Tarif progressif, efficience et équité

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Absolute energy poverty: Electricity access in 2009

	Population without electricity (million)	Electrification rate %	Urban electrification rate %	Rural electrification rate %
Africa	**587**	**41.8**	**68.8**	**25.0**
North Africa	2	99.0	99.6	98.4
Sub-Saharan Africa	585	30.5	59.9	14.2
Developing Asia	**675**	**81.0**	**94.0**	**73.2**
China & East Asia	182	90.8	96.4	86.4
South Asia	493	68.5	89.5	59.9
Latin America	31	93.2	98.8	73.6
Middle East	21	89.0	98.5	71.8
Developing countries	**1 314**	**74.7**	**90.6**	**63.2**
World*	**1 317**	**80.5**	**93.7**	**68.0**

* World total includes OECD and Eastern Europe / Eurasia

Source: *WEO-2011* www.worldenergyoutlook.org/resources/energydevelopment/accesstoelectricity/

Relative energy poverty

- Even in developed countries, energy (or fuel) poverty is a serious issue, likely to become even more serious in the future.

- It is hard to give a clear definition of energy poverty.

- Policy makers respond by doing what they can, not what they should.

- A lot remains to be done in the microeconomics of energy poverty and public intervention.

1. What is fuel poverty?

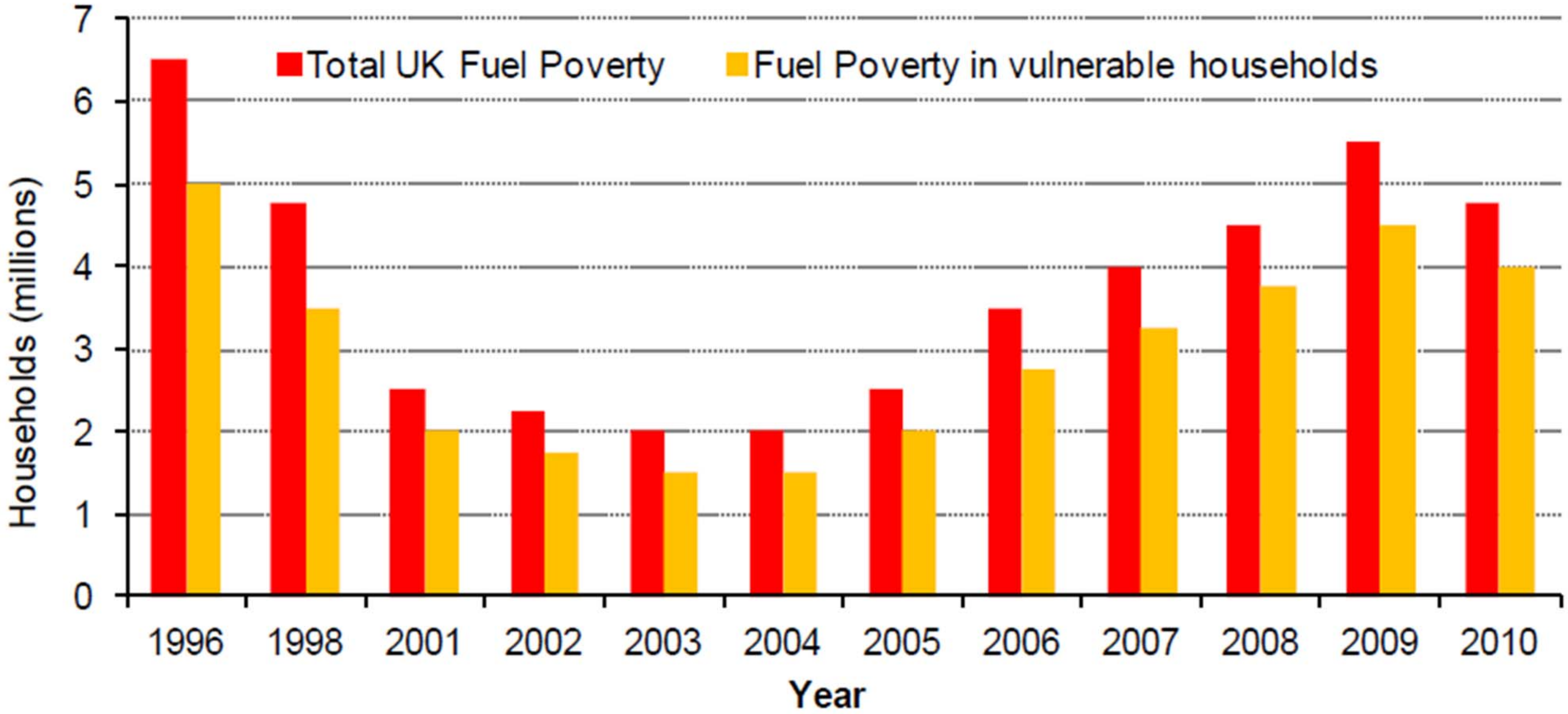
- In the UK, objective definition: *a household is said to be fuel poor if it needs to spend more than 10 per cent of its income on fuel to maintain an adequate level of warmth* (21°C in the living room and 18°C in the other occupied rooms according to WHO)**.**

- Fuel poverty is therefore based on modelled spending on energy (*what is necessary for…*), rather than actual spending (*what is done for…*).

- Although the emphasis in the definition is on **heating** the home, modelled fuel costs in the definition of fuel poverty also include spending on **heating water, lights and appliance usage and cooking costs**.

www.decc.gov.uk/assets/decc/11/stats/fuel-poverty/5270-annual-report-fuel-poverty-stats-2012.pdf

Evolution of fuel poverty in the UK



A vulnerable household is one that contains the elderly, children or someone who is disabled or has a long term illness

www.decc.gov.uk/assets/decc/11/stats/fuel-poverty/5270-annual-report-fuel-poverty-stats-2012.pdf

France using the UK definition

- Under the 10% index, France counts 3.8 millions energy-poor households (14.4 % of French households, 8 millions people).
  - 70 % of them are among the poorest.
  - 19.5 % own their dwelling
  - 25.4 % are above 65
  - 17.1 % live in individual houses.
- Fuel poverty can be felt differently: subjective definition.
  ⇒ many "objectively poor households" do not ask for subsidies.

www.colloque-precarite-energetique.fr/documents/Actes_colloque_Precarite.pdf

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Fuel poverty likely to grow

- Energy unit costs most likely to increase to accommodate carbon constraint (regressive tax)
- Energy efficiency may reduce energy spent, but requires investment (owner *vs*. renter)
- Living conditions of most vulnerable unlikely to improve markedly.

Energy circumstances are varied

- Multiple domestic energy usages: heating, lighting, cooking, computing, moving, etc.

- Multiple energy sources: heating fuel, natural gas, wood, electricity, gasoline.

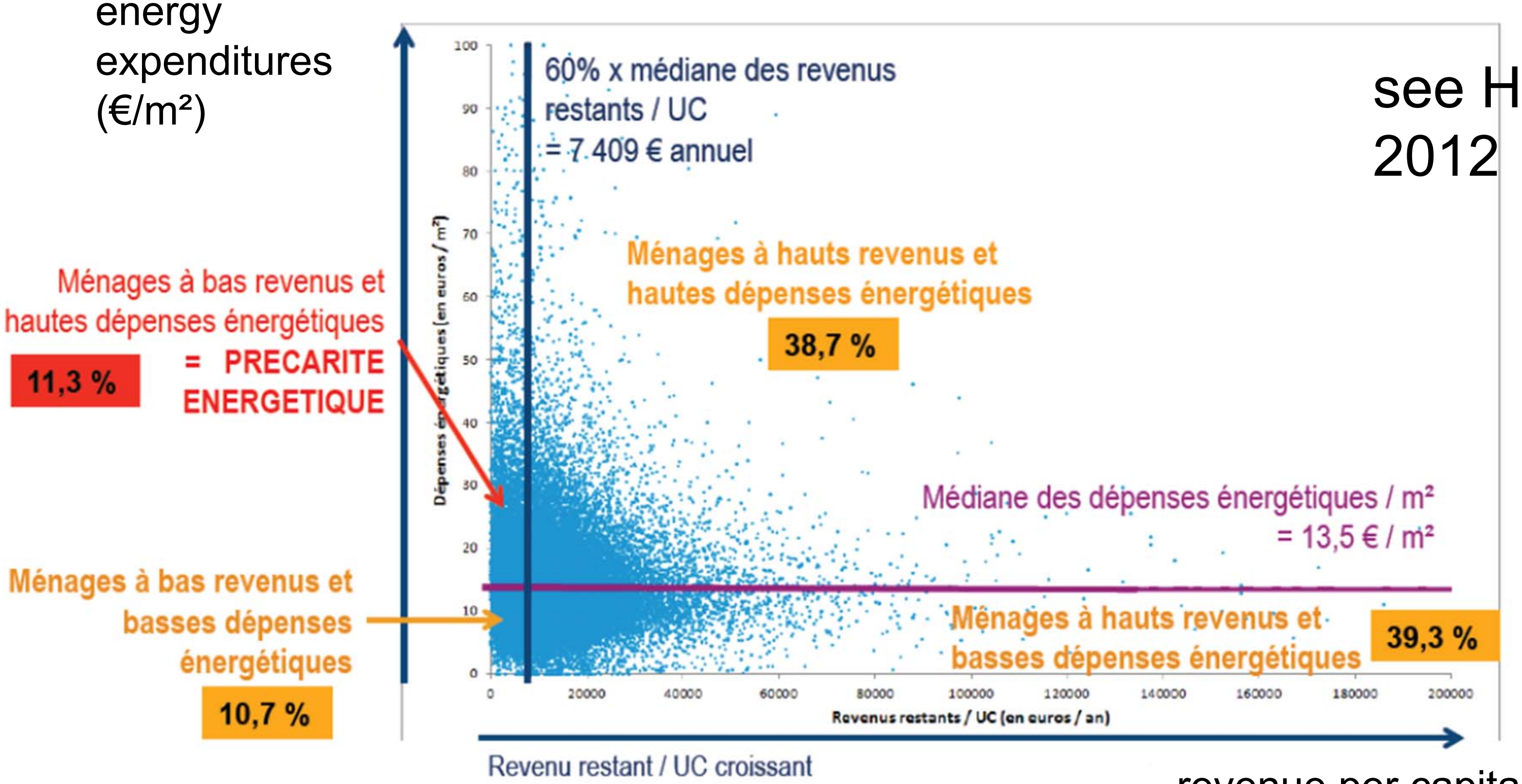
- Multiple circumstances: urban vs. rural, single *vs*. family, young *vs*. old, rich *vs*. poor, owner *vs*. renter, employed *vs*. unemployed.

Energy spent almost uncorrelated to income

source: www.cdcclimat.com/IMG//pdf/13-09_etude_climat_lutte_contre_la_precarite_energetique.pdf

energy expenditures (€/m²)

see Hills 2012



revenue per capita, net of energy expenditures(€/year)

Pr(high energy spent/high income) = 49.6%
Pr(high energy spent/low income) = 51.4%

Source: French ONPE, 2013

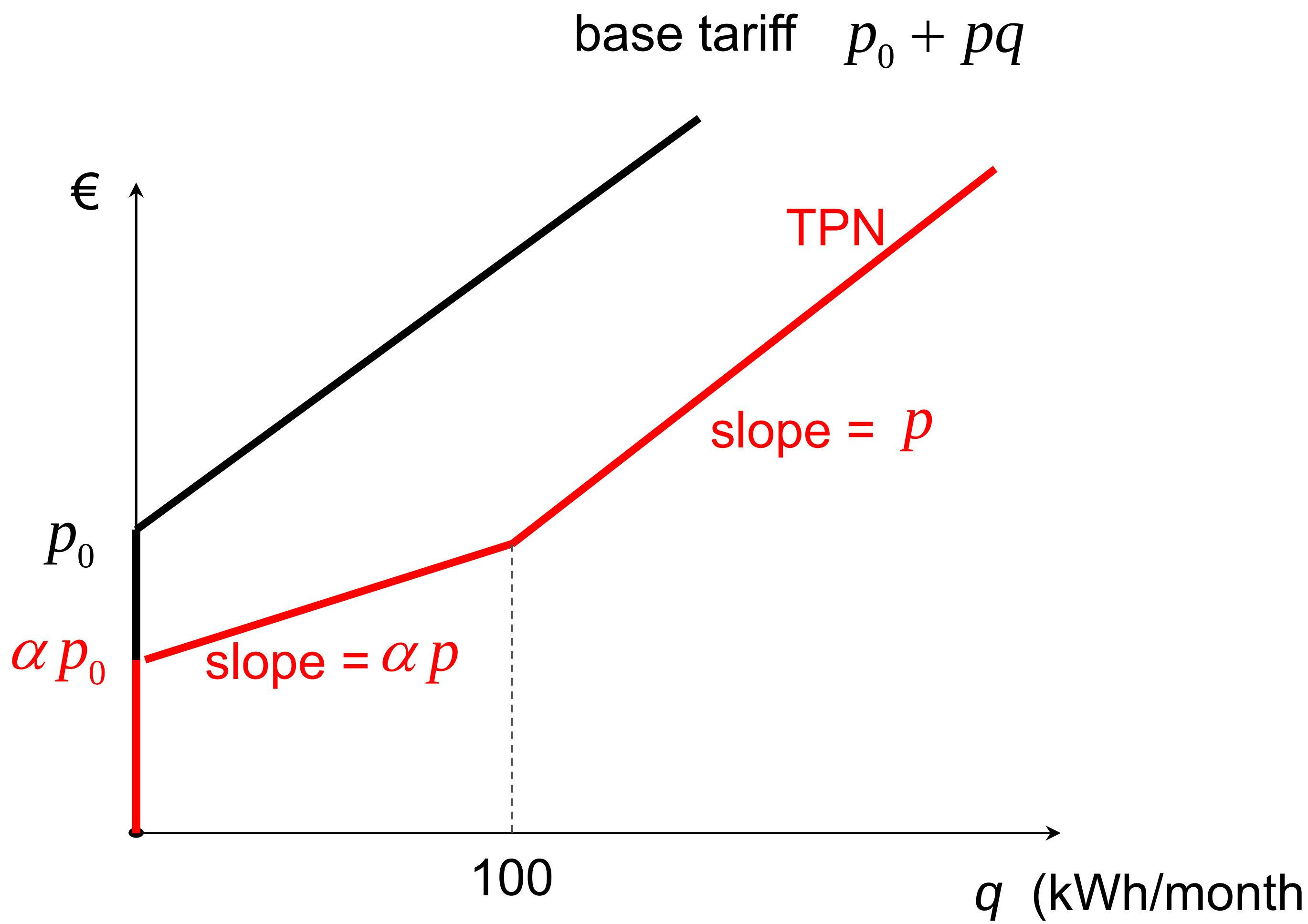
France: current social remedies

- remark: article 11 of the Grenelle II Law (July 12, 2010) links fuel poverty to house poverty.

- for electricity:
  « Essential Needs Tariff » (TPN), since a 2004 decree;
- for natural gas:
  « Solidarity Special Tariff » (TSS), since a 2008 decree.
- means test: the beneficiaries of TPN and TSS are the holders of the CMU-C card (health insurance)

- TPN: 40 to 60 % rebate (depending on the household members) on the first 100 kWh consumed each month and on the fixed part of the tariff.

France: TPN



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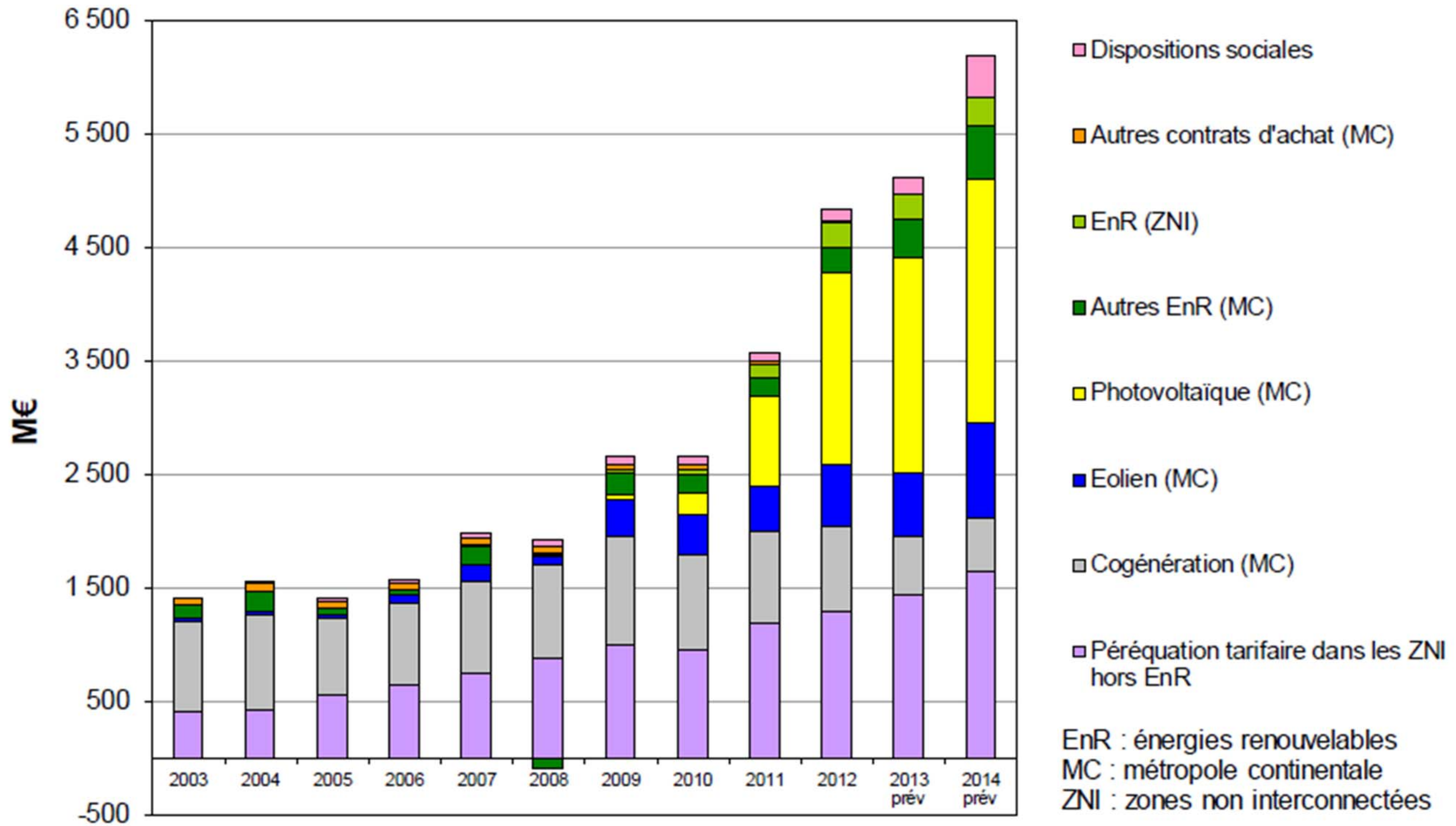
basic needs

www.lenergieenquestions.fr/que-fait-on-avec-un-kilowatt-heure-infographie/

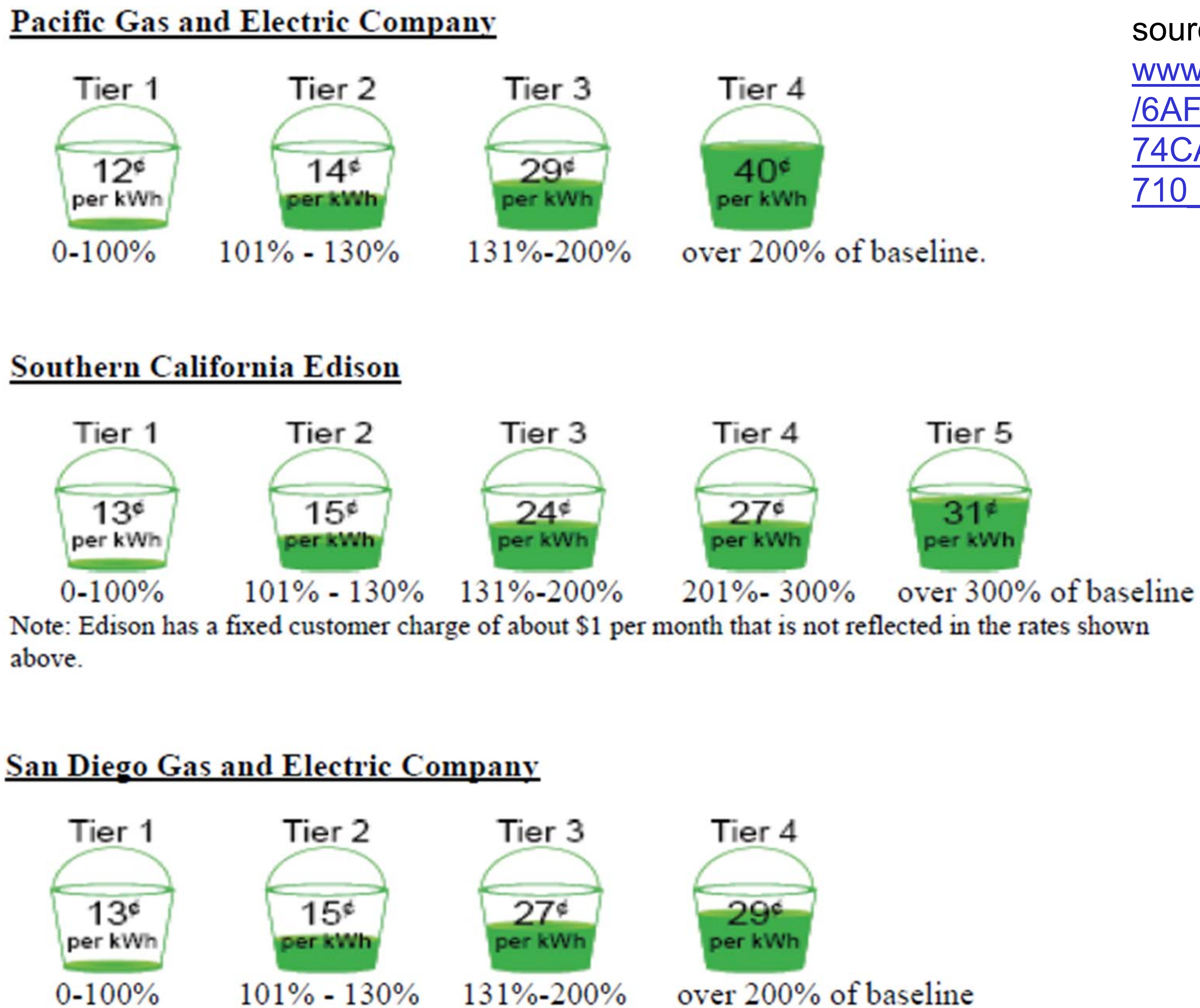
France: how much it costs



CRE, “ Communication du 18 novembre 2013 relative aux charges de service public de l’électricité et à la contribution unitaire pour 2014 »

www.cre.fr/documents/deliberations/proposition/cspe-2014/consulter-la-communication

California: block-pricing without means test



source: www.cpuc.ca.gov/NR/rdonlyres/6AF20251-011C-4EF2-B99D-74CA315A4C40/0/RatesFAQ0710_3.pdf

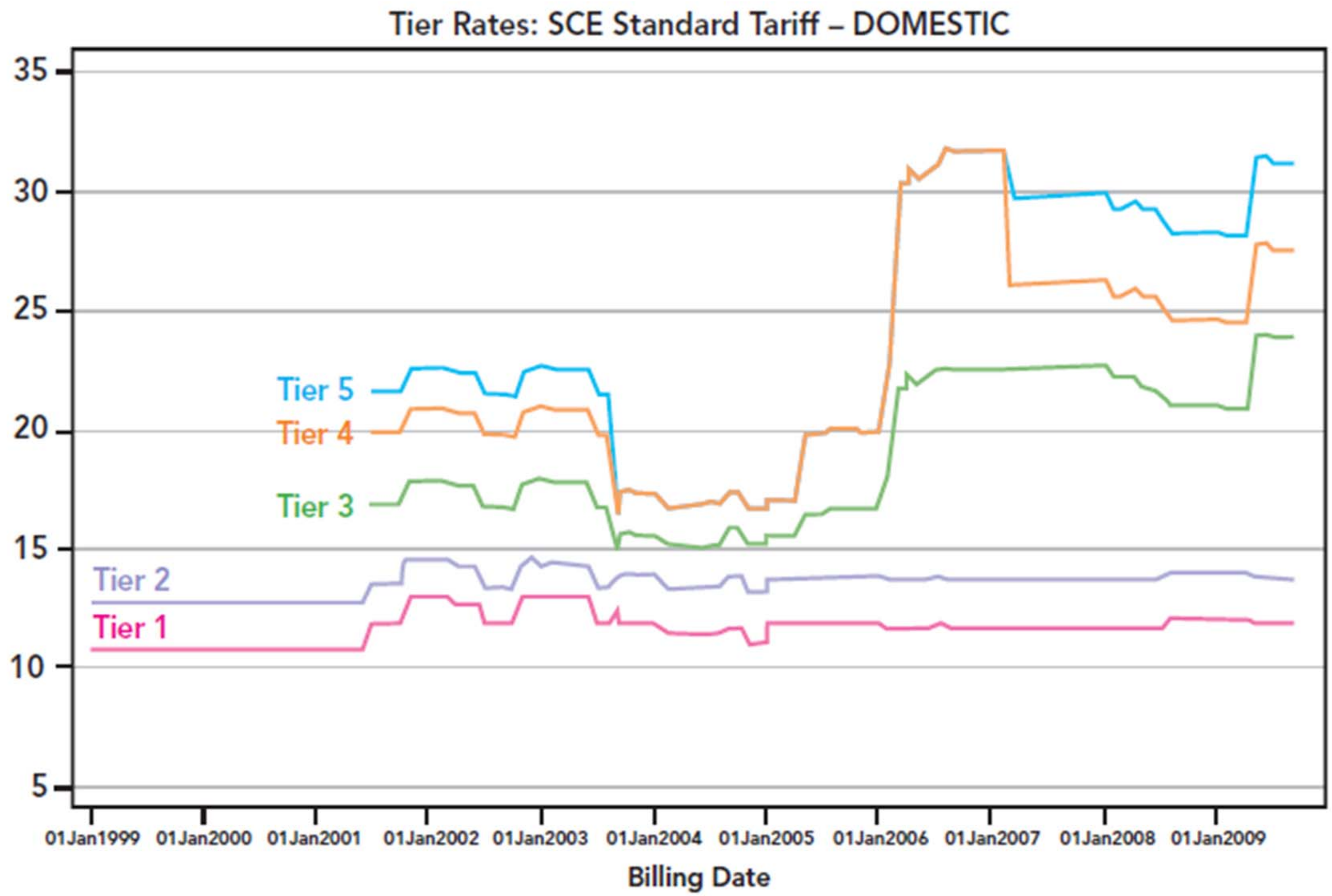
- The size and price of tiers 1 et 2 are fixed by CPUC.
- Suppliers fix the other parameters.

California: daily baseline allocation

Daily Baseline Allocation New Baseline Regions Only (kilowatt hours)				
Baseline Region	Basic		All-Electric	
	Summer	Winter	Summer	Winter
5	9.1	9.8	10.0	16.7
6	9.2	9.6	10.0	16.2
8	10.2	9.2	10.0	16.2
9	13.9	10.5	16.9	24.1
10	16.0	10.5	17.4	24.1
13	18.6	11.0	29.0	32.8
14	16.1	10.6	20.3	29.5
15	43.9	9.0	42.7	27.4
16	11.5	10.9	14.3	28.5

source: http://wwwt10.sce.com/CustomerService/billing/tiered-rates/baseline-chart-map.html

California: time change in tier rates



source: ei.haas.berkeley.edu

2. Block pricing of electricity

- In several countries (California, Italy) electricity is priced at increasing rate; China, France and others are contemplating the same approach
- The first MWh, corresponding to basic needs, are priced lower than the later MWh, corresponding to luxury consumption
- Politicians argue this is good for both *energy efficiency* (decrease in total demand) and *energy equity* (transfer from rich to poor)
- Economists are less convinced …

Results synthesis

- equity
  - progressive tariff reduces inequalities on average;
  - but
    - not true for all
    - monetary transfers are better;
- energy saving;
  - neither decrease in consumption nor decrease in industry cost are certain;
  - efficient pricing commands price increasing with **total** consumption, not with **individual** consumption;
  - more generally, efficient pricing must be variable in time, location and state of nature.

Basic microeconomics for increasing-block tariff

- preferences are defined on two goods:
  - numéraire *x*
  - electricity consumption *e*
- quasi-linear utility

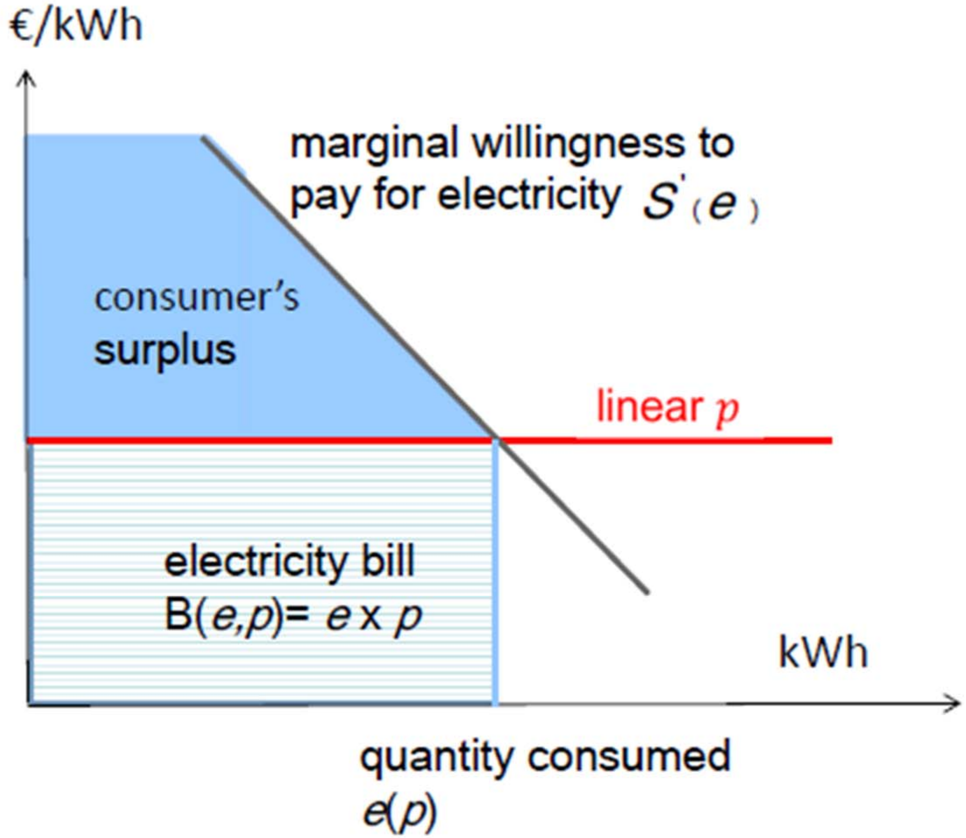
$$U(x, e) = x + S(e)$$

$$x + pe \leq I$$

- Best choice

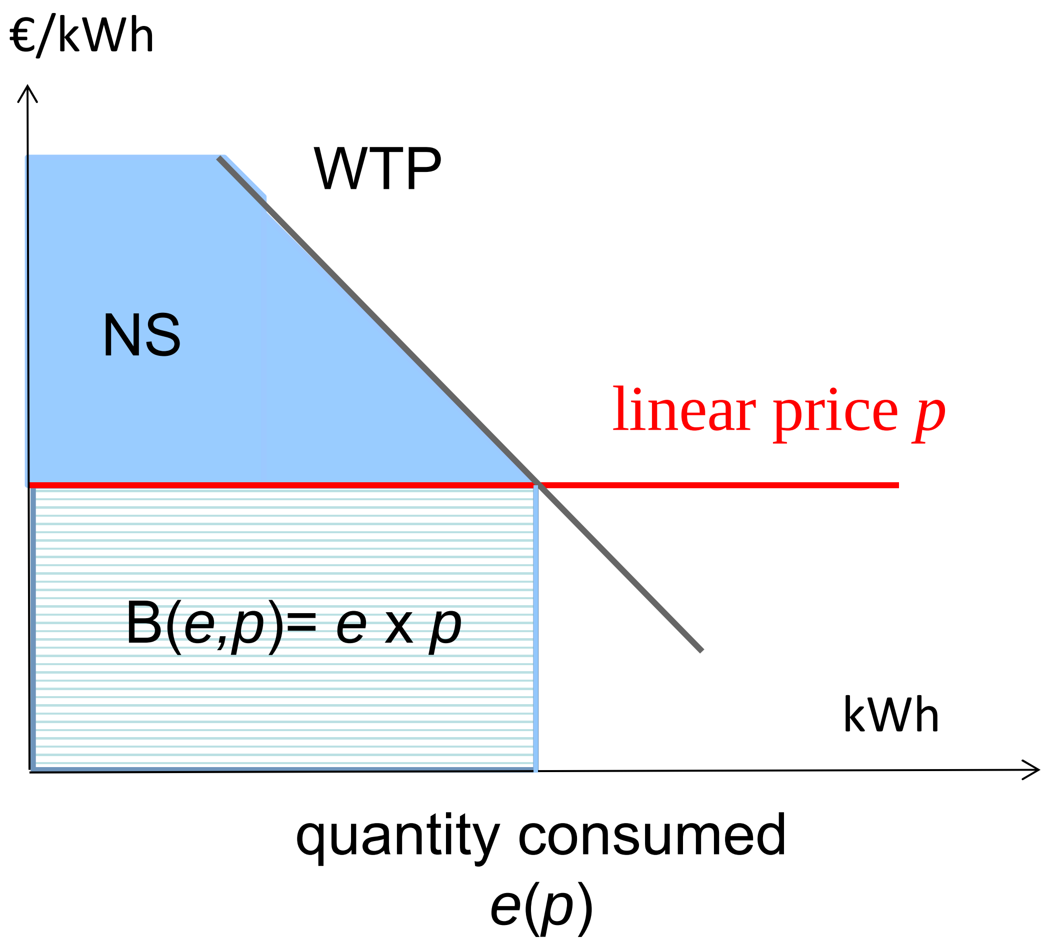
$$S'(e^*) = p$$

$$x^* + pe^* = I$$



poverty criteria

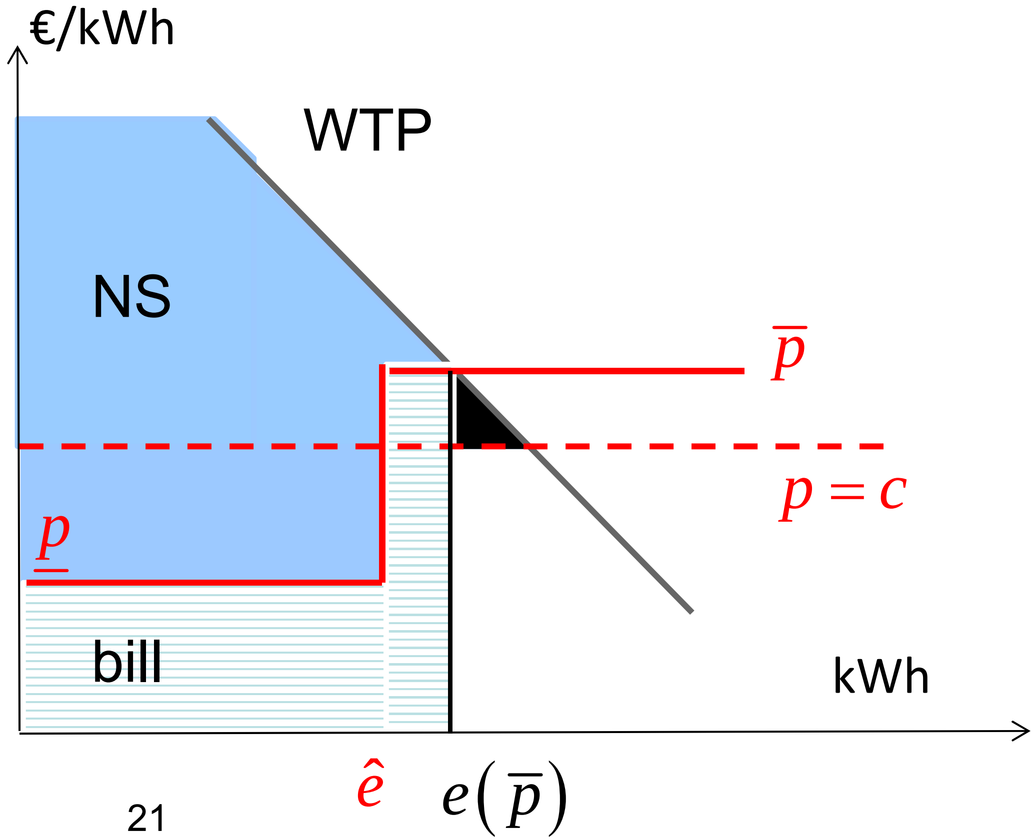
- bill too large
- *p* too high
- *e* too small
- net surplus too low
- ratio F/SN too high
- absolute criteria *vs.* relative criteria



two-tier tariff

$$B\left(e,\underline{p},\overline{p},\hat{e}\right)=\begin{cases}\underline{p}e & \text{si} \quad e\leq\hat{e}\\ \underline{p}\hat{e}+\overline{p}\left(e-\hat{e}\right) & \text{otherwise}\end{cases}$$

- in theory, the quantity consumed depends on marginal price
- depending on the value of the three parameters, consumption, bill and net surplus can increase or decrease.
- if p=c, in any case there is a surplus loss.

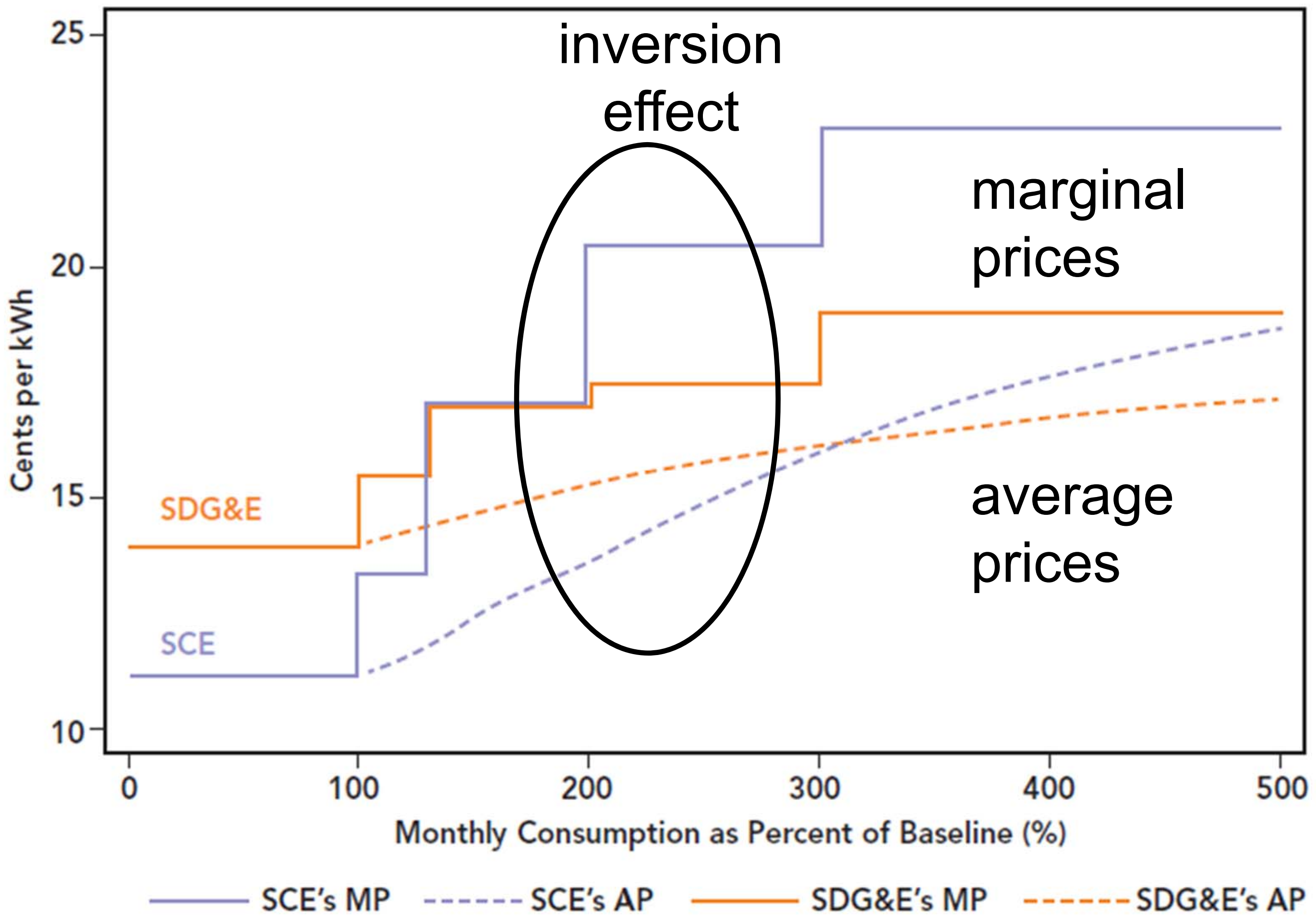


(self)financing

- « the French way »:
  - the first price $\underline{p}$ is reserved for consumers with low WTP; then the efficiency loss (i.e. the distortion due to $\overline{p} > c$ is small;
  - difficulty: how to separate *high WTP* from *low WTP*? In France, social tariffs are reserved to the holders of the free-healthcare card (CMU)

- « the Californian way »:
  - the progressive tariff is for all consumers, then no risk of opportunism.
  - drawback: very strong distortion on the upper blocks is necessary to balance the financial losses on the lower blocks.

starting low to finish high



California: Standard Residential Electricity Price Schedules in SCE and SDG&E in 2002

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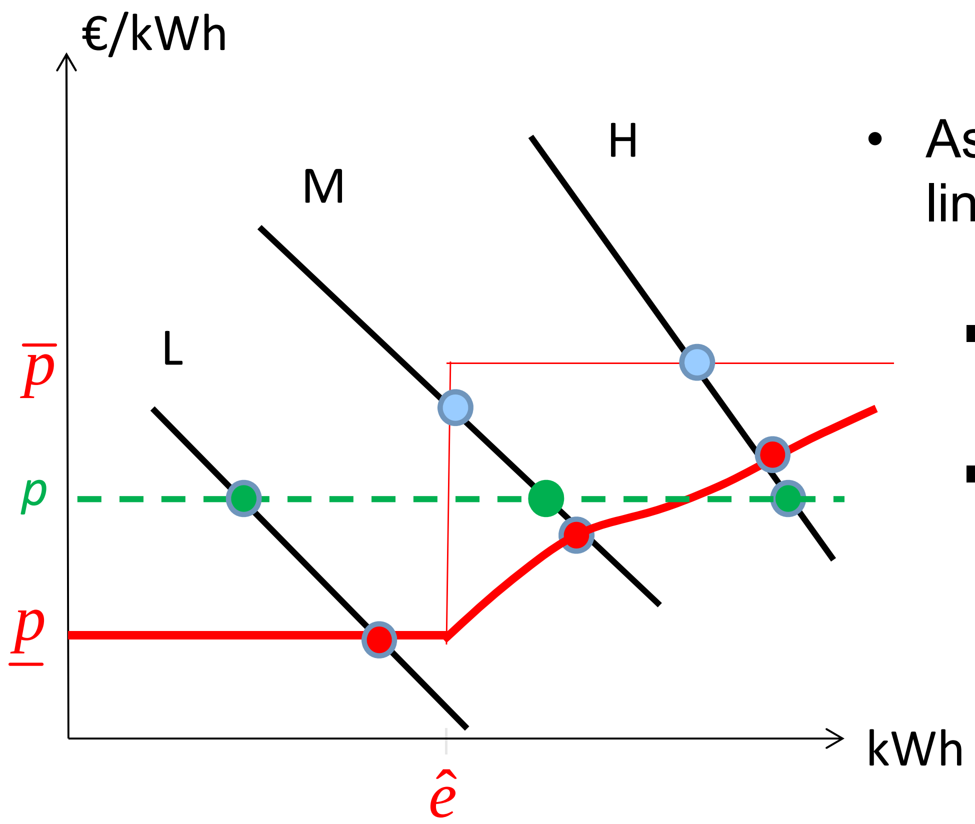
how to read the bill? marginal price *vs.* average price

- Koichiro Ito, "*Do Consumers Respond to Marginal or Average Price? Evidence from Nonlinear Electricity Pricing*," EI @ Haas WP-210, November 2010.
- Ito compares the consumption observed under a 5-block pricing to the consumption estimated under a linear price giving the same profit to suppliers. He finds that, contrary to the objective of progressive tariff, observed consumption is 0,54% **above** estimated consumption.
- his explanation: households adapt their consumption to average price rather than marginal price.

opportunistic adaptation to block pricing



- As compared with choices under linear pricing *p*,
  - H decreases his consumption, however less than expected
  - M increases his consumption instead of decreasing it.

The French project of block-pricing

- engagement
  - « Je ferai adopter une nouvelle tarification progressive de l'eau, de l'électricité et du gaz afin de garantir l'accès de tous à ces biens essentiels et d'inciter à une consommation responsable. Elle permettra de faire sortir de la précarité énergétique 8 millions de Français. »

    (*engagement n°42 du programme de François Hollande*).
- 'proposition de loi instaurant une tarification progressive de l'énergie' (Brottes' law proposal)
  - « La tarification progressive est avant tout un outil écologique. Les consommateurs dispendieux vont subventionner la consommation des consommateurs vertueux." (*exposé des motifs*)

    www.assemblee-nationale.fr/14/propositions/pion0150.asp
- The aim is clearly twofold.
  - firstly, to reduce energy consumption by giving consumers a clear price signal regarding higher levels of use;
  - secondly, to provide assistance to the 4 million households in France that are described as "energy-precarious (those who spend more than 10% of their income on energy costs).

method (law proposal n°579, janvier 2013)

- baseline
  - A yearly volume V is computed for each dwelling, based on the type of heating (electricity, natural gas or local heating network), the geographical location, the number of people in the dwelling and the consumption per head of most efficient users (first quartile)

$$V = V_i \times t \times f$$

where

V_i is the benchmark volume;

$i = 1$ if it is the energy mainly used for heating, $i = 2$ otherwise;

$t \in [0.8, 1.5]$ stands for geographical location;

$f = 1 + .5 + .3 + .3 + \ldots$ stands for the number of people living in the residence ($f \equiv .5$ for a second home)

method (continued)

- bonus-malus
  - three distinct blocks:
    - below V,
    - between V and $3V$,
    - above $3V$.
  - a rebate (bonus) on the first block
  - a penalty (malus) on the two other blocks
- example

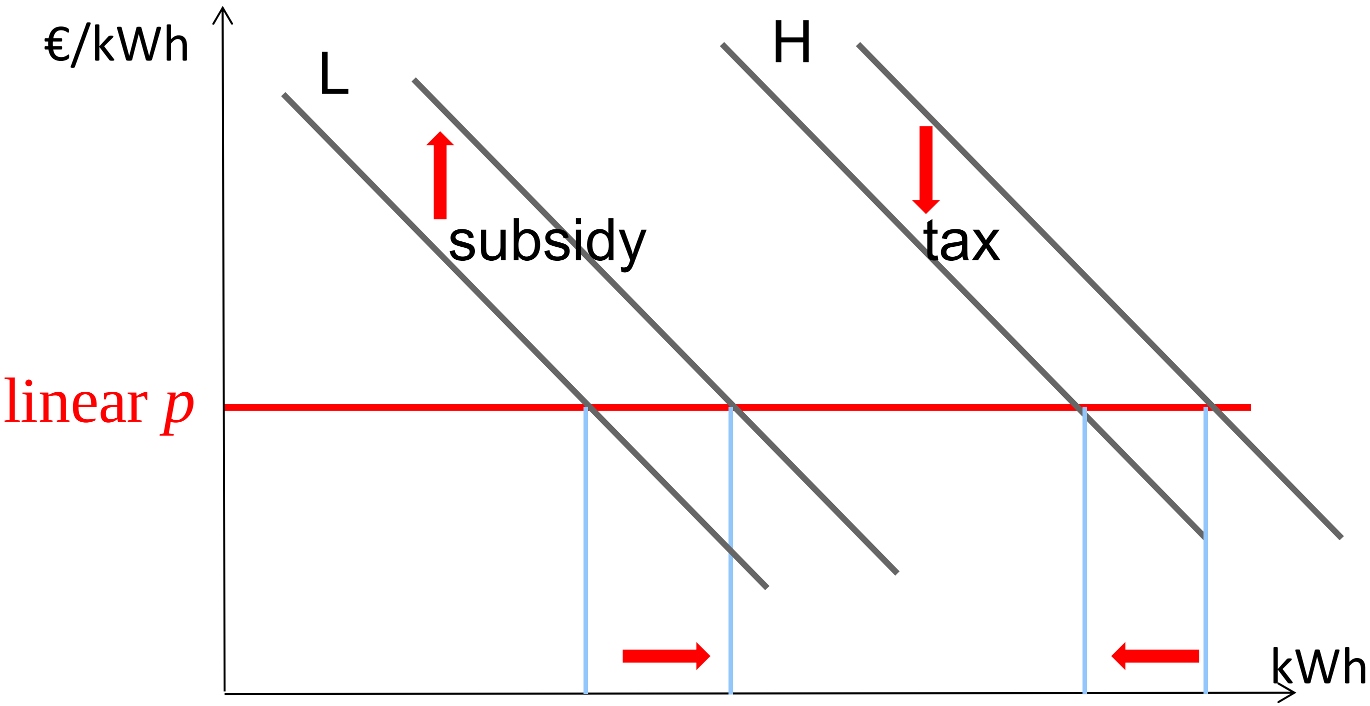
individual consumption *(euros/MWh)*

Year of consumption	Bonus on first block	Malus on second block	Malus on third block
2015	-5 et 0	0 et 3	0 et 20
2016	-20 et 0	0 et 6	0 et 40
2017 on	-30 et 0	0 et 9	0 et 60

(malus can be decreased for poor people)

should equity rely on revenues or prices?

- basic principle:
  - distorted tariffs send erroneous signals, with the effect of pushing to inefficient behavior;
  - revenue reallocation is generically better.



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merit goods

- *a priori* "non-specific aid" is superior to "targeted aid" (example of the latter: a check to energy expenses);
  - what degree of paternalism ?
  - what degree for freedom of choice?
- for electricity, we must distinguish among utilizations
  - lightening, appliances, ICT: no competitor
  - heating and cooling, cooking, hot water competing with natural gas, fuel, coal, etc.
- examples:
  - price or revenue incentive to the consumption of electricity for heating in poorly insulated buildings should be proscribed;
  - price or revenue support to Internet connection prevents social foreclosure.

are progressive prices a reflect of costs?

- preconceived idea:
  - marginal cost of the electrical system is increasing (merit order)
  - therefore increasing unit prices reflect the costs, which "encourages environmental friendly consumption.
- double misunderstanding:
  - between individual peak demand and total peak demand
  - between energy cost and capital cost

matching peak demand

- as soon as the end of the 19th century, debate between
  - ‘*price increasing with individual consumption*’ (Wright 1896)
  - ‘*price increasing with total consumption*’ (Gibbings 1894)
- Gibbings ideas are correct but note that everywhere there is a two-part tariff with the fixed part depending on the maximum potential consumption (even though the fixed part is for transportation), the bill increases with the individual consumption; nevertheless, two-part tariff ⇨ the kWh price is decreasing.
- the optimal policy is « peak-load pricing » (see for example M. Boîteux 1949):
  - off-peak demand only pays for energy cost
  - on-peak demand pays for energy cost and all capital cost.

Paying for energy and capacity

- Assume that A consumes 1MWh and B consumes 2MWh.
- If they have the same load profile, for sure supplying B is more costly than supplying A
- Assume now that it takes
  - one hour to consume 1MWh at A's
  - ten hours to consume 2MWh at B's
- We then have that
  - $C_A(1) = c + r$
  - $C_B(2) = 2c + 0.2\, r$
- If $c < 0.8\, r$, $C_B(2) < C_A(1)$
- Then to save on costs, flattening profiles is at least as important as decreasing consumption.

In a nutshell

- Transfers of revenues rather than price distortions (particularly in a competitive framework).
- A targeted aid for specific utilization of electricity (Internet, phone).
- If any price progressivity, it must be with total consumption, that is a time-varying price: on-peak/off-peak.

3. Poverty and the consumption of energy services

- The willingness-to-pay for electricity depends on
  – revenues
  – household composition and size
  – building insulation
  – equipment for heating, cooking, hot water, etc.
- consequently, no clear correlation between WTP for energy and revenue:
  – under a test of resources, risk of opportunism (ex: bill > 10% revenue)
  – WTP depends on the effort of other agents (ex: insulation by the building's owner)
  – what about subsidies to efficient appliances?

basic model

- utility of household *i*

equipment

$$U^i \equiv U\left(x^i, s^i\right) \equiv U\left(x^i, f\left(e^i, \phi^i\right)\right)$$

numéraire electricity

- budget constraint

equipment purchase

$$x_i = I^i - p_e e^i - p_\phi \phi'^i$$

income prices

- How to tax/subsidize electricity and/or equipment purchase when income or installed equipment or both are not observable?

A two-type model

- Crampes-Lozachmeur, «Tarif progressif, efficience et équité. 2. Redistribution et distorsions tarifaires », novembre 2012

- two types of households: *L*, *H*
- they differ in terms of
  - income $I^H > I^L$
  - and/or consumption equipment $\phi^H > \phi^L$
- problem:
  - determine the contract(s) that implement utilitarian redistribution when the revenues and/or equipment are not observable by the regulator.

assumptions

- utility function

energy service

equipment

$$U(x,s) = U\left(I - p_e e, f(e,\phi)\right)$$

numéraire

revenue

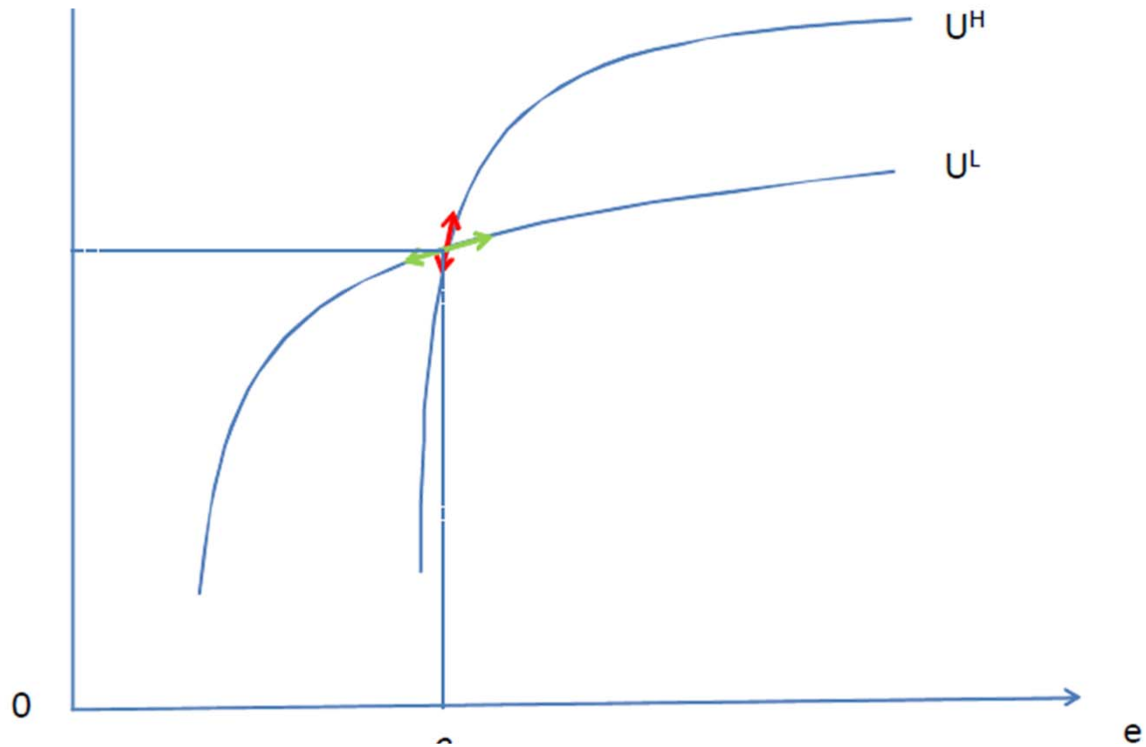
electricity

- $U(x,s)$ increasing and concave, $U_{x,s} \equiv 0$
- $f_e, f_\phi > 0,\ f_{ee}, f_{\phi\phi} < 0$, $f_{e\phi} \geq 0$

marginal willingness-to-pay for electricity

- $$MRS_{ex} = \left.\frac{de}{dx}\right|_{\bar{u}} = f_e(e,\phi)\,\frac{u_s\left(\tilde{I} - p_e e, f(e,\phi)\right)}{u_x\left(\tilde{I} - p_e e, f(e,\phi)\right)}$$

- MRS_{xe} increasing in / *I-x*



willingness-to-pay (continued)

- MRS_{xe} decreasing (increasing) in ϕ if $\frac{f_{e\phi}}{f_e f_\phi} < (>) - \frac{U_{ss}}{U_s}$

index of technical complementarity

index of saturation

egoistic behavior

- $\max_{x,e} U\left(x, f\left(e, \phi\right)\right)$ subject to $x + p_e e \leq I$
- FOCs: $$MRS_{xe} = p_e$$ $$x + p_e e = I$$
- demand for electricity: $e\left(p_e, I, \phi\right)$
- statistically, $\frac{\partial \phi}{\partial I} > 0$. Then

$\frac{f_{e\phi}}{f_e f_\phi} \geq -\frac{U_{ss}}{U_s}$ is sufficient but not necessary for $\frac{de}{dI} > 0$

$\frac{f_{e\phi}}{f_e f_\phi} < -\frac{U_{ss}}{U_s}$ is necessary but not sufficient for $\frac{de}{dI} < 0$

first-rank policy

* $\max_{x^i, e^i} \sum_{i=\{L,H\}} \pi^i U\left(x^i, f\left(e^i, \phi^i\right)\right)$

  s.t. $\sum_i \pi^i \left(I^i - x^i - p_e e^i\right) \geq 0$

* FOCs:

$$U_x^H = U_x^L$$

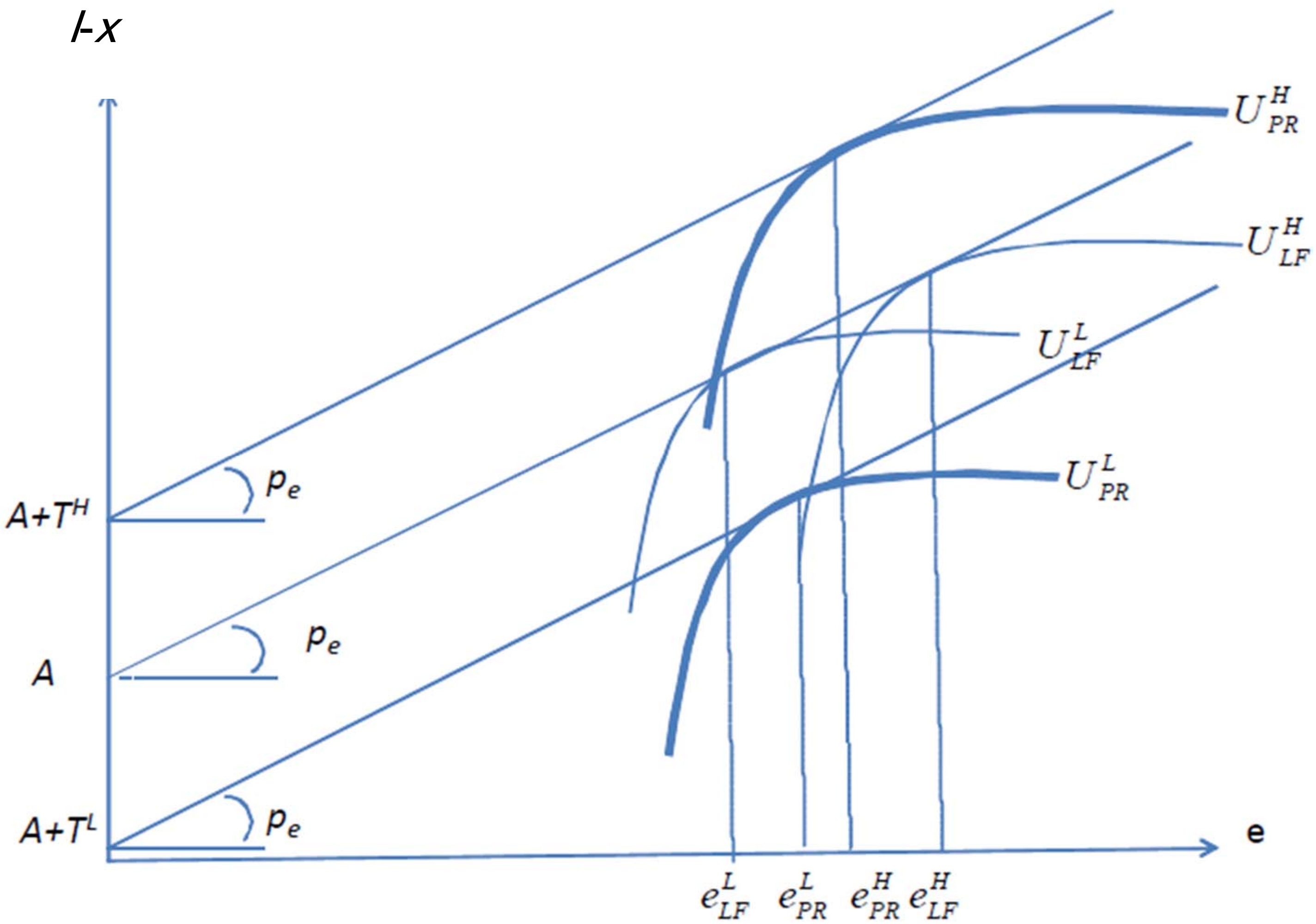
$$MRS_{x,e}^i = p_e \quad i = H, L$$

* implementation: fix a tariff $T^i = T\left(e^i, I^i, \phi^i\right) \quad i = H, L$ such that $\pi^H T^H + \pi^L T^L = 0$ knowing that consumers will solve

$$\max_{e^i} U\left(I^i - p_e e^i - T^i, f\left(e^i, \phi^i\right)\right)$$

* solution: to reach first best, we need $\frac{\partial T}{} \equiv 0$ (and $T^L < 0$ et $T^H > 0$

example: implementation by a two-part tariff



second-rank policy 1

- Assume first $\phi^H = \phi^L$ and $I^H > I^L$, and income is not observable by the tariff designer;
- we know that

$$MRS_{xe}^H > MRS_{xe}^L$$

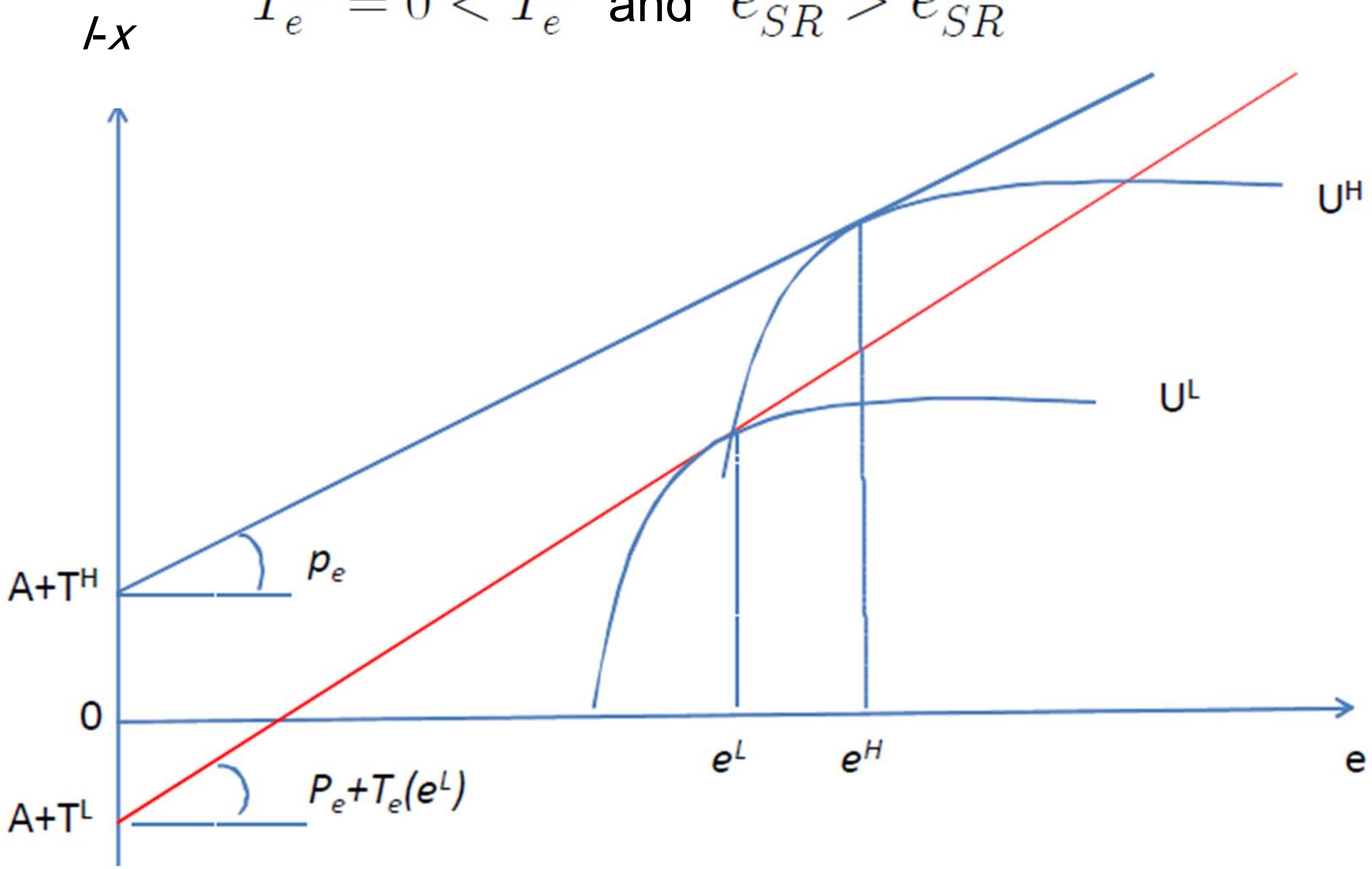
- H has an incentive to pretend he is a type-L household.
- The tariff designer must constraint the social objective by

$$U^H = U\left(I^H - T^H - p_e e^H, f\left(e^H, \phi\right)\right)$$
$$\geq U^{HL} = U\left(I^H - T^L - p_e e^L, f\left(e^L, \phi\right)\right)$$

second-rank price distortion 1

- concave tariff to relax the incentive compatibility constraint

$$T_e^H = 0 < T_e^L \text{ and } e_{SR}^H > e_{SR}^L$$



second-rank policy 2

- Assume now $\phi^H > \phi^L$ and $I^H = I^L$, and the consumption equipment is not observable by the tariff designer;
- under $\frac{f_{e\phi}}{f_e f_\phi} < -\frac{U_{ss}}{U_s}$, we have that

$$MRS_{xe}^H < MRS_{xe}^L$$

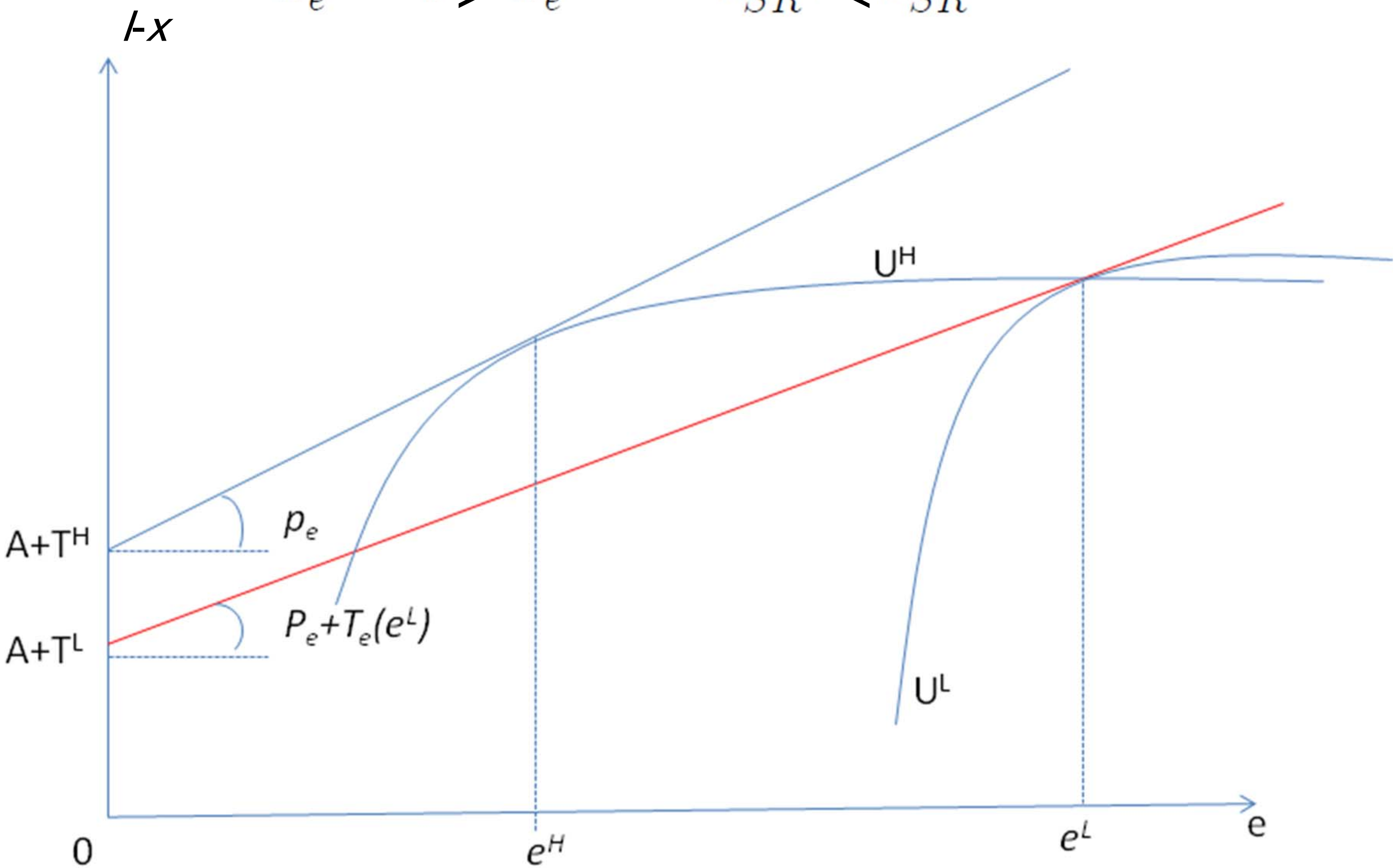
- H still has an incentive to pretend he is a type-L household.
- The tariff designer must constraint the social objective by

$$U^H = U\left(I - T^H - p_e e^H, f\left(e^H, \phi^H\right)\right)$$
$$\geq U^{HL} = U\left(I - T^L - p_e e^L, f\left(e^L, \phi^H\right)\right)$$

second-rank price distortion 2

- concave tariff to relax the incentive compatibility constraint

$$T_e^H = 0 > T_e^L \text{ and } e_{SR}^H < e_{SR}^L$$



second-rank policy 3

- When both income and equipment are not observable,
  - don't distort the price charged to H,
  - tax the price charged to L if the heterogeneity in terms of income is larger than the heterogeneity in terms of equipment
  - subsidize the price charged to L if the heterogeneity in terms of equipment is larger than the heterogeneity in terms of income
  - meet social goals by revenue transfers $T^L < 0$ et $T^H > 0$

second-rank price distortion 3

$$U(x,s) = \log(1+x) + \frac{1}{1-\sigma}s^{1-\sigma}; \sigma = 0.5$$

$$f(e,\phi) = \left[ae^r + (1-a)\phi^r\right]^{1/r}; \eta = 1/(1-r)$$

	$\eta = 3.33$			$\eta = 1.43$		
ϕ^H	2	4	10	2	4	10
ϕ^L	2	2	2	2	2	2
T^H	0.10	0.07	0.03	0.11	0.14	0.19
T^L	-0.41	-0.27	-0.12	-0.45	-0.58	-0.78
e^H	1.31	1.10	0.80	1.47	1.61	1.83
e^L	0.15	0.16	0.19	0.39	0.38	0.39
T_e^L	0.41	0.34	0.23	0.45	0.49	0.51

$I^H = 10, I^L = 5, \pi^H = 0.8 \qquad a = 0.5$

equipment purchase

- $U\left(x, f\left(e, \phi + \phi'\right)\right)$
- marginal willingness-to-pay for the equipment

$$MRS_{x\phi'} \stackrel{def}{=} -\left.\frac{dx}{d\phi'}\right|_{dU=0} = f_\phi \frac{U_s}{U_x}$$

increasing in I, decreasing in ϕ

- substitution between electricity and equipment

$$MRS_{\phi' e} \stackrel{def}{=} -\left.\frac{d\phi'}{de}\right|_{dU=0} = \frac{f_e}{f_\phi}$$

independent of I, increasing in ϕ

$$x + p_e e + p_{\phi'} \phi' \leq I - T\left(e, \phi'\right)$$

redistribution

- under perfect information:
  - no price distortion
  - revenue transfer: $x^H = x^L$
- under imperfect information (but ϕ' observable):
  - $$\max_{T^i, e^i, \phi'^i} \sum_i \pi^i U\left(I^i - T^i - p_e e^i - p_\phi \phi'^i, f\left(e^i, \phi^i + \phi'^i\right)\right)$$
    $$\sum_i \pi^i T^i \geq 0$$
    $$U\left(I^H - T^H - p_e e^H - p_\phi \phi'^H, f\left(e^H, \phi^H + \phi'^H\right)\right) -$$
    $$U\left(I^H - T^L - p_e e^L - p_\phi \phi'^L, f\left(e^L, \phi^H + \phi'^L\right)\right) \geq 0$$
  - results unchanged as regards electricity prices
  - equipment purchase by L must be encouraged $\frac{T^L_{\phi'}}{p_{\phi'}} < \frac{T^L_e}{p_e}$

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Conclusions

- Limit price distortion when implementing social policy.
- In the short run, transfer revenues and rely on time contingent prices.
- For the long run, give incentives to efficient investment in consumption equipment.
- Main risk: households' opportunism.