Université catholique de Louvain
Louvain School of Management - CORE

Coordination, Conflict and Network Investment Incentives among National Energy Regulators

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University of Girona, Workshop on Energy and the Environment

October 2, 2002

ceSCM
Louvain School of Management

Outline

Transeuropean networks

- Investments
- Access pricing

Model

Analysis

- Regimes
- Multiplicity of equilibria
- Investment incentives
- Downstream market power

Conclusion

Agrell and Pouyet (2008) Regulatory Competition in Network Interconnection Pricing, *Review of Network Economics*, 7(1), 111-135.

Diversity in infrastructure management

EU Model

EU Model

Infrastructure

EU Model

Infrastructure

Infrastructure

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EU Model

Infrastructure Manager

Infrastructure

Louvain School of Management

EU Model

National Regulator

Infrastructure Manager

Infrastructure

Louvain School of Management

EU Model

National Regulator

Infrastructure Manager

REGULATION

Infrastructure

COMPETITION

Operator

User

User

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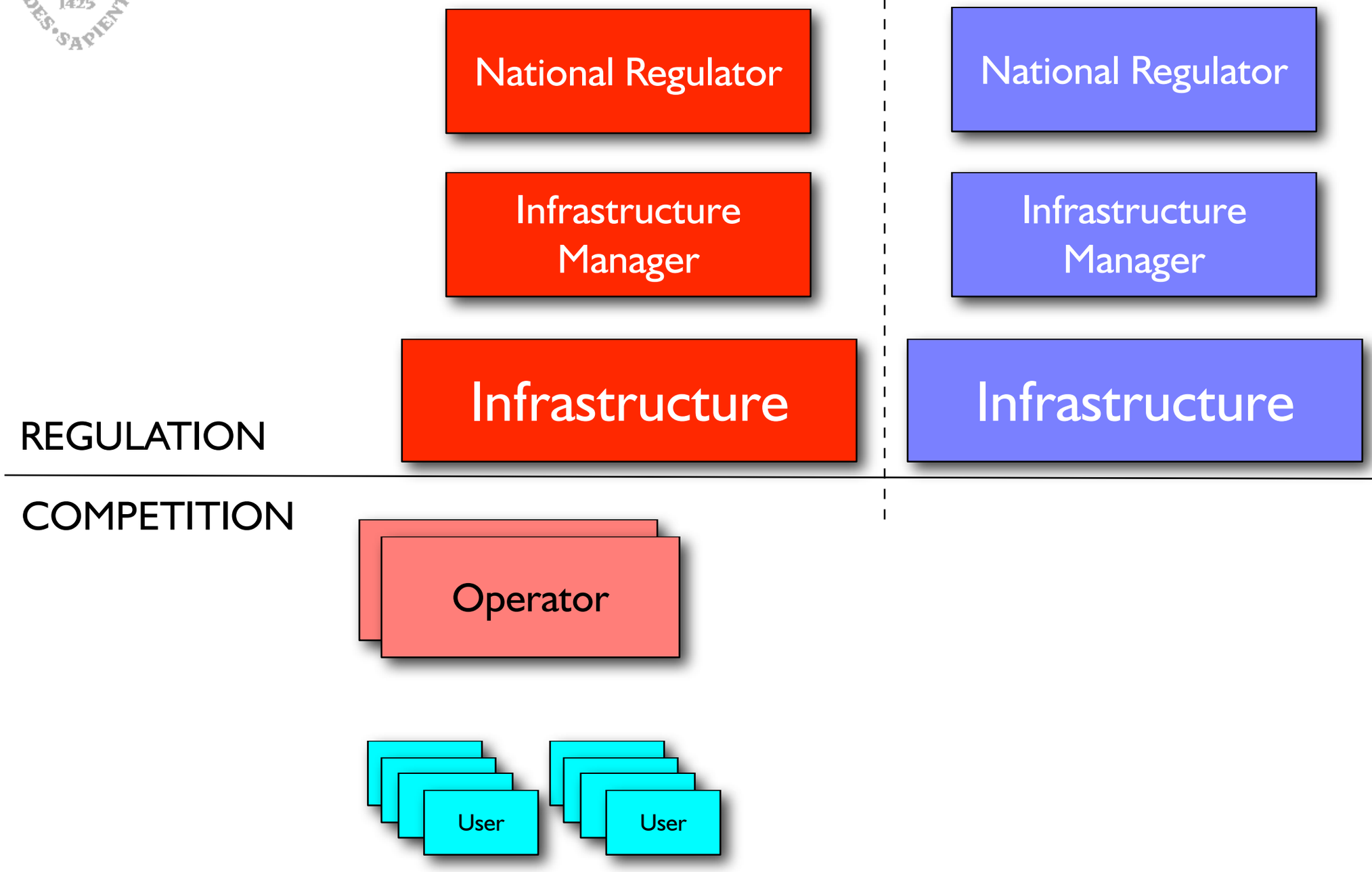
EU Model


National Regulator
National Regulator
Infrastructure Manager
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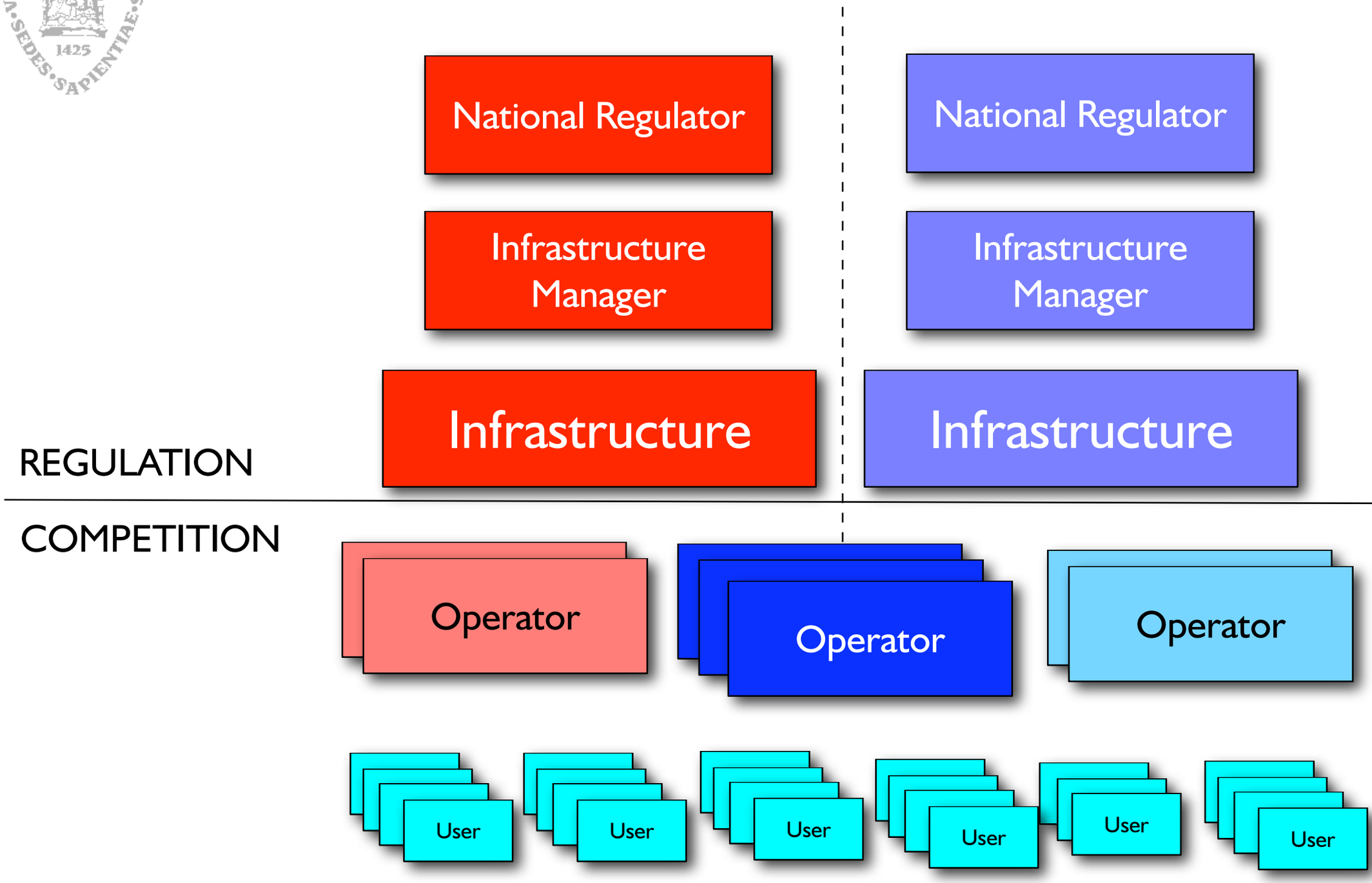
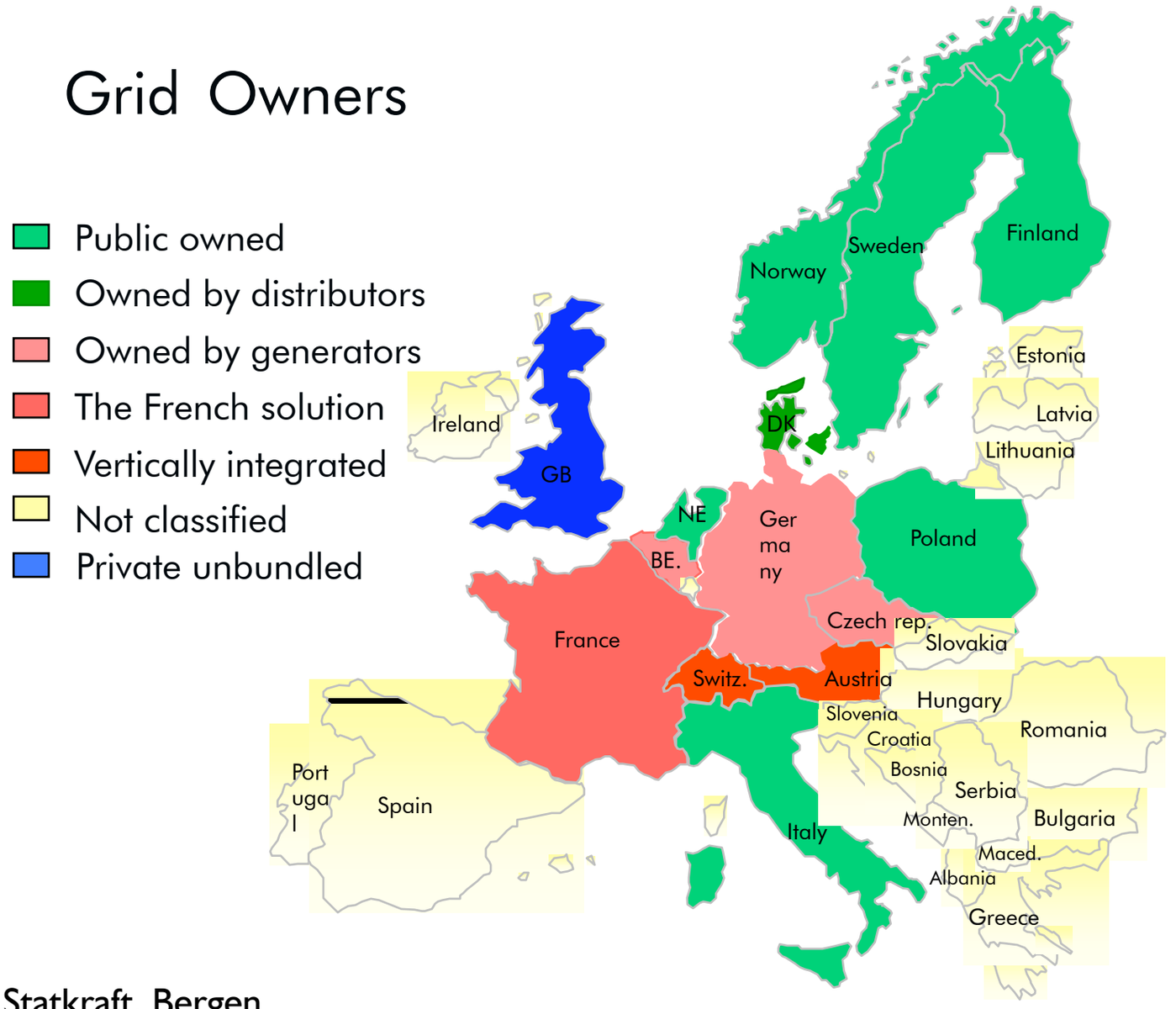
EU Model



Ownership diversity: Electricity transmission



Kildahl (2001), Statkraft, Bergen

The IEM Idea

Supranational framework

- IEM Directives 2003/53 and 2003/54
  - Definition of agents:
    - TSO, DSO decision rights
    - Regulator competencies
  - Modus operandi SO
    - TPA, USO, non-discrimination, transparency (TSO)
  - Modus operandi Regulator
    - Existence, minimal competence, ex ante, non-discretionary methodology

National implementation

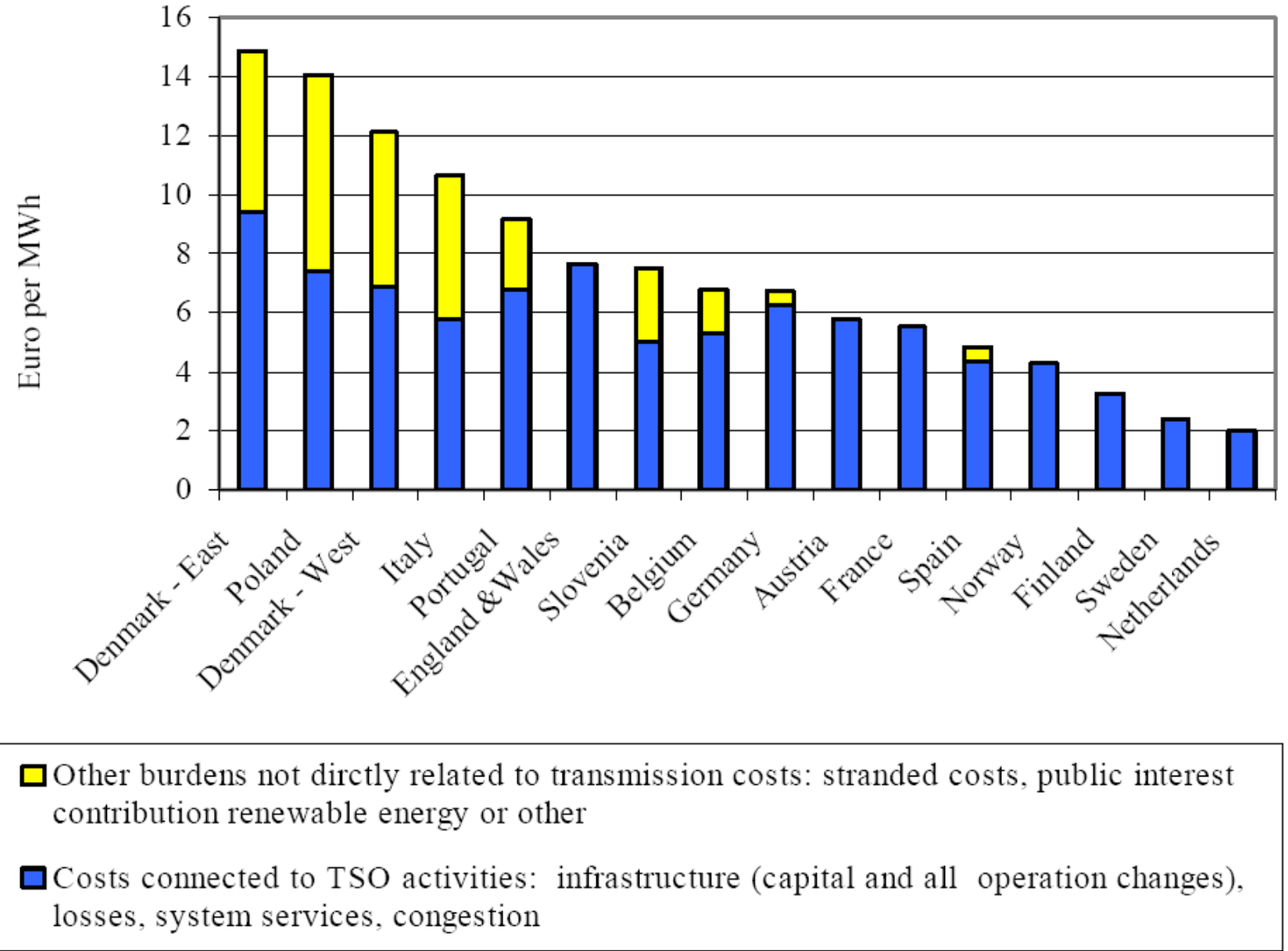
- National legislation
  - Methodology (Regime)
  - Parameters of the regime

Regulatory objectives

« Charges applied by network-operators for access to networks shall be transparent, take into account the need for network security and reflect actual costs incurred insofar as they correspond to those of an efficient and structurally comparable network operator and applied in a non discriminatory manner. Those charges shall not be distance-related »

Art 4:1, Regulation (EC) No 1228/2003 on CBT

Differences in transmission charges



Multiple equilibria in electricity transmission

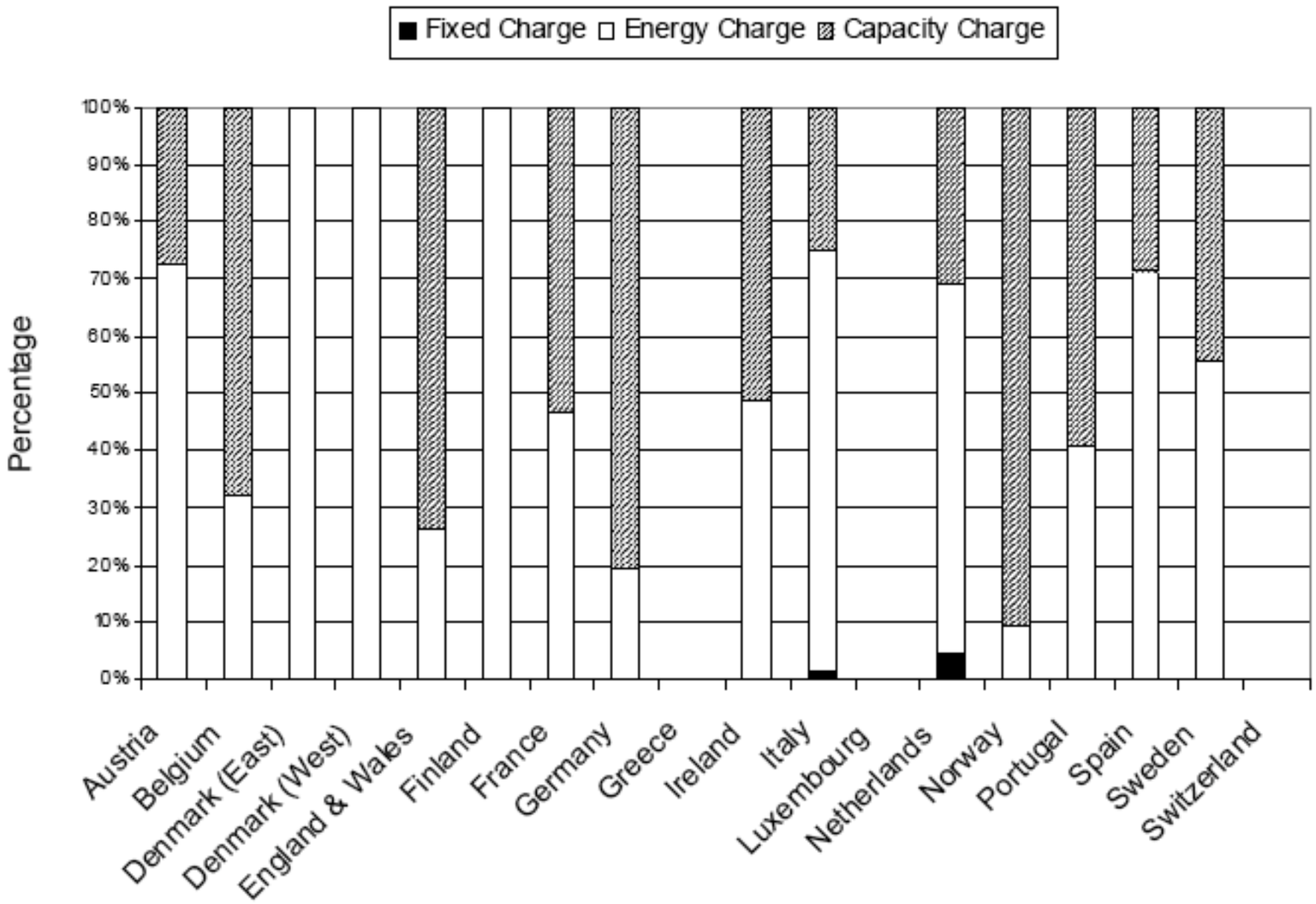


Figure 43: Split between capacity, energy and fixed charges in tariff B

Perez-Arriaga et al (2002) Benchmark of Electricity Transmission Tariffs, Final Report for DG TREN.

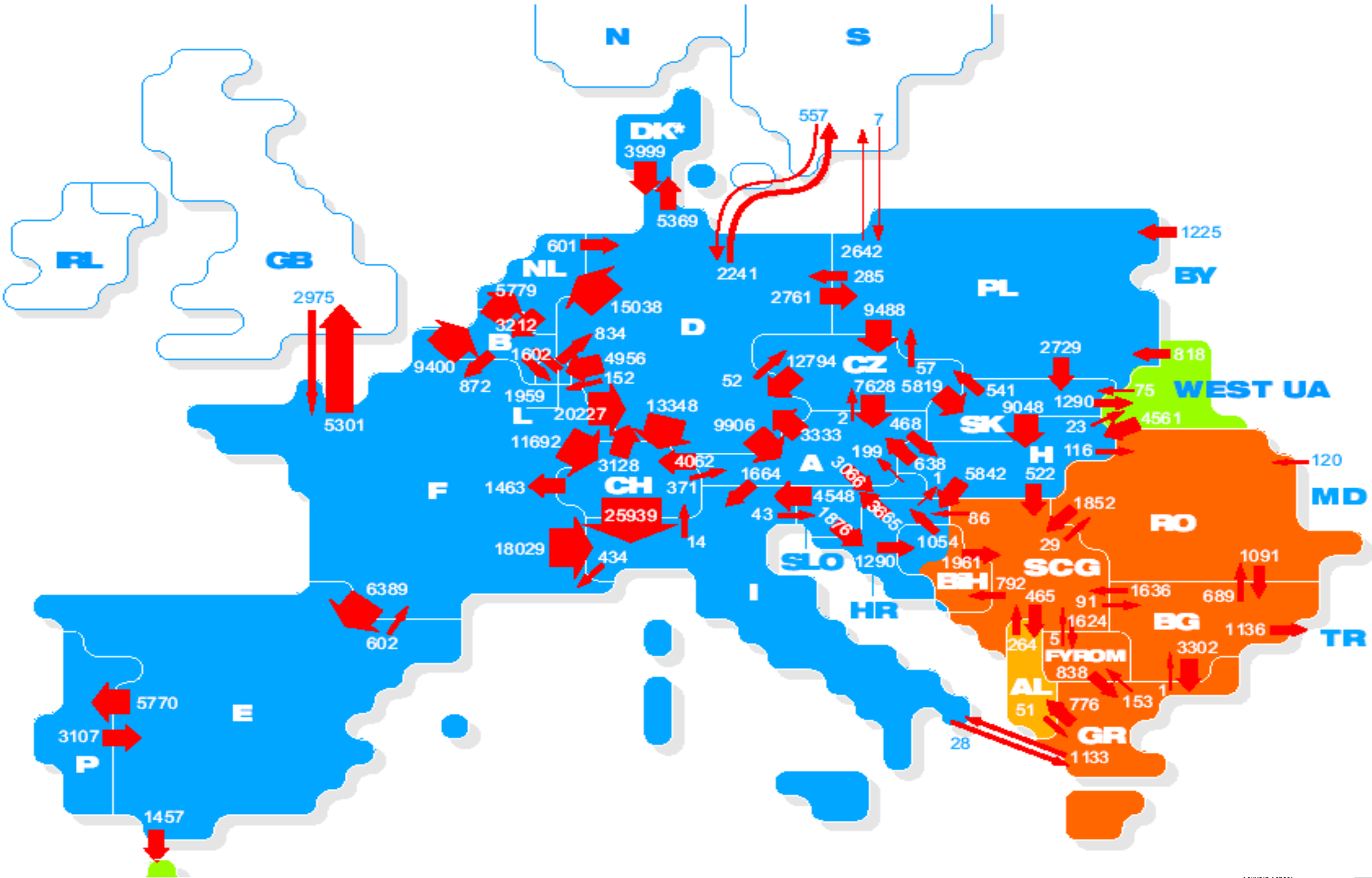
EU Transmission tariff structure

Source: ETSO Comparison on transmission pricing in Europe, synthesis 2004, April 2005.

		Sharing of network operator costs among customers	
		Producer	Consumer
Austria		16.5 %	83.5 %
Belgium		0%	100%
Czech Republic		0%	100%
Denmark	West	11%	89%
	East	3%	97%
England & Wales		27% TNUoS Tariff 50% BSUoS Tariff	73% TNUoS Tariff 50% BSUoS Tariff
Finland		7%	93%
France		2%	98%
Germany		0%	100%
Greece		30 % Use of system 0 % Uplift charges	70 % Use of system 100 % Uplift charges
Hungary		0%	100%
Italy		2-6%	94-98%
Netherlands		0% (since July 2004)	100% (since July 2004)
Norway		32%	68%
Poland		0.5%	99.5%
Portugal		0%	100%
Romania		50% Transmission tariff 0% System services	50% Transmission tariff 100% System services
Slovenia		0%	100%
Spain		0%	100%
Sweden		25%	75%

Infrastructure investments

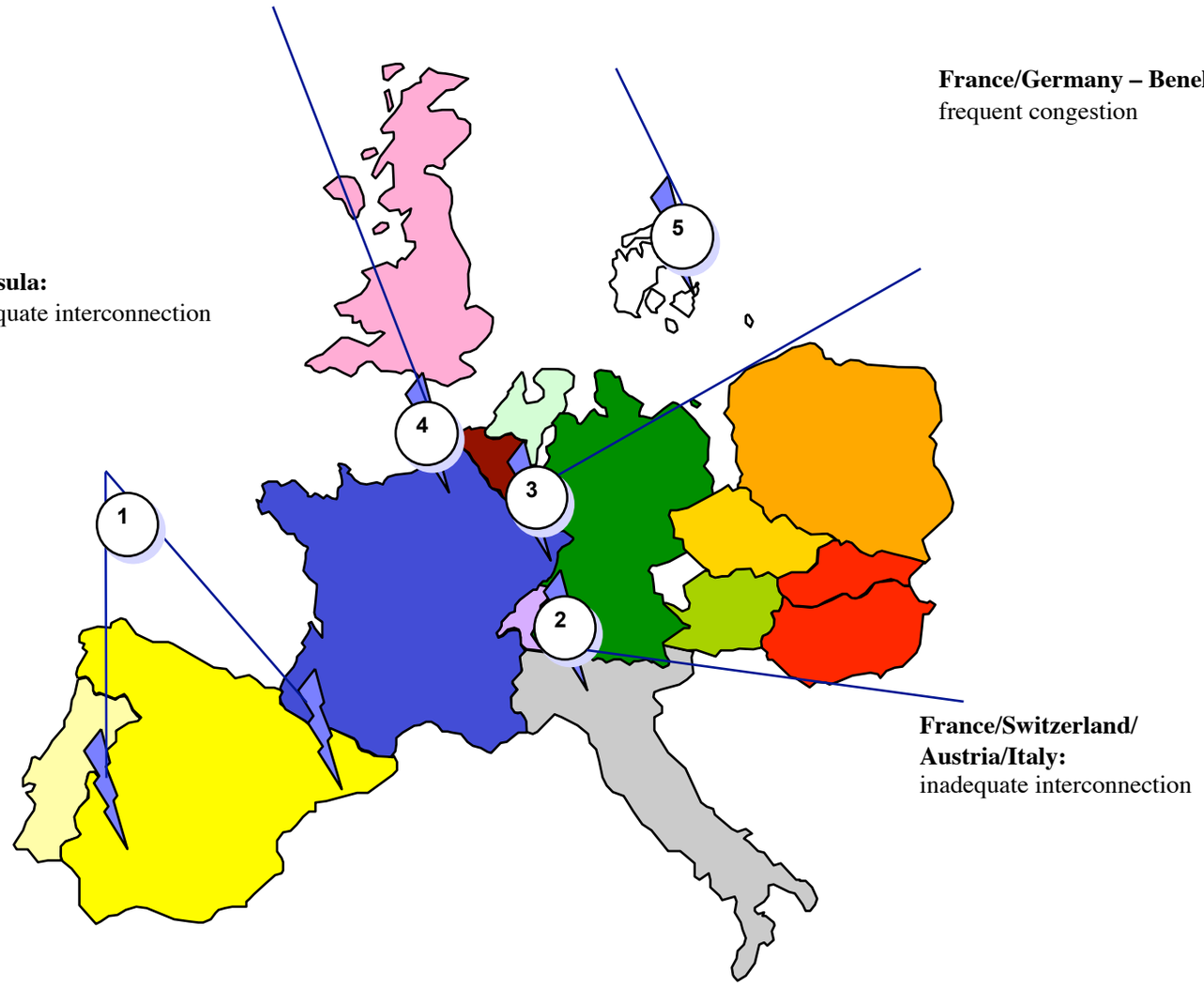
Physical electricity exchanges 2003 *



Bottlenecks in the power grid

UK-France:
a single inter-connection, with limited capacity

Scandinavia:
limited capacity



France/Germany – Benelux:
frequent congestion

Iberian Peninsula:
isolated, inadequate interconnection with France

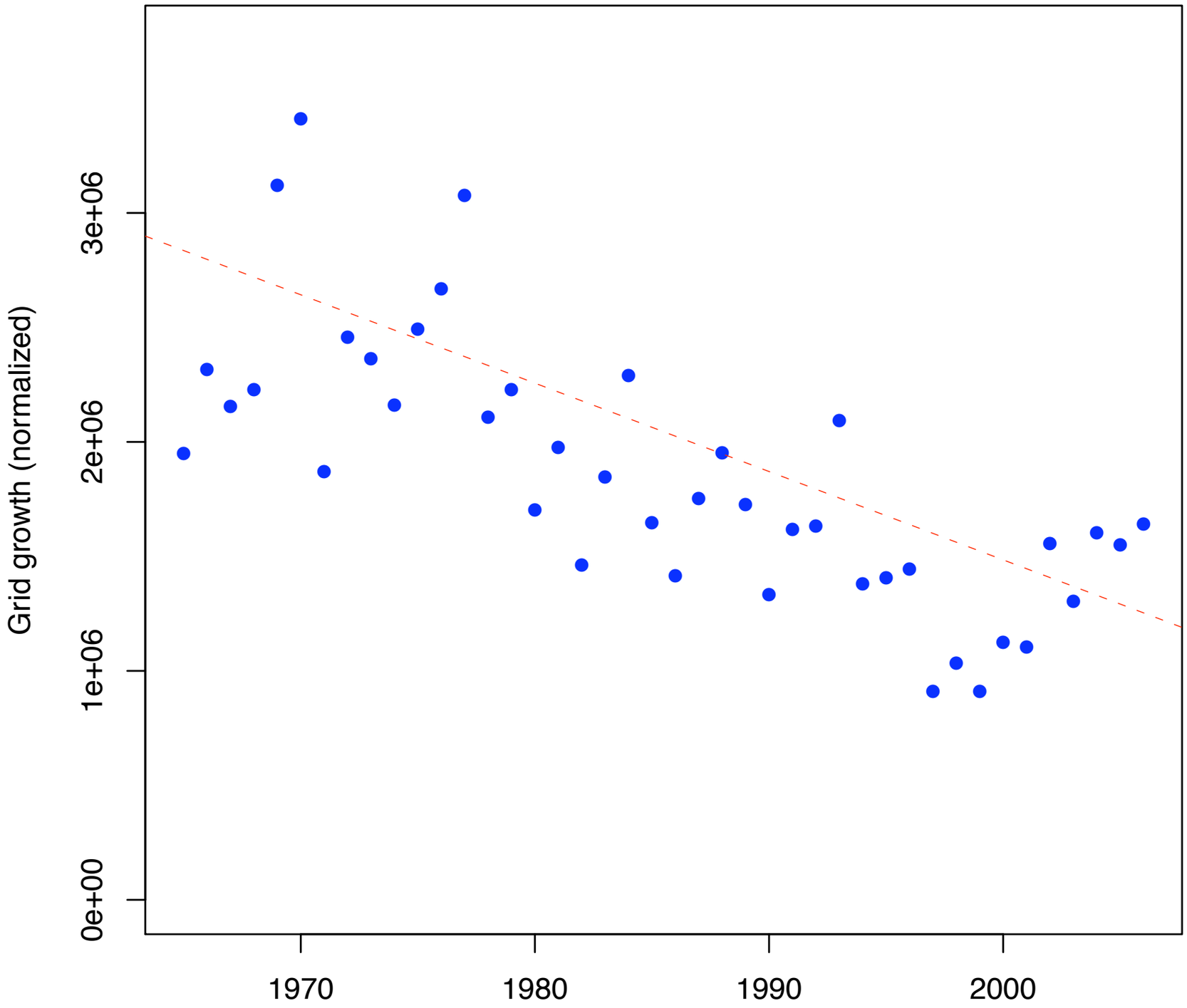
France/Switzerland/ Austria/Italy:
inadequate interconnection

Example: Electricity Transmission

COM(2006) 846 (10/01/2007)

Priority Interconnection Plan

- "Urgent action needed
- Despite this legislation, progress on the development of networks is insufficient. Significant obstacles remain."
- "Amounts invested in cross-border infrastructure in Europe appear dramatically low. Only €200 million yearly is invested in electricity grids with as main driver the increase of cross-border transmission capacity. This only represents 5% of total annual investment for electricity grids in the EU, Norway, Switzerland and Turkey.
- These figures do not even match the needs of an effective infrastructure in line with the objectives of the EPE. The EU will need to invest, before 2013, at least €30 billion in infrastructure (€6 billion for electricity transmission, €19 billion for gas pipelines and €5 billion for Liquefied Natural Gas (LNG) terminals), if it wants to address fully the priorities outlined in the TEN-E Guidelines."



UCL/CORE/Agrell/e3GRID/2009

Coordination of investment decisions

How to solve the underinvestment problem?

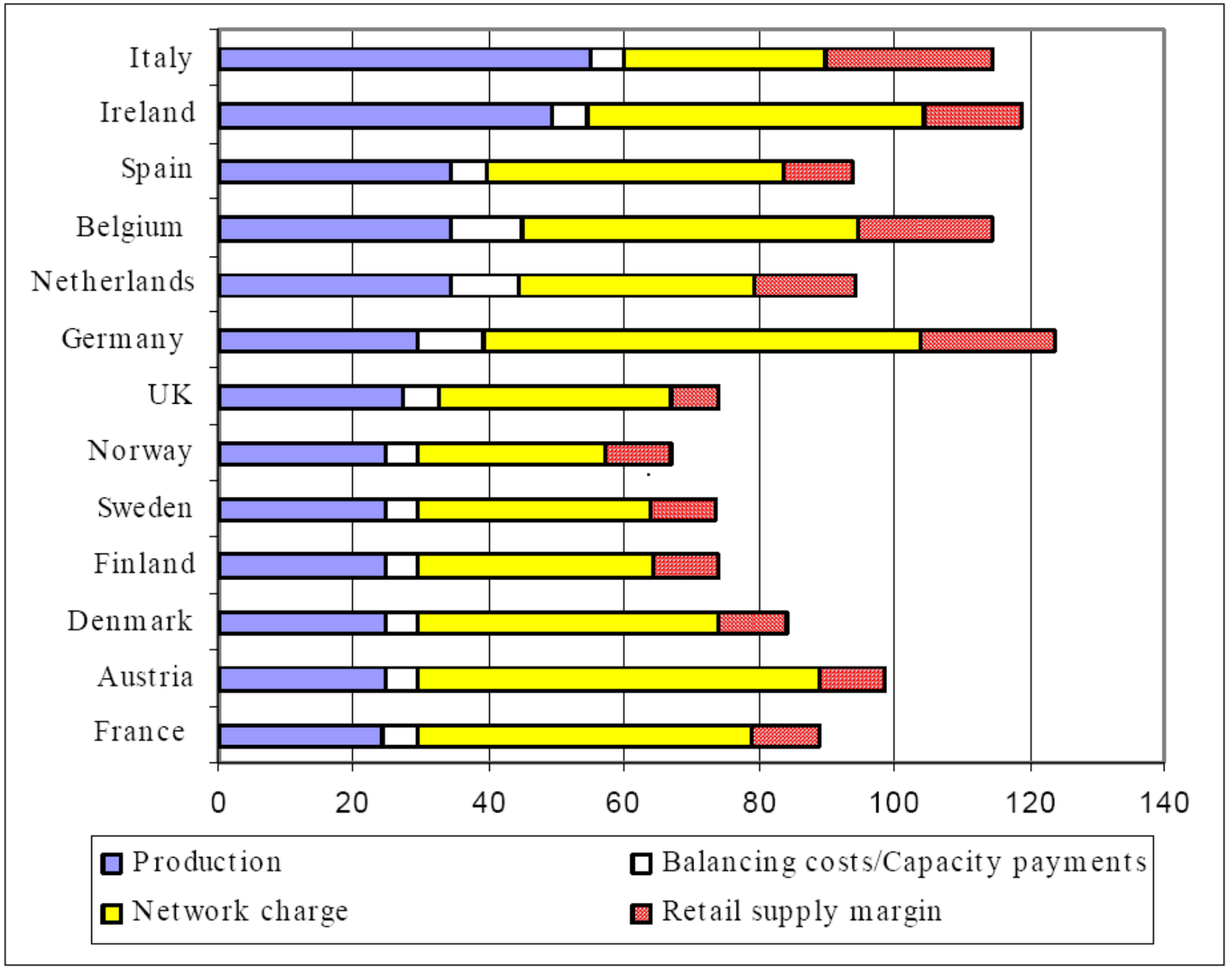
- Coordinate timing of decision
- Organize side-transfers between countries
- Discipline and harmonize downstream market conditions

Anecdote for you:

- TEN-E identified France-Spain as priority area for electricity transmission
- RTE and RED get approval for interconnection
- RED constructs even 8 km of 300 kV line...
- 2001: RTE halts the process due to local protest
- 2002: EdF takes control of Hidrocantabrico
- EC requires an investment of 2,700 MW to approve the acquisition

Competitive retail markets?

Differences in regional energy prices



European Commission, (2004)

International groupings of network operators

The EU-model assumes that the non-regulated segment is competitive, at least in expectation.

However

- Electricity: clear tendencies of concentration downstream, even in "mature" markets such as NordPool (NO: 57% share of 5 largest firms)
- Gas: Eon largest retailer in Central Europe, second retailer in North Europe

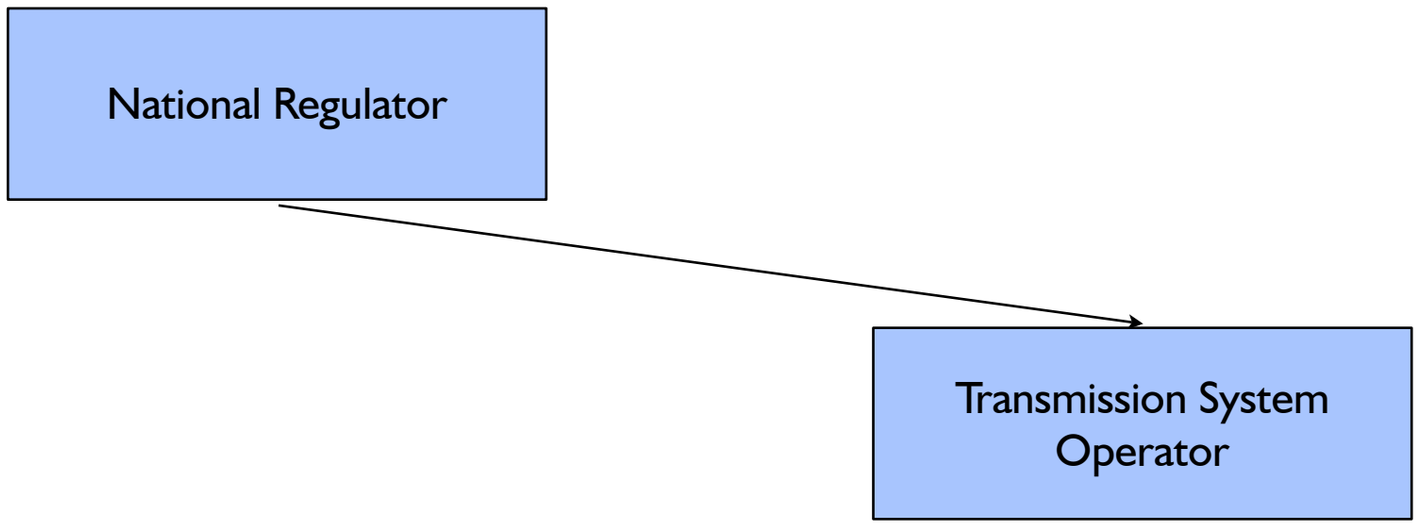
- Ownership: Mixed solutions regarding ownership of infrastructure (state, mixed, private) and the relations to the incumbents (unbundling limits). Resistance to radical changes in ownership and management from states (energy but primarily rail…)

Coordination

Infrastructure institutional landscape: Energy

Infrastructure institutional landscape: Energy

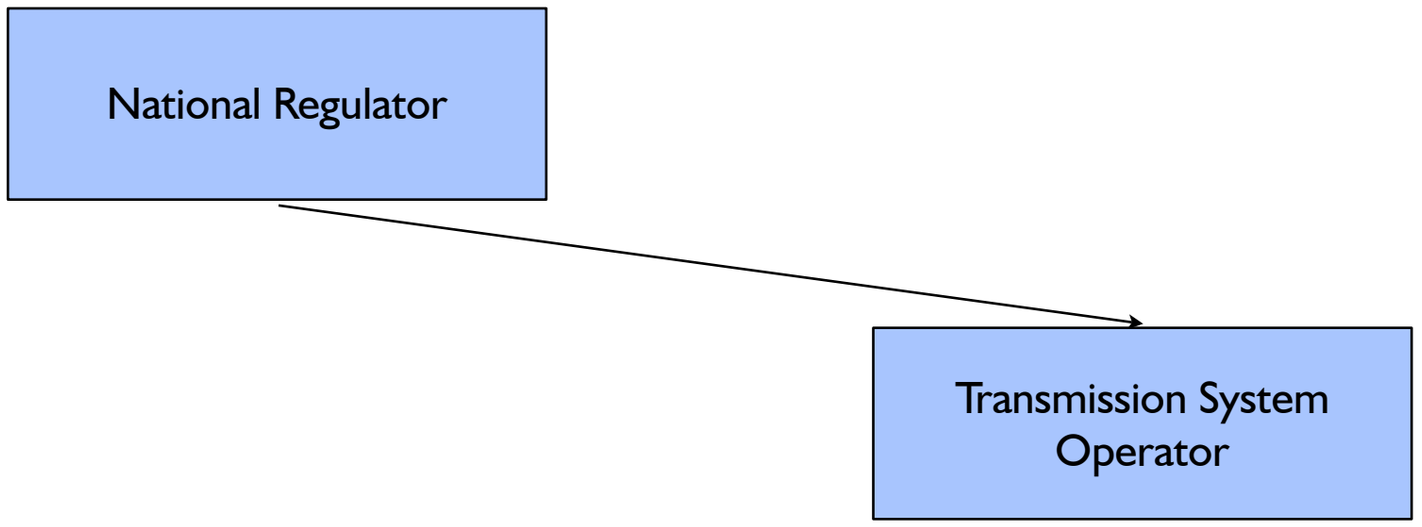
National



Infrastructure institutional landscape: Energy

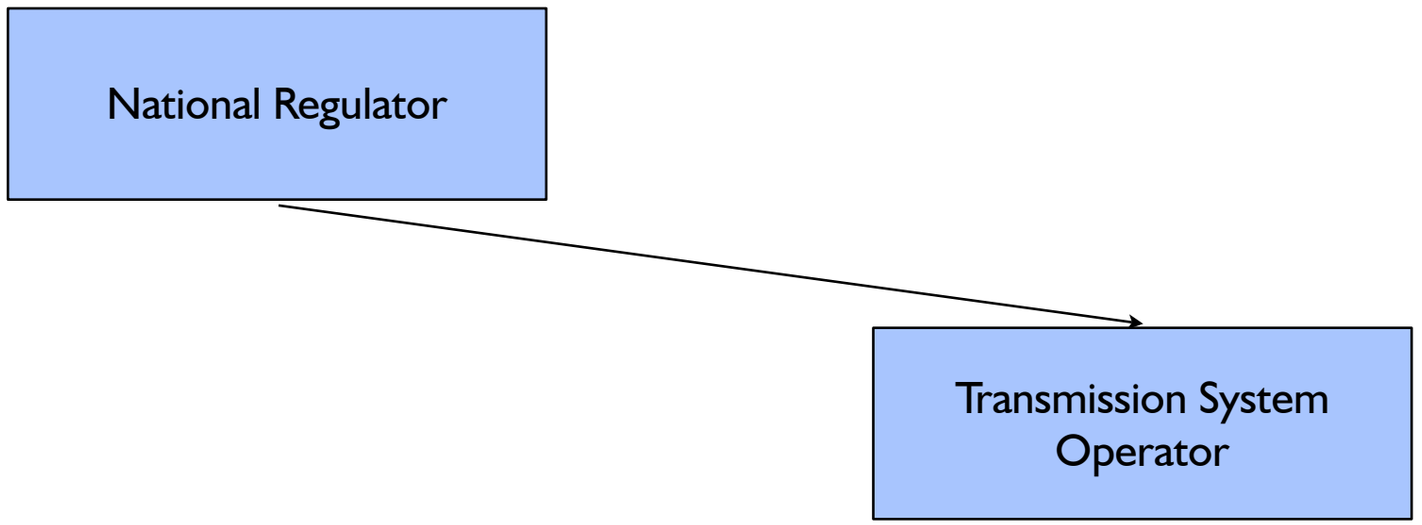
CEER (2000) 2003

National



Infrastructure institutional landscape: Energy

National

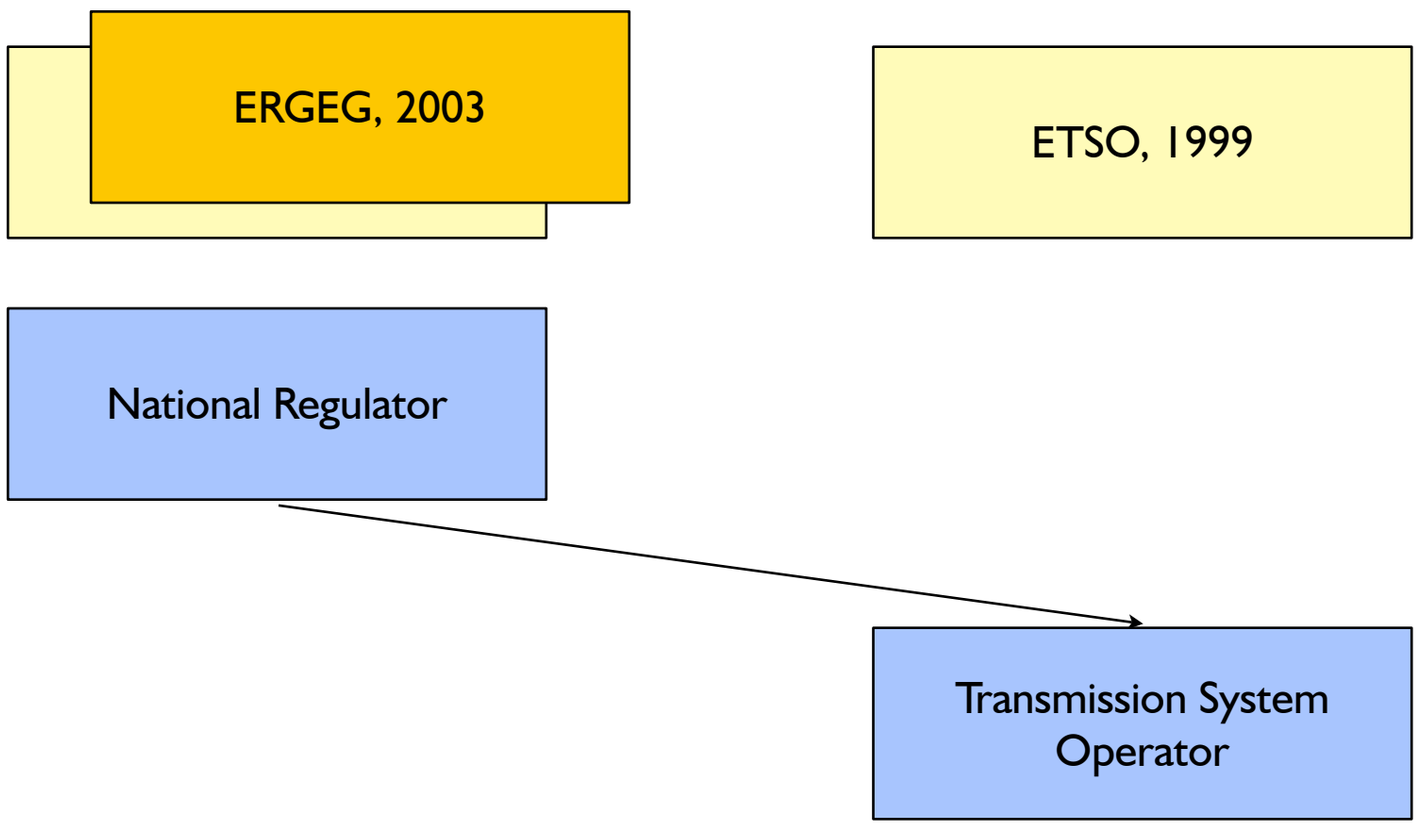


Infrastructure institutional landscape: Energy

ERGEG, 2003

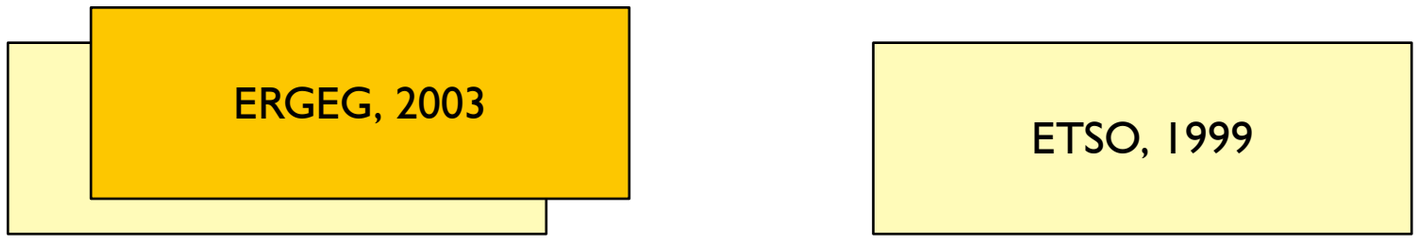
ETSO, 1999

National

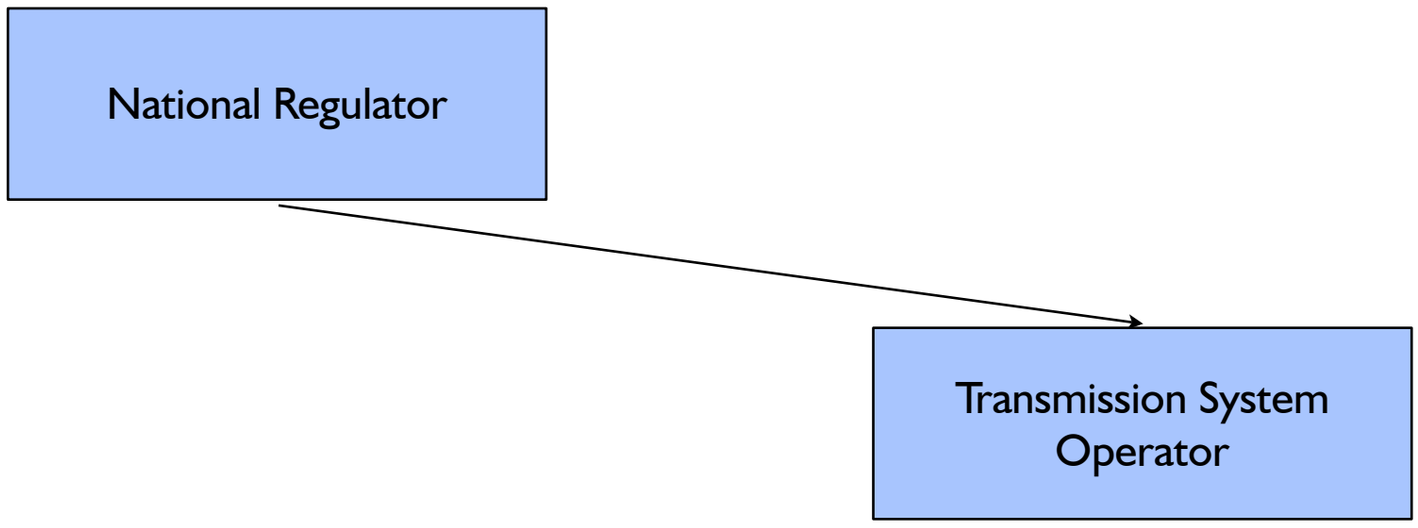


Infrastructure institutional landscape: Energy

Europe

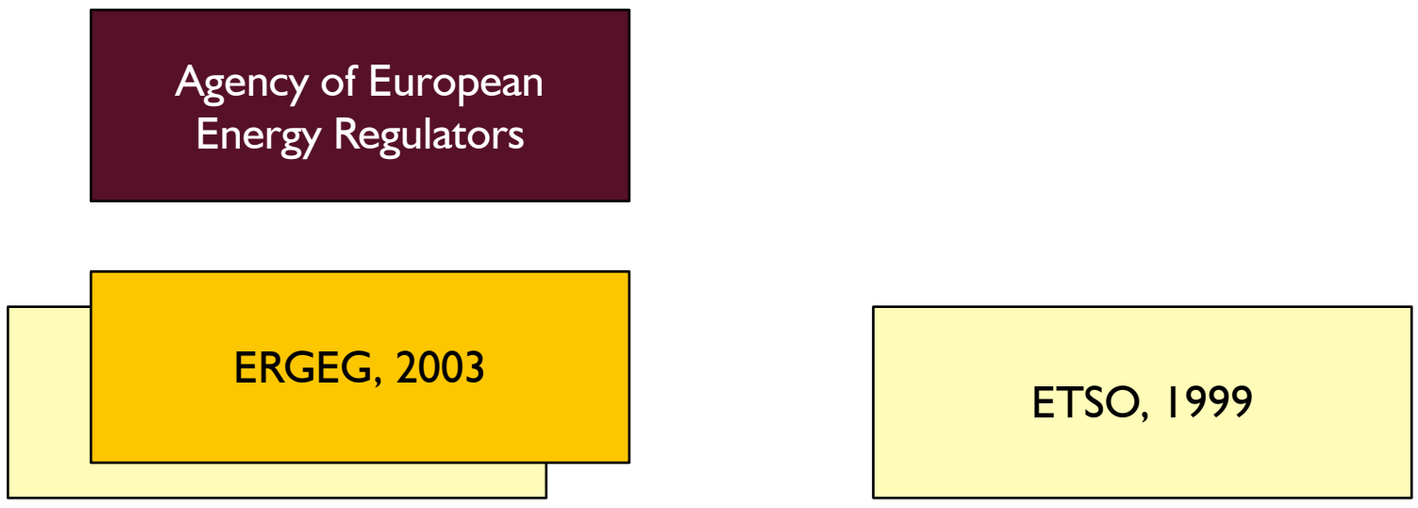


National



Infrastructure institutional landscape: Energy

Europe



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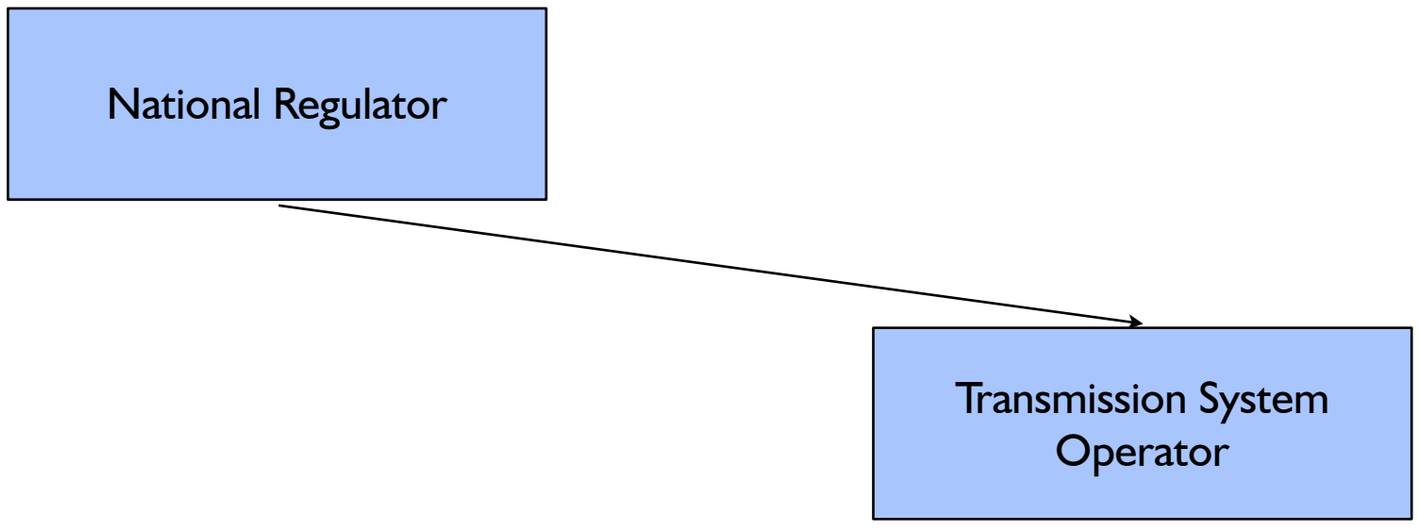

Infrastructure institutional landscape: Energy

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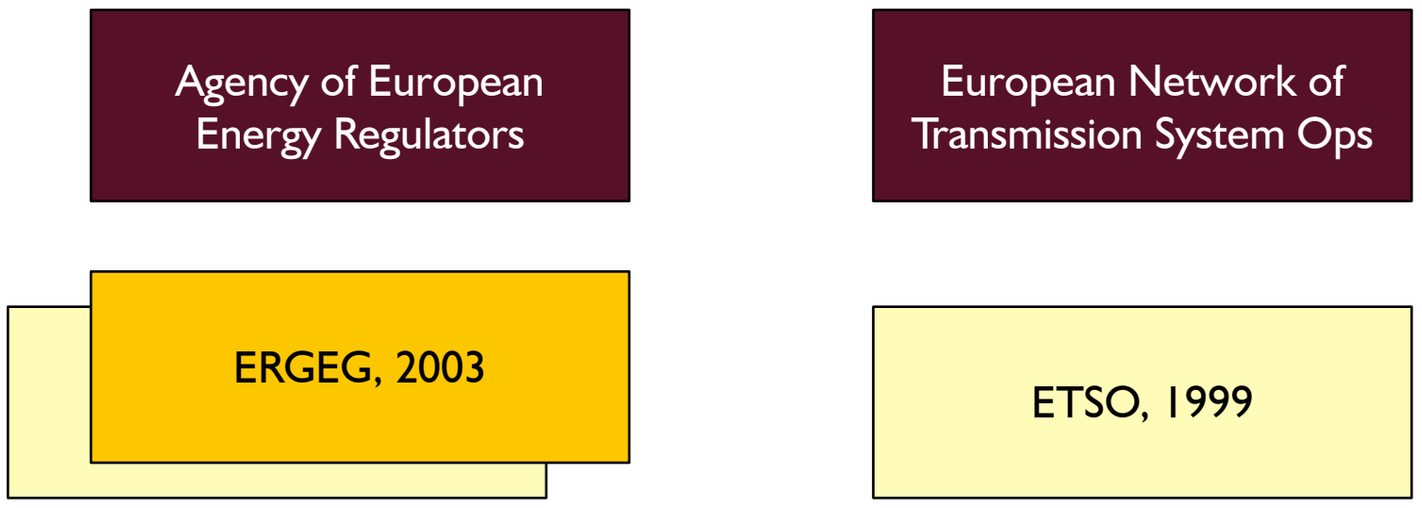
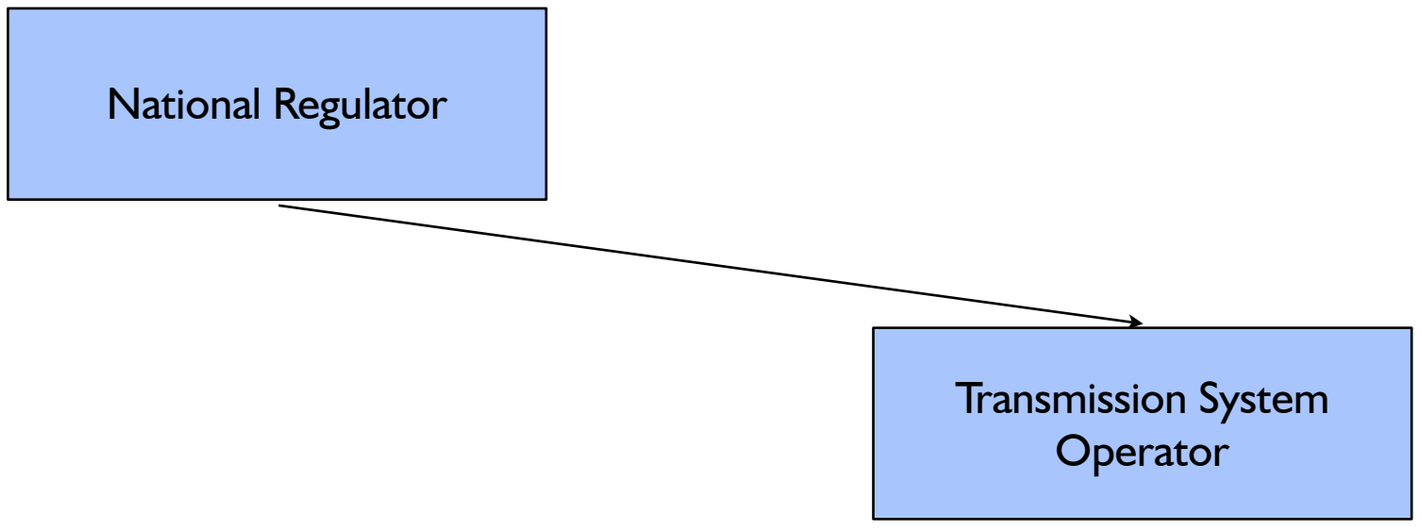


National



Infrastructure institutional landscape: Energy

EC, 2009

Agency of European Energy Regulators

European Network of Transmission System Ops

Europe

ERGEG, 2003

ETSO, 1999

National

National Regulator

Transmission System Operator

Agenda of the Agency for European Energy Regulators

Supervision of

- The TSO coordination body ENTSO
  - Joint investment plans
  - Joint research and development
  - Application of TPA and unbundling
- Inter-regulatory conflicts
  - Access rights
  - Application of directive
  - Capacity determination

Will this be enough? Will it work?

Research questions

Diversity and multiplicity of financing solutions

- Will access pricing converge to a unique NE under non-cooperation?

Underinvestment in infrastructure

- What are the investment incentives in common infrastructure?
- How do they depend on financing solution?
- What is the impact of level of cooperation?

Downstream market power

- What is the impact on access pricing and investment incentives from prevailing downstream market power among the operators?

Coordination

- What is potential for supra-state coordination gains?

Model

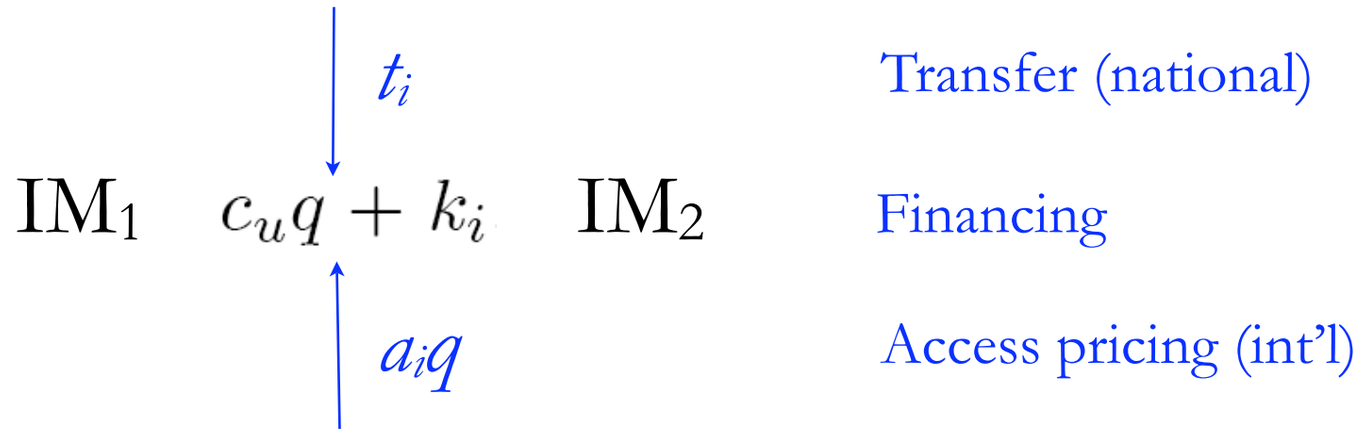
Model

National regulators		
Infrastructure managers	IM_1	IM_2

Model

National regulators

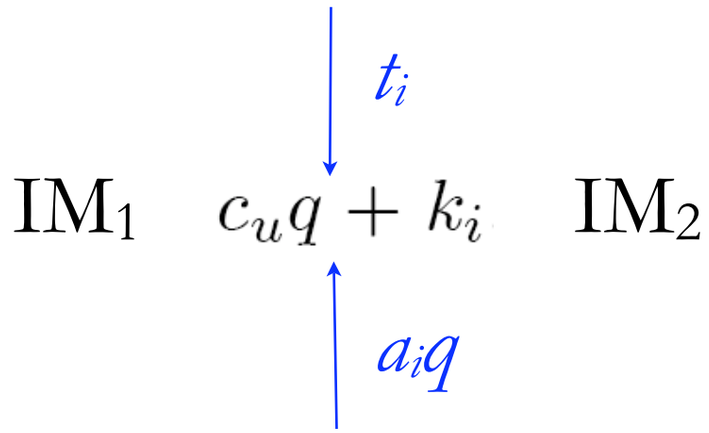
Infrastructure managers



Model

National regulators

Infrastructure managers



Downstream international [Bertand] competition

$$p = a_1 + a_2 + c_d$$

$$\eta = \frac{-q'p}{q}$$

Problem of IM

$$p_* = a_1 + a_2 + c_d$$

$$\max_{\{a_i, t_i \geq 0\}} \theta_i S(q(p_*)) - (1 + \lambda_{pf}) t_i + \pi_i^{infra}$$

$$\text{s.t. } (BB_i) : \pi_i^{infra} \equiv t_i + (a_i - c_u) q - k_i \geq 0$$

Problem of IM

$$p_* = a_1 + a_2 + c_d$$

(Share of) Social welfare

$$\max_{\{a_i, t_i \geq 0\}} \theta_i S(q(p_*)) - (1 + \lambda_{pf}) t_i + \pi_i^{infra}$$

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Costly transfers

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(Share of) Social welfare — Infrastructure profit

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Costly transfers

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Budget balancing

Competition between IM

(Technical assumption A1 on the demand shape to ensure best-responses by first-order conditions)

Regime 1: No subsidy and profitable infrastructure (sufficienctly low access price)

Regime 2: No subsidy and no infrastructure profit (intermediate access price)

Regime 3: Subsidy and no infrastructure profit (sufficiently high access price)

Competition between IM

(Technical assumption A1 on the demand shape to ensure best-responses by first-order conditions)

Regime 1: No subsidy and profitable infrastructure (sufficienctly low access price)

$$a_i^1(a_j) \text{ such that } \frac{a_i^1 - c_u}{p_*} = (1 - \theta_i)\frac{1}{\eta(p_*)}$$

Regime 2: No subsidy and no infrastructure profit (intermediate access price)

Regime 3: Subsidy and no infrastructure profit (sufficiently high access price)

Competition between IM

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Regime 2: No subsidy and no infrastructure profit (intermediate access price)

$$a_i^2(a_j) \text{ such that } \frac{a_i^2 - c_u}{p_*} = \frac{1+\lambda_i-\theta_i}{1+\lambda_i}\frac{1}{\eta(p_*)}$$

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Regime 3: Subsidy and no infrastructure profit (sufficiently high access price)

$$a_i^3(a_j) \text{ such that } \frac{a_i^3 - c_u}{p} = \frac{1+\lambda_{pf}-\theta_i}{1+\lambda_{pf}}\frac{1}{\eta}$$

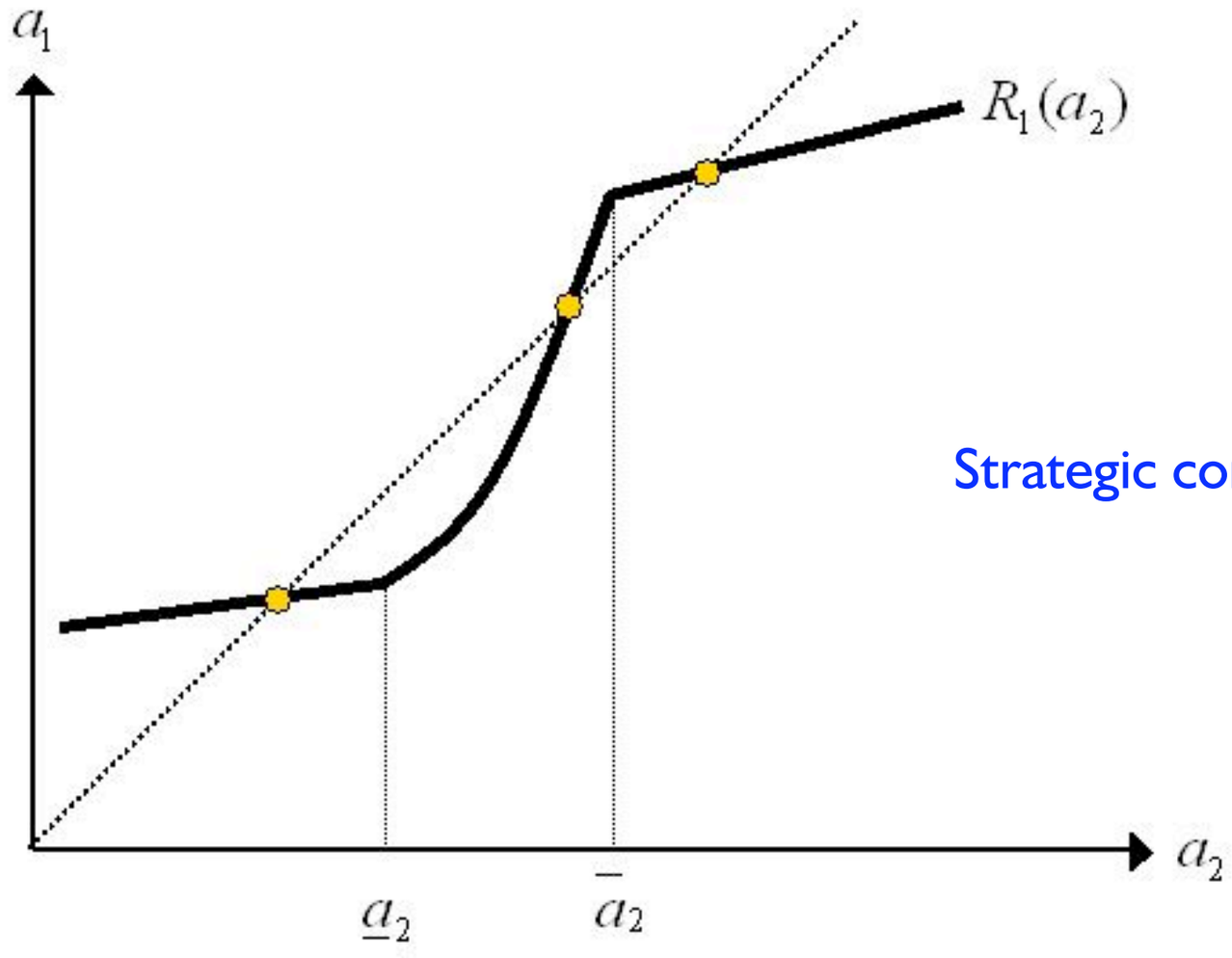
Equilibria

Non-cooperative game, simultaneous moves

Lemma 1. *The strategic interaction between access pricing decisions is characterized as follows:*

$$\frac{da_i}{da_j} = \begin{cases} \frac{(1-\theta_i)\delta}{1-(1-\theta_i)\delta} & \text{in Regime 1,} \\ \frac{1+\lambda_i-\theta_i}{\theta_i} & \text{in Regime 2,} \\ \frac{(1+\lambda_{pf}-\theta_i)\delta}{1+\lambda_{pf}-(1+\lambda_{pf}-\theta_i)\delta} & \text{in Regime 3.} \end{cases}$$

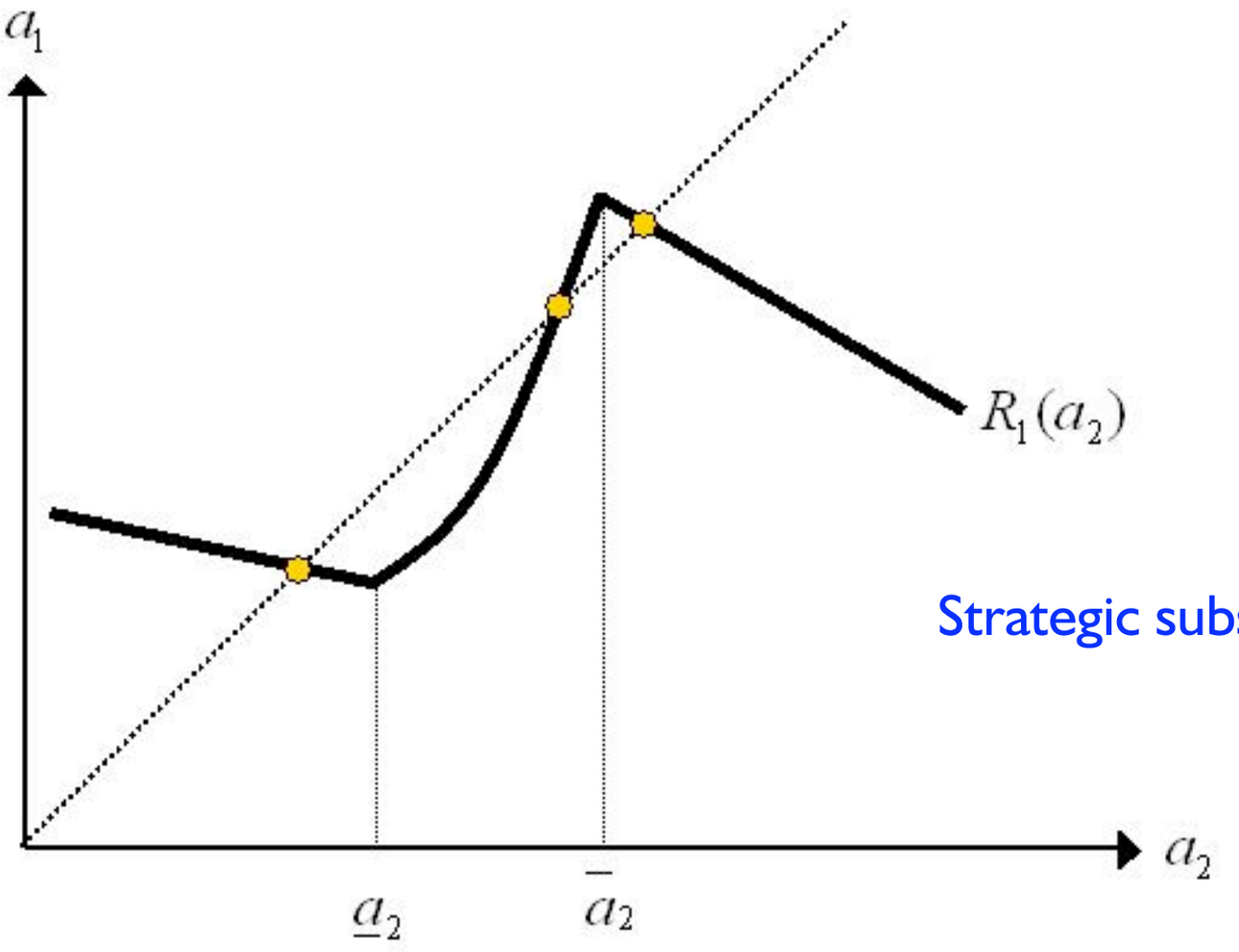
Symmetric equilibria (1)



Strategic complements

$$\delta \geq 0$$

Symmetric equilibria (2)



Strategic substitutes

$$\delta \leq 0$$

Observations

$$\max_a \{(a - 2c_u)q - (k_i + k_j)\}$$

$$\frac{p_* - c}{p_*} = [2 - (\theta_i + \theta_j)]\frac{1}{\eta}$$

$$\theta_i + \theta_j < 1$$

Observations

Compare with integrated benchmark

$$\max_a \{(a - 2c_u)q - (k_i + k_j)\}$$

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$$\frac{p_* - c}{p_*} = [2 - (\theta_i + \theta_j)]\frac{1}{\eta}$$

– Full integration of consumer welfare in regime I yields integrated price = equivalent to centralized super-IM

$$\theta_i + \theta_j < 1$$

Observations

Compare with integrated benchmark

$$\max_a \{(a - 2c_u)q - (k_i + k_j)\}$$

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- Full integration of consumer welfare in regime I yields integrated price = equivalent to centralized super-IM
- Partial integation of consumer welfare $\theta_i + \theta_j < 1$ yields price > monopoly price

Observations

Compare with integrated benchmark

$$\max_a \{(a - 2c_u)q - (k_i + k_j)\}$$

$$\frac{p_* - c}{p_*} = [2 - (\theta_i + \theta_j)]\frac{1}{\eta}$$

- Full integration of consumer welfare in regime I yields integrated price = equivalent to centralized super-IM
- Partial integation of consumer welfare $\theta_i + \theta_j < 1$ yields price > monopoly price
- No valuation of consumer surplus (transit) conincides with Regime I

Investment incentives (1)

Game:

- Non-cooperative simultaneous choice of cost-reducing investment level $\psi(y_i)$
- IM choose financing policies for their infrastructure (Regime 2)

Social welfare $W_i^2 = \theta_i S(q(a_{i*}^2 + a_{j*}^2))$

IM investment problem $\max_{y_i} \{W_i^2 - \psi(y_i)\}$

Direct MC effect

$$\frac{d}{dy_i}[W_i^2 - \psi(y_i)] = \left[-\theta_i q \left(1 + \frac{da_j^2}{da_i}\right) \frac{da_{i*}^2}{dc_{ui}}\right] c'_{ui}(y_i) - \psi'(y_i)$$

Strategic effect Investment cost

Investment incentives (2)

$$\frac{da_i^2}{dc_{ui}} = \left[1 - \frac{1+\lambda_i-\theta_i}{1+\lambda_i}\frac{1+\lambda_j}{\theta_j}\right]^{-1}$$

$$\frac{da_i}{da_j} = \frac{-(a_j - c_{uj})q'}{q + (a_j - c_{uj})q'}$$

$$\left[\frac{da_i}{dc_{ui}}\right]^{-1} = q + (a_i - c_{ui})q'\left(1 + \frac{da_i}{da_j}\right) = q\,\frac{q + (a_i + a_j - c_{ui} - c_{uj})q'}{q + (a_j - c_{uj})q'}$$

Investment incentives (3)

Non-cooperative equilbrium:

- Strict budget-balancing
- Strategic interaction effect
- Distorted price above centralized monopoly

Reducing marginal infrastructure cost in given country leads to negative welfare effects in that country through increased final prices

Proposition 1. *Consider that countries do not provide public funds to finance their networks and that strict infrastructure budget constraints are binding. At a non-cooperative equilibrium, countries choose not to invest in their respective infrastructure.*

Investment incentives (4)

Cooperative setting, investment coordination

$$\max_{\{y_i,y_j\}} \{W_i + W_j - \psi(y_i) - \psi(y_j)\}$$

$$-(\theta_i + \theta_j)q \left(1 + \frac{da_j^2}{da_i}\right) \frac{da_{i*}^2}{dc_{ui}} c'_{ui}(y_i) - \psi'(y_i) = 0,\ i \neq j. \qquad <0$$

>0 <0 <0 >0

Proposition 2. *Assume that no countries provide public funds to finance their networks and that strict infrastructure budget constraints are binding. Assume that countries perfectly cooperate when deciding infrastructure investment levels, but behave non-cooperatively at the access pricing stage. Then, at equilibrium, no investment is undertaken.*

Subsidized investments (1)

Non-cooperative setting, (Regime 3), subsidy

$$W_i \equiv \theta_i S(q(p_*^3)) + (1 + \lambda_{pf}) \left[a_{i*}^3 - c_{ui}(y_i)\right] q(p_*^3)$$

$$\max_{y_i} \{W_i - \psi(y_i)\}$$

$$\underbrace{\frac{\partial W_i}{\partial y_i}}_{\text{direct effect}} + \underbrace{\frac{\partial W_i}{\partial a_j} \frac{da_j^3}{da_i} \frac{da_{i*}^3}{dc_{ui}} c'_{ui}(y_i)}_{\text{strategic effect}} = \psi'(y_i)$$

Subsidized investments (2)

Results (A7.2)

- Welfare in a given country decreases with access price set in the other country
- Reduced marginal cost of infrastructure in a given country leads to lower access price in that country
- Investment incentives crucially depend on strategic effects
- Strategic effect depends on demand characteristics
  - Strategic substitutes: lower investment incentives (access price increase)
  - Strategic complements: higher investment incentives (access price decrease)
  - Different valuation of downstream service $\theta_i \geq \theta_j$ reinforces these conditions

Subsidized investments (2)

Compare cooperative benchmark (coordinated investment)

Proposition 3. *Assume that infrastructure managers use public funds to finance their networks and behave non-cooperatively at the access price setting stage. Then, non-cooperative infrastructure managers always under-invest with respect to the cooperative benchmark.*

Proposition 4. *The optimal investment levels under cooperation are identical across countries if and only if* $c_{ui}(.) = c_{uj}(.)$.

"Supranational" regulator invests based on cost impact, not welfare valuation

Perfect cooperation - perfect downstream discrimination

Monopoly infrastructure and retailer.

$$\begin{aligned} \max_{\{t\geq 0, a\}} \quad & \pi^{infra}, \\ \text{s.t.} \quad & \pi^{infra} = t + (a - 2c_u)q(a + c_d) + A - (k_i + k_j) \geq 0, \\ & A = S(q(a + c_d)) - (1 + \lambda_{pf})t. \end{aligned}$$

Results

- No efficiency loss from price discrimination
- Two-part tariff allows free redistribution of profits (subsidies)
- No shut-down $\Leftrightarrow S^* \equiv S(q(p^*)) \geq k_i + k_j$

Non-cooperation - perfect downstream discrimination

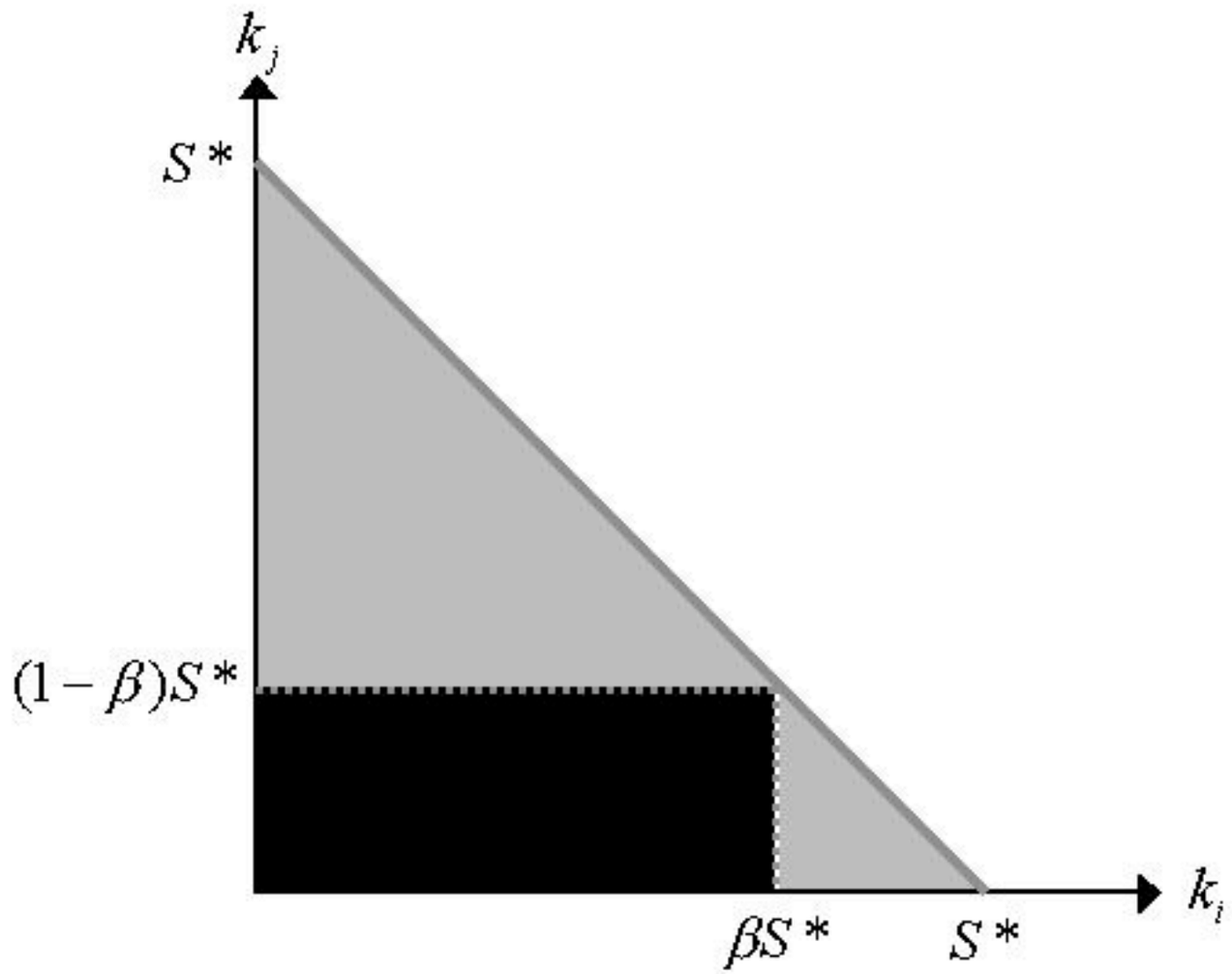
Downstream operator's profit:

$$\begin{aligned}
\max_{\{A_i,a_i\}} \quad & \pi_i^{infra} + \alpha_i \pi_m^{down}, \\
\text{s.t. } & \pi^{infra} = (a_i - c_u)q(a_i + a_j + c_d) + A_i - k_i \geq 0, \\
& \pi_m^{down} = S(q) - (A_i + A_j) \geq 0,
\end{aligned}$$

Results:

- No incentives to use subsidies
- Downstream monopoly enables IMs to coordinate their access pricing decisions
- All downstream profits extracted by IMs $A_i = \beta S^* \text{ and } A_j = (1-\beta)S^*$
- Different shut-down $\beta S^* \geq k_i \text{ and } (1-\beta)S^* \geq k_j$

Shut-down decisions under downstream market power



Conclusion

Model for interacting network regulators

- Mimicks the "EU standard model"
- Observed heterogeneity in terms of access pricing
- Observed underinvestment in infrastructure

Several serious problems for policy makers

- Multiplicity of equilibria
- Instability of equilibria (Regime 2)
- No investment incentives under strict budget balancing
- Downstream market power may worsen incentives

Regulatory coordination can work if simultaneuosly considering

- Investment
- Access pricing
- Financing policy