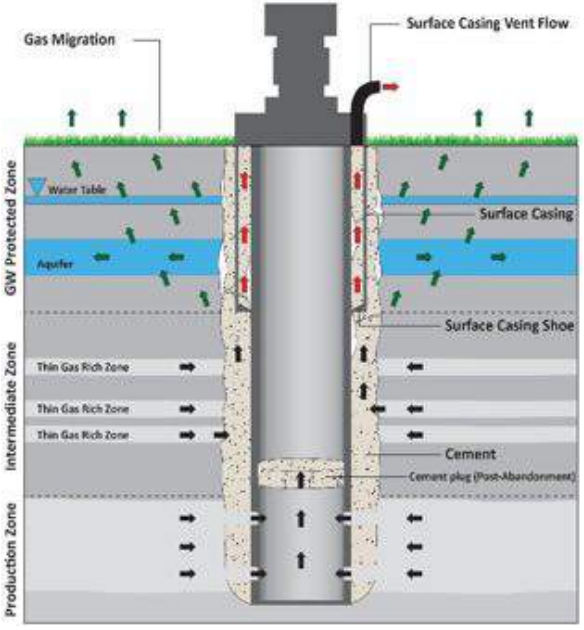
Coal (lignite)	215.4
Coal (subbituminous)	214.3
Diesel fuel and heating oil	161.3
Gasoline (without ethanol)	157.2
Propane	139.0
Natural gas	117.0

eia: U.S. Energy information Administration

www.takepart.com/article/2016/04/18/methane-emissions-oil-gas-more-cows

Key Considerations

- Between 1 and 3% of unconventional wells have fugitive emissions through structural leaks[1]
- Between 0.6 and 7.7% of methane emissions happen at the upstream and midstream sectors [2]



(1) Steelman, C. M., Klazinga, D. R., Cahill, A. G., Endres, A. L., & Parker, B. L.

(2017). Monitoring the evolution and migration of a methane gas plume in an unconfined sandy aquifer using time-lapse GPR and ERT. *Journal of Contaminant Hydrology*, *205*(August), 12–24. https://doi.org/10.1016/j.jconhyd.2017.08.011

(2) Caulton, D. R., Shepson, P. B., Santoro, R. L., Sparks, J. P., Howarth, R. W.,

Ingraffea, A. R., … Miller, B. R. (2014). Toward a better understanding and quantification of methane emissions from shale gas development. *Proceedings of the National Academy of Sciences*, *111*(17), 6237–6242. https://doi.org/10.1073/pnas.1316546111

Key Considerations

- A study in Northern BC found detectable levels of fugitive emissions in 47% of active wells [1]

- Inaccuracy of inventory levels of emissions
  - inventories updated approximately every 5 years
  - unreported and fugitive sources of emissions

(1) Johnson, M. R., Tyner, D. R., Conley, S., Schwietzke, S., & Zavala-Araiza, D. (2017). Comparisons of Airborne Measurements and Inventory Estimates of Methane Emissions in the Alberta Upstream Oil and Gas Sector. *Environmental Science & Technology*, *51*(21), 13008–13017. https://doi.org/10.1021/acs.est.7b03525

Main Takeaway

- Environmental benefits of using natural gas get eroded if it is released before combustion
- **Natural gas** is better than **coal** only if less than 2.7% of the produced natural gas is emitted before it is used
- **Natural gas** is better than **diesel** if less than 1% of the produced natural gas is emitted before it is used

Alvarez, R. A., Pacala, S. W., Winebrake, J. J., Chameides, W. L., & Hamburg, S. P. (2012). Greater focus needed on methane leakage from natural gas infrastructure. *Proceedings of the National Academy of Sciences*, *109*(17), 6435–6440. https://doi.org/10.1073/pnas.1202407109

Policy Options

- **Policy Categories:**
  - market-based policies
  - technology-based standards policies
  - performance standard policies
  - voluntary approaches

Policy Options

- **Market-based policies**
  - Tradable permits and Taxes
  - Lack of firm-level inventories make this policy inefficient
- **Technology-based standards**
  - Regulator prescribes the technologies that should used across the sector
  - Solution may be more expensive than the problem

Policy Options

- **Performance standards**
  - Regulator needs to determine an emission baseline
  - Lack of firm-level inventories make this policy inefficient

- **Voluntary approaches**
  - Firms preemptively adopt technologies or processes to reduce emissions
  - Make firms uncompetitive / no third party checks in place /no accountability

Policy Options

- All these policies focus on the supply side
- What about policies targeting consumers / the demand side?
- Can consumers, instead of a regulator, trigger changes in the oil and gas industry?

Policy Alternative

- **Demand side policies inducing voluntary approaches**
- **Third-party certification process**
  - public and private resources used for campaigns
  - importance of consuming energy from certified suppliers
  - can potentially accomplish two goals

1) make consumers reduce their own energy consumption

2) consumers could induce industry to:

➡ adopt **more sustainable** management practices

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- http://oee.nrcan.gc.ca/publications/statistics/cvs08/chapter2.cfm?attr=0
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CH_4, CO_2, or Cars/Year Assumptions

- CO_{2eq}:CH_4 is 25:1 GWP over 100 year time frame (1)
- 15,600 km/year driven (2)
- 118.1 gCO_2/km (3)

(1) Myhre, G., Shindell, D., Bréon, F.-M., Collins, W., Fuglestvedt, J., Huang, J., … Zhang, H. (2013). Anthropogenic and Natural Radiative Forcing. In Intergovernmental Panel on Climate Change (Ed.), *Climate Change 2013 - The Physical Science Basis* (pp. 659–740). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781107415324.018
(2) http://oee.nrcan.gc.ca/publications/statistics/cvs08/chapter2.cfm?attr=0
(3) https://ec.europa.eu/clima/policies/transport/vehicles/cars_en

Policy Alternative

- **Demand side policies with voluntary approaches**
- **Third-party certification process**

  - forestry industry's
  - voluntary + demand-based policy
  - public and private resources used for campaigns
  - importance of consuming energy from certified suppliers
  - no additional administrative costs on the regulator
  - consumers would induce industry to:

➡ adopt **more sustainable** management practices