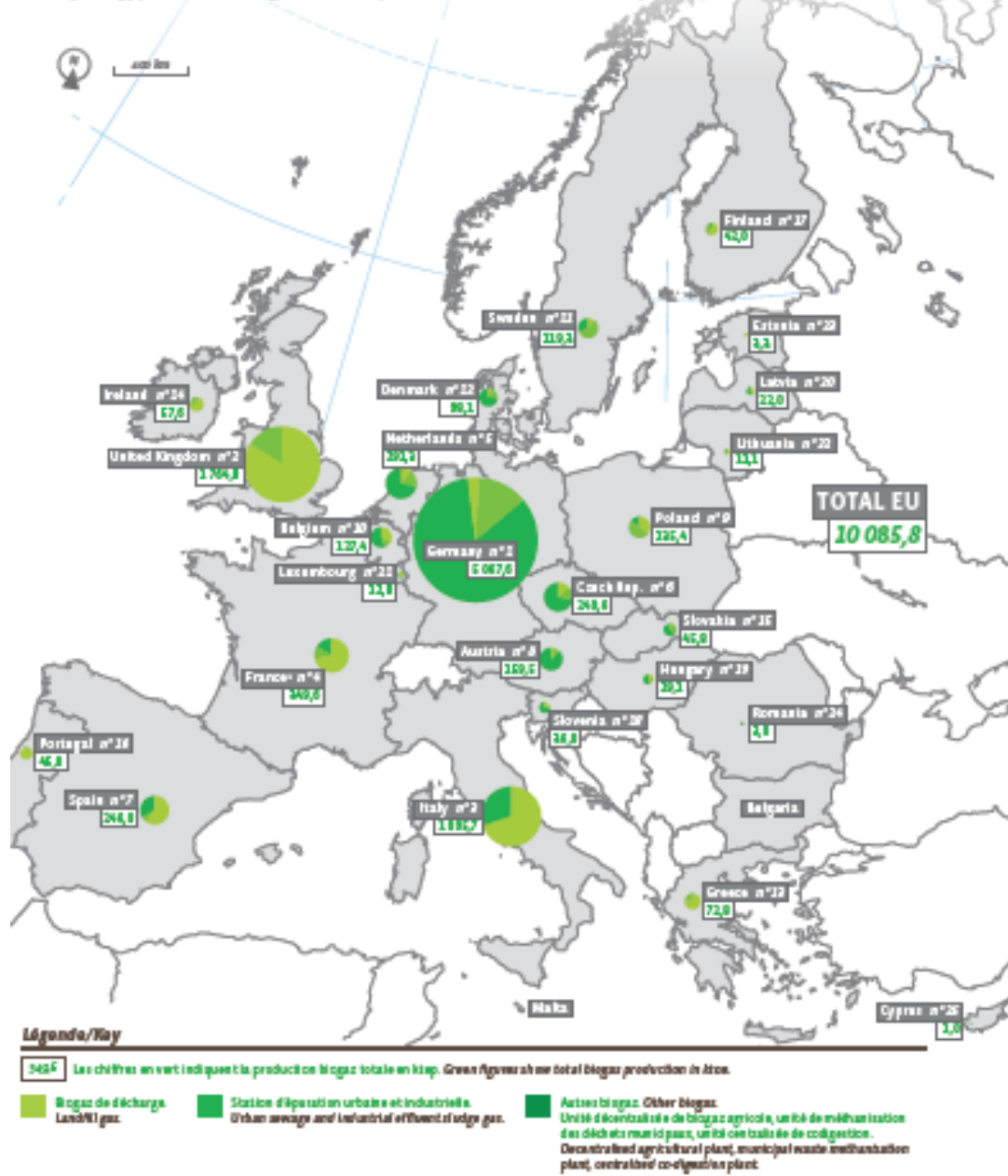


# Lecture 7: Anaerobic digestion of energy crops: European case studies - Italy -

David Bolzonella



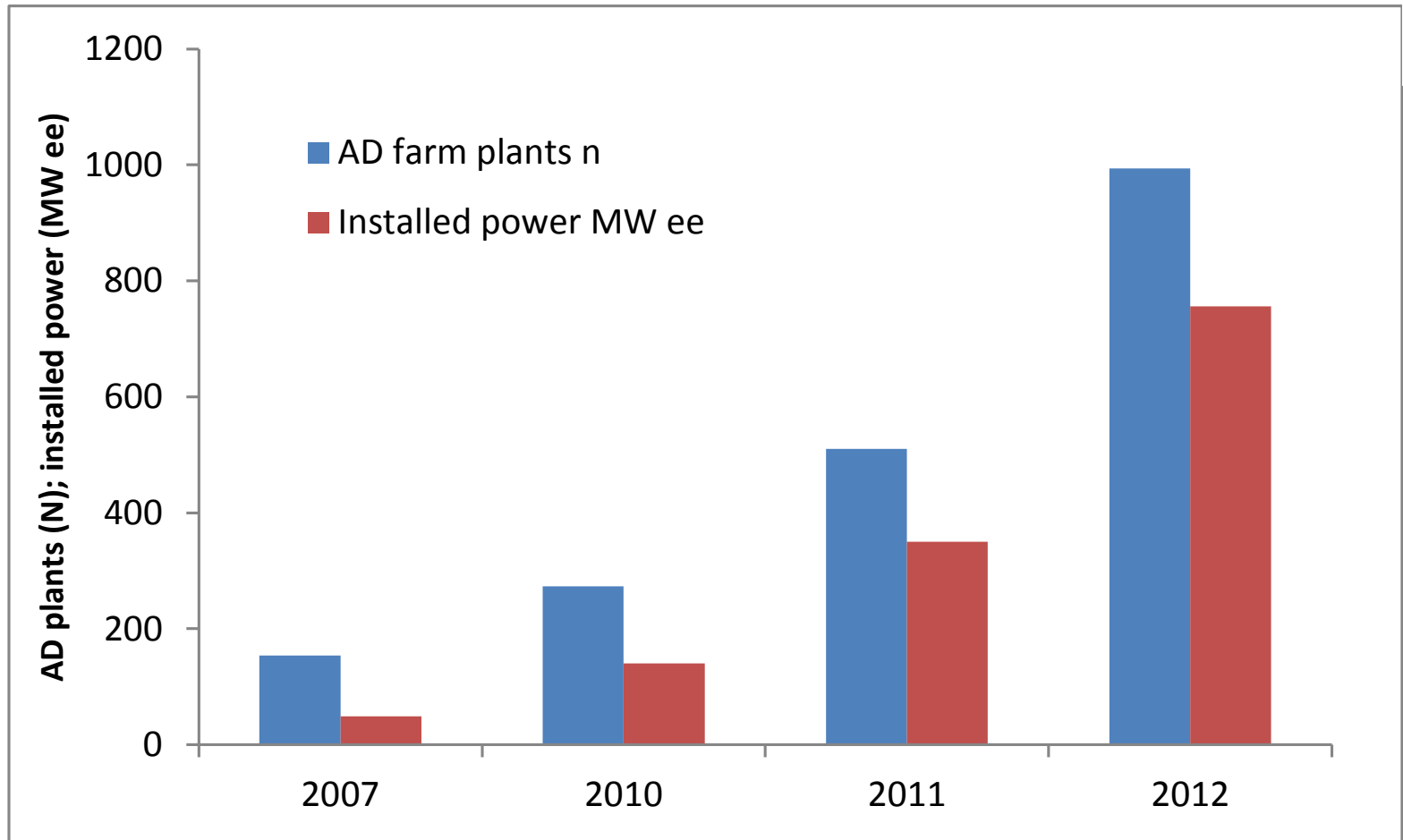
Production d'énergie primaire de biogaz dans les pays de l'Union européenne à la fin 2012\* (en kttep)  
 avec les parts respectives de chaque filière  
 Primary energy production of biogas in the European Union in 2012\* (kttep) with respective shares of each sector



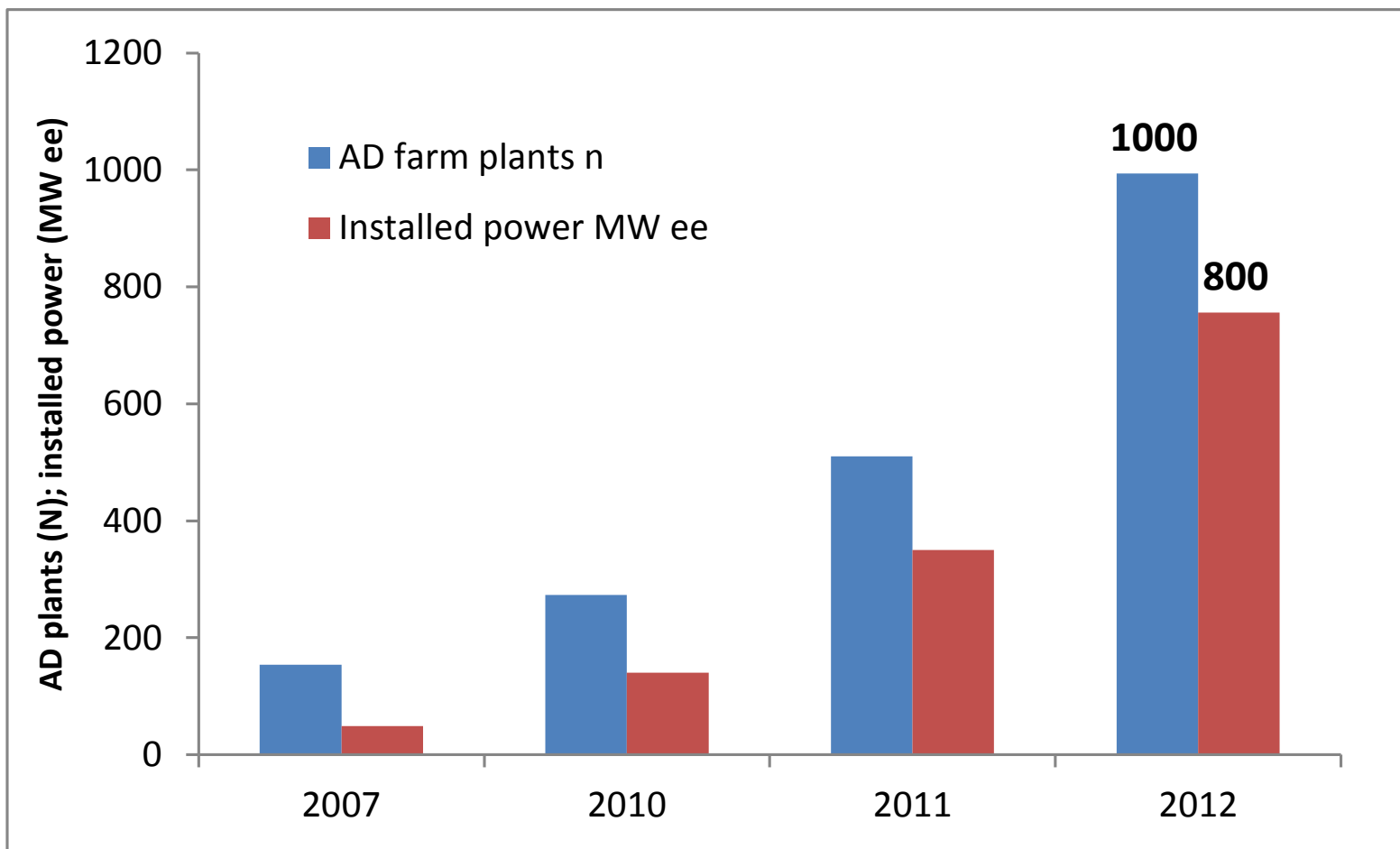
Source  
 Biogas  
 Barometer  
 Euroserv'er  
 Dec 2012



# The Italian scenario in the agricultural context



# The Italian scenario in the agricultural context



**2011 → 2012 +100% (tariff @ 280 euro/MWh)**





# First driver: nitrates reduction



**Vulnerable zones**

**Year of official publication**

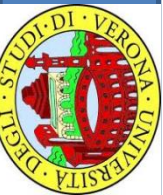
- Designated zone before 2000
- Designated zone 2000-2003
- New designated zones (since 2004)
- Draft zone in progress
- Valid drafted zone
- Proposed NVZs (zones designated after 31/10/2004 and before 31/12/2005)
- ADAS estimates of areas requiring further studies
- ADAS estimates of areas requiring designation

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Map produced by Institute for Environment and Sustainability

**EUROPEAN COMMISSION**  
 DIRECTORATE-GENERAL  
**Joint Research Centre**

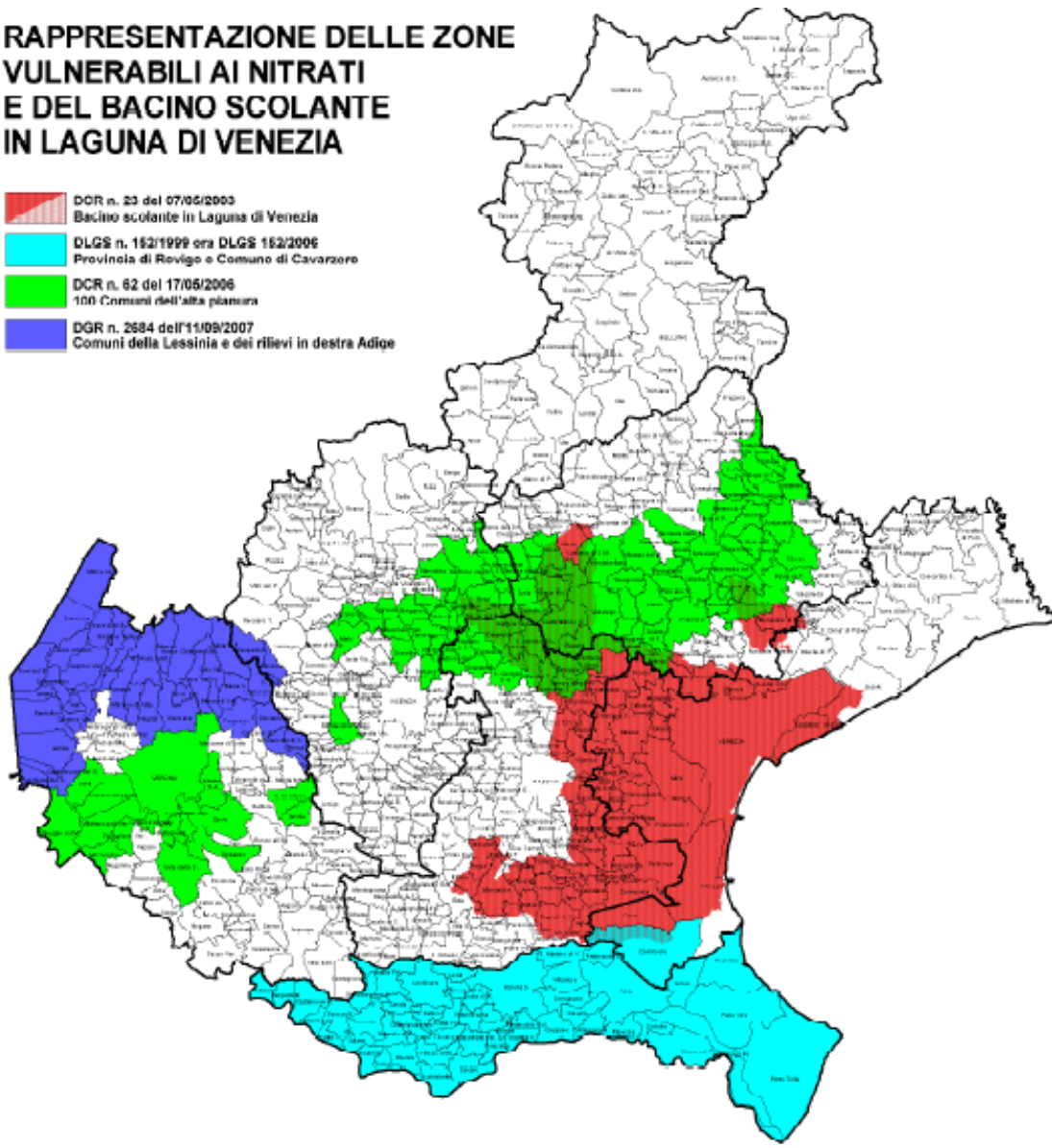
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**NITRATE VULNERABLE ZONES**



### RAPPRESENTAZIONE DELLE ZONE VULNERABILI AI NITRATI E DEL BACINO SCOLANTE IN LAGUNA DI VENEZIA

-  DCR n. 23 del 07/05/2003  
Bacino scolante in Laguna di Venezia
-  DLGS n. 152/1999 ora DLGS 152/2006  
Provincia di Rovigo e Comune di Cavarzere
-  DCR n. 82 del 17/05/2006  
100 Comuni dell'alta pianura
-  DGR n. 2584 dell'11/09/2007  
Comuni della Lessinia e dei rilievi in destra Adige



**Admitted N load  
170 kg/ha·year**







Because of this situation the Italian Government decided to support the production of biogas in farm plants with an installed power up to 1 MW and feeding material coming from a distance lower than 30 km with a subside of

**0.28 € per kWh for 15 years**

The basic idea for this was to use the revenues for nitrogen management (removal and/or recovery)



Because of this situation the Italian Government decided to support the production of biogas in farm plants with an installed power  $< 1$  MW feeding material coming from an area less than 30 km with a subside of



**0.28 € per kWh for 15 years**

The basic idea for this was to use the revenues for nitrogen management (removal and/or recovery)



kWh







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kWh



€





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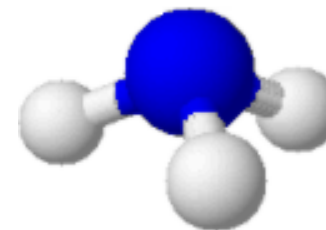
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kWh



€



NH<sub>3</sub>





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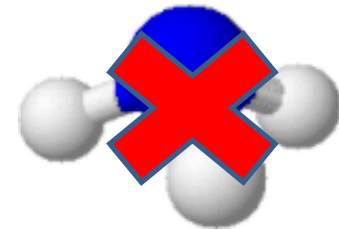
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kWh



€



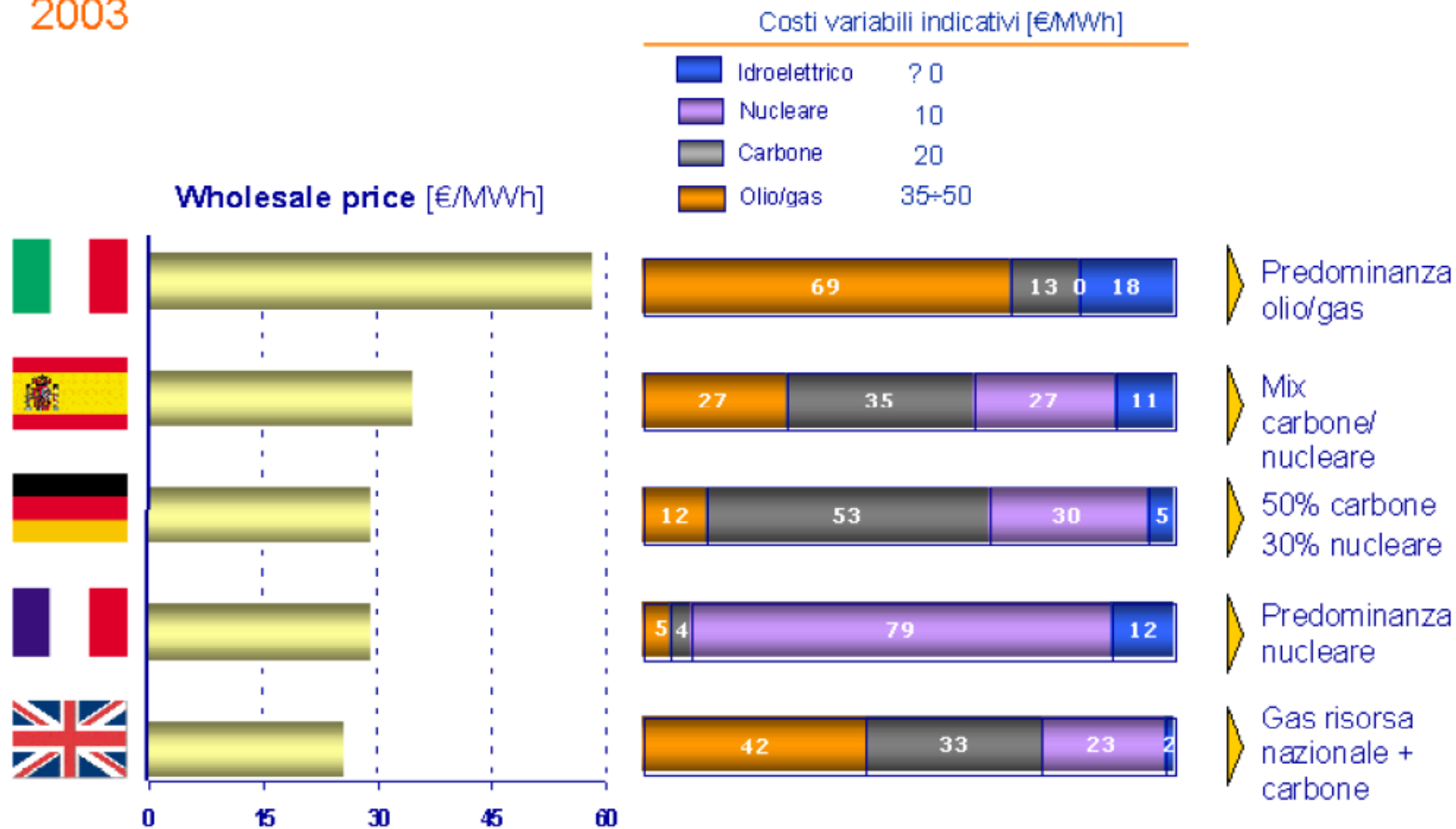
NH<sub>3</sub>



# The second driver is clearly the necessity for renewable energy

## Wholesale prize (as function of the energy mix)

2003



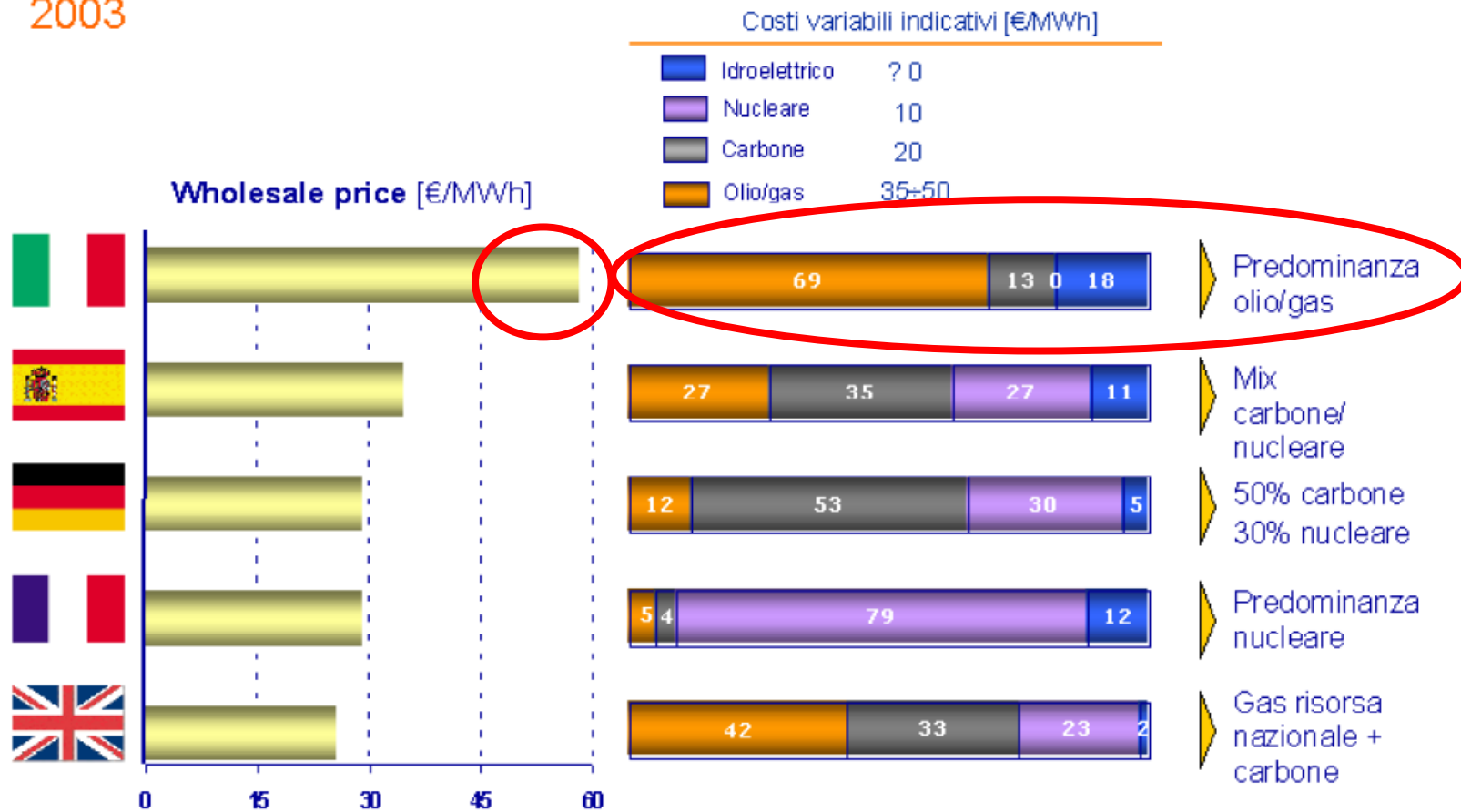
Fonte: Enerdata database (Gennaio 2004)



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## Wholesale prize (as function of the energy mix)

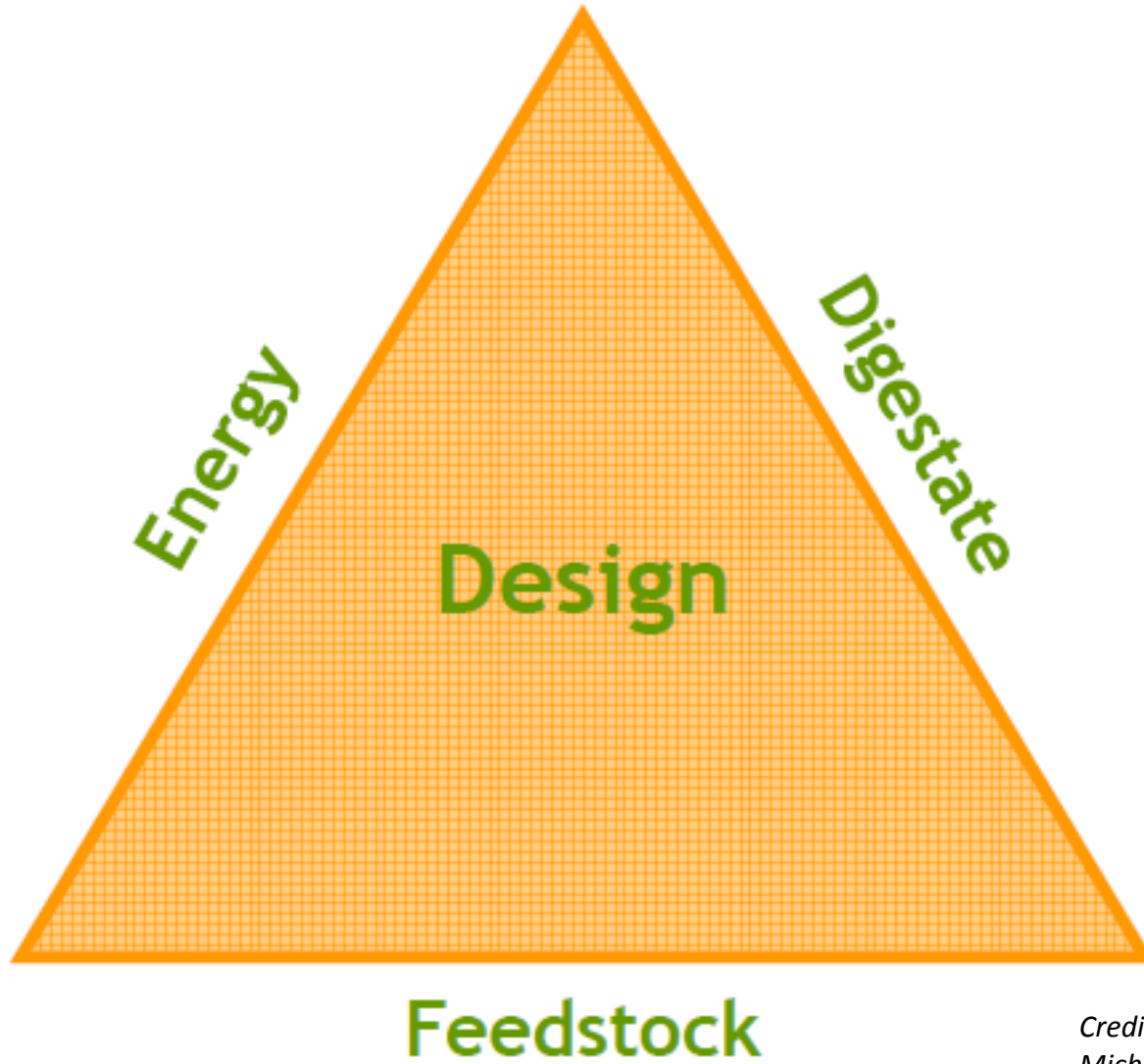
2003



Fonte: Enerdata database (Gennaio 2004)



# Fixing flat tariff at 280 euros per MWh

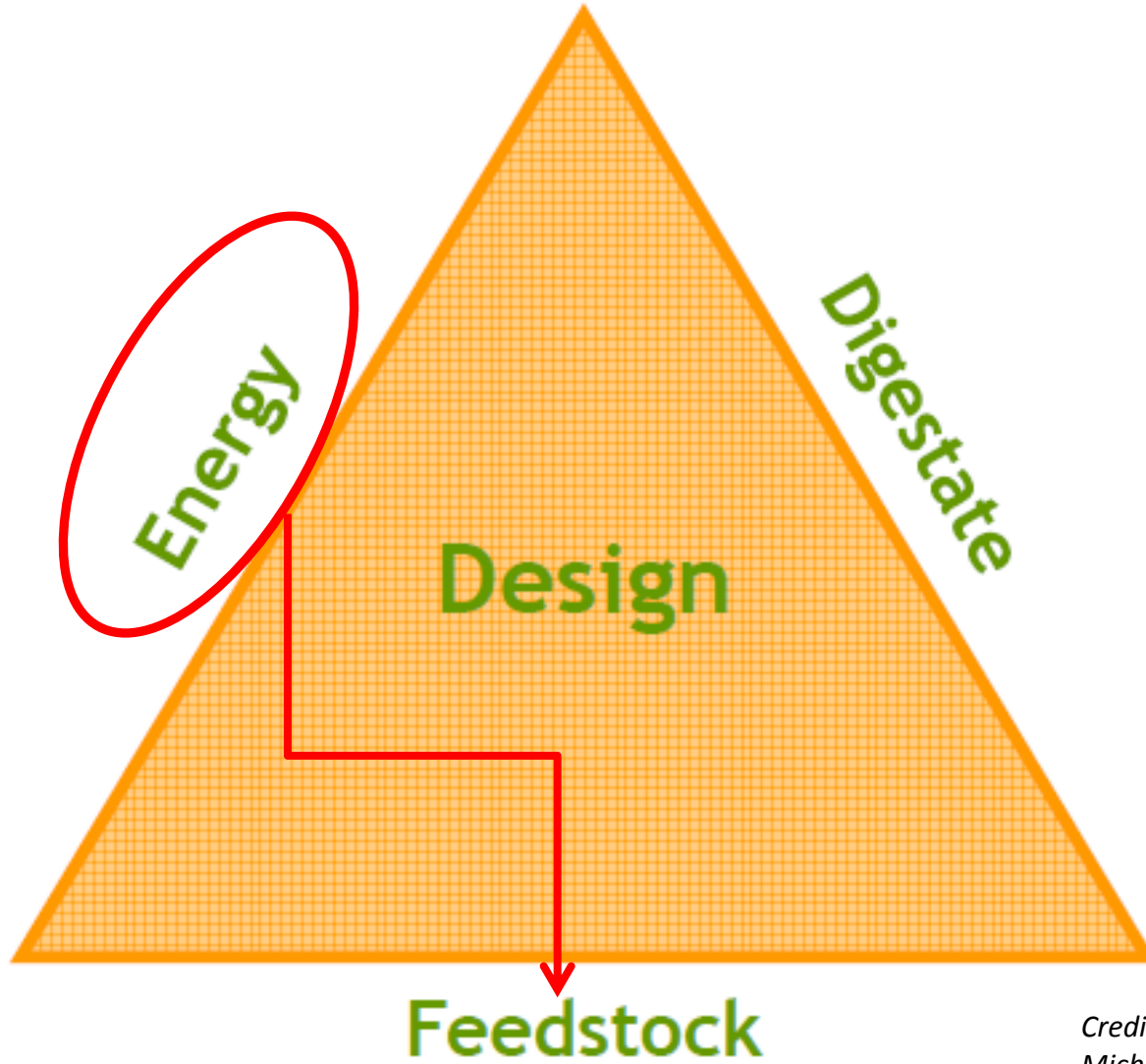


Credits:  
Michael Chesshire





# Fixing flat tariff at 280 euros per MWh



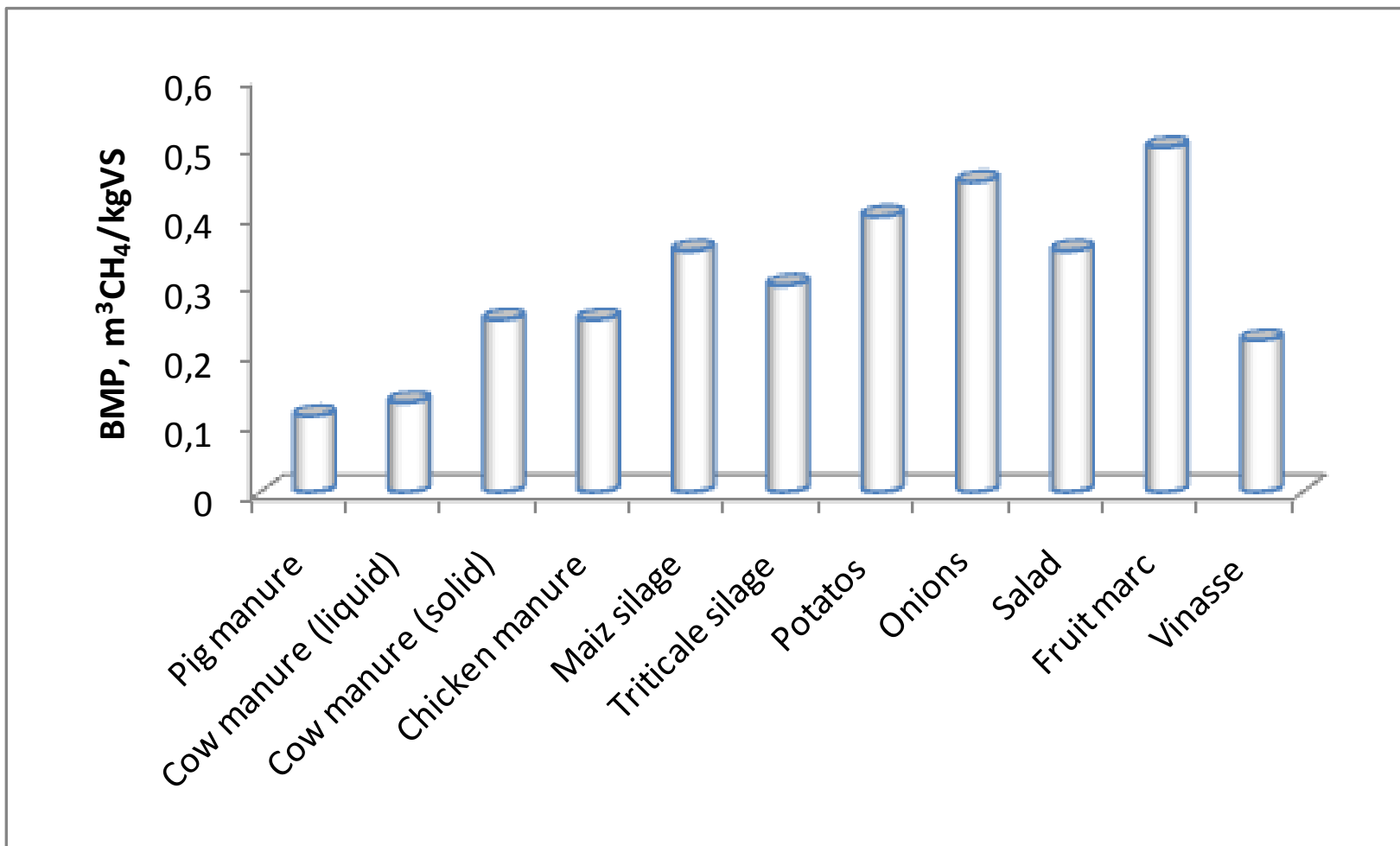
Credits:  
Michael Chesshire





# How to produce 1 MWh<sub>e</sub> (12,000 m<sup>3</sup> biogas per day) ?

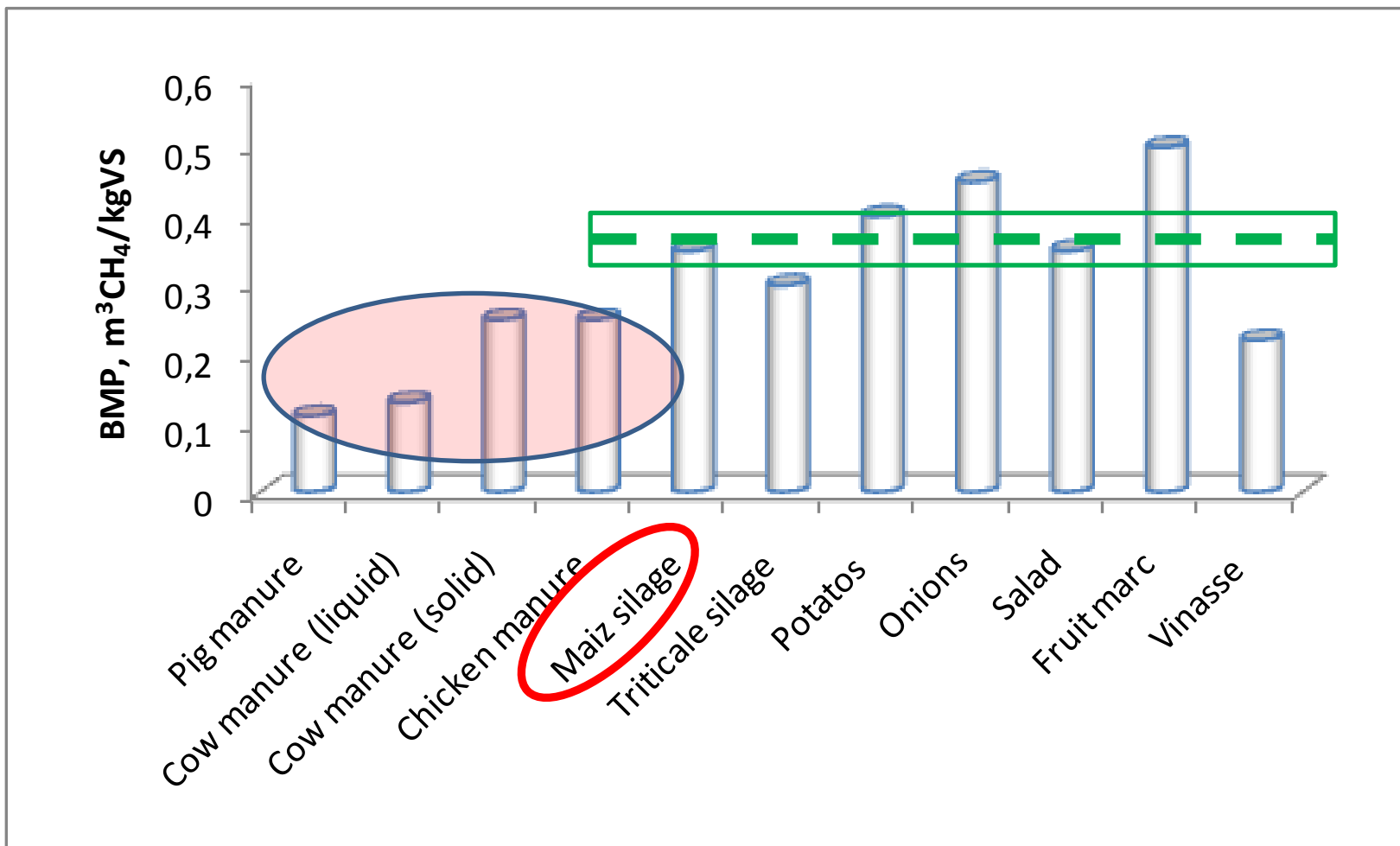
## Biogas potential for different substrates





# How to produce 1 MWh (12,000 m<sup>3</sup> biogas per day) ?

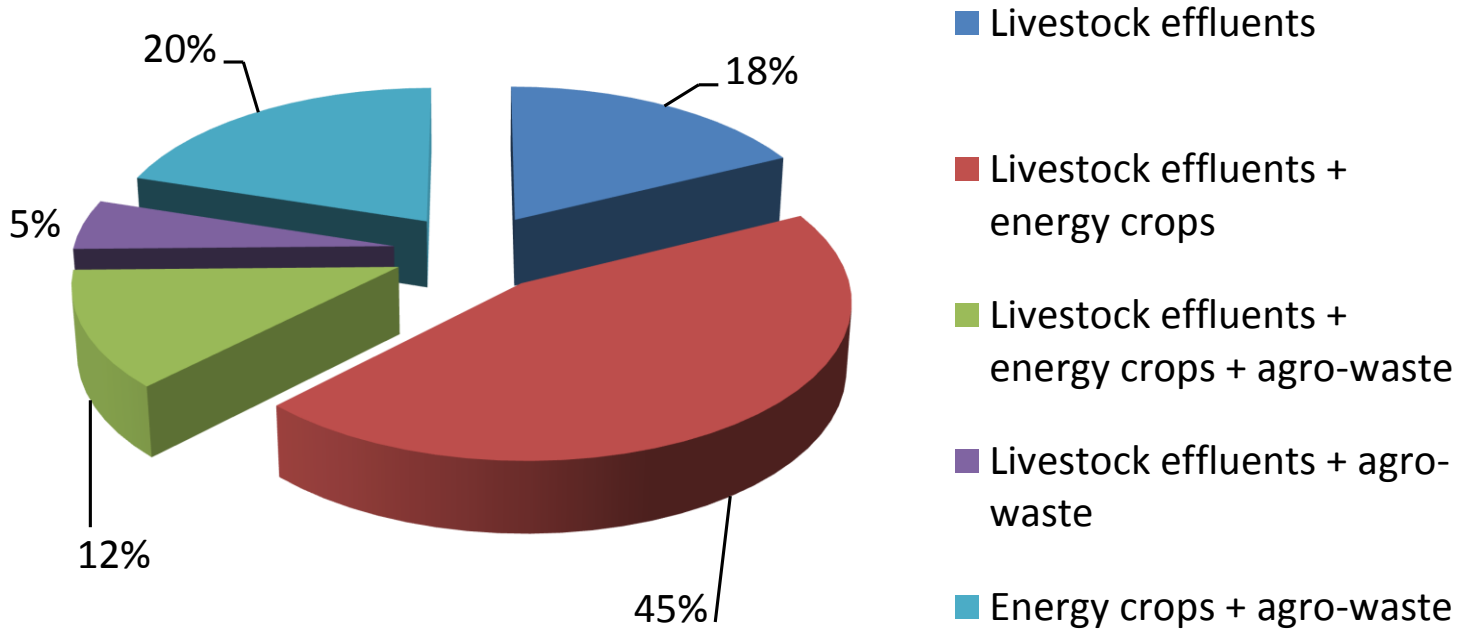
## Biogas potential for different substrates





# The role of energy crops

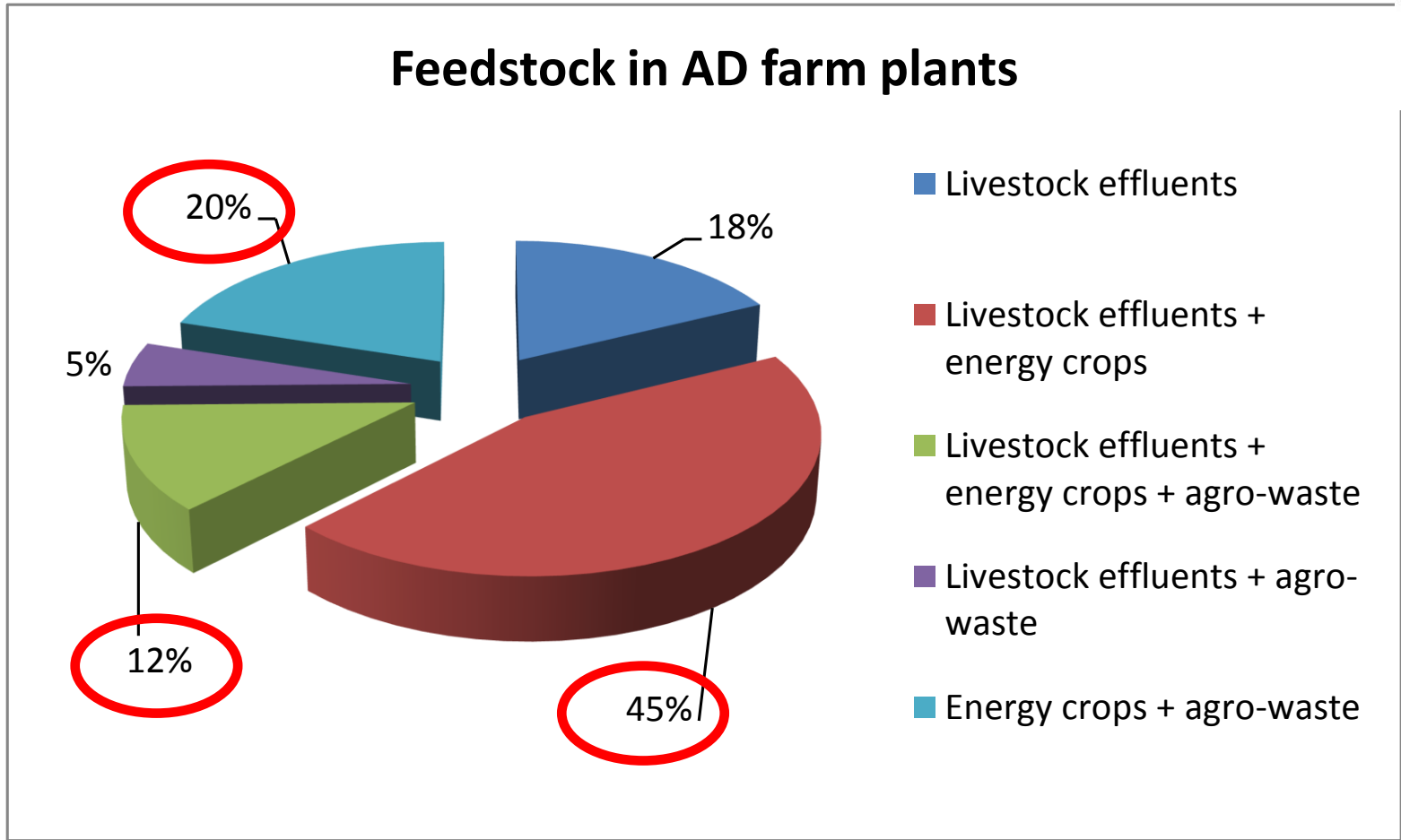
## Feedstock in AD farm plants





# The role of energy crops

## Feedstock in AD farm plants



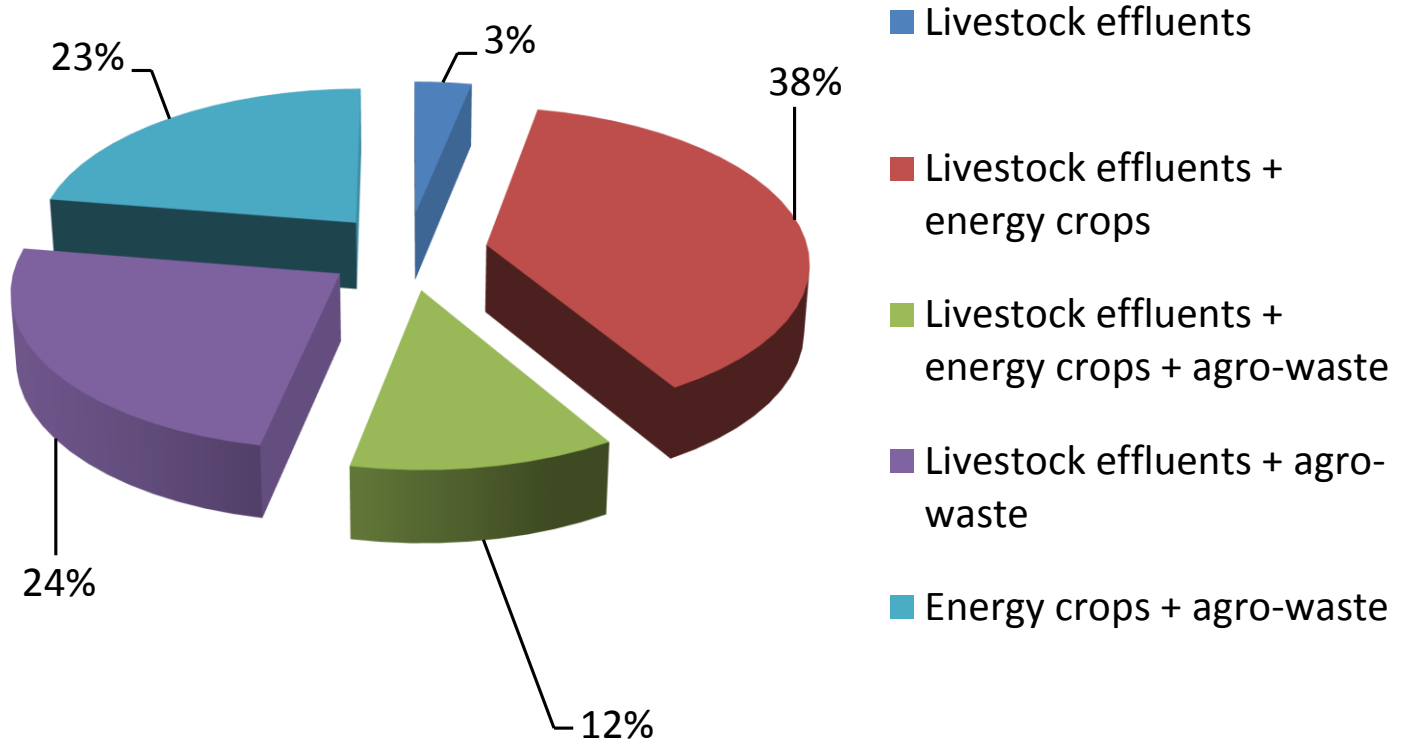
**80% of farm AD plants use energy crops in the feedstock**



# The role of energy crops



## Power production in farm AD plants

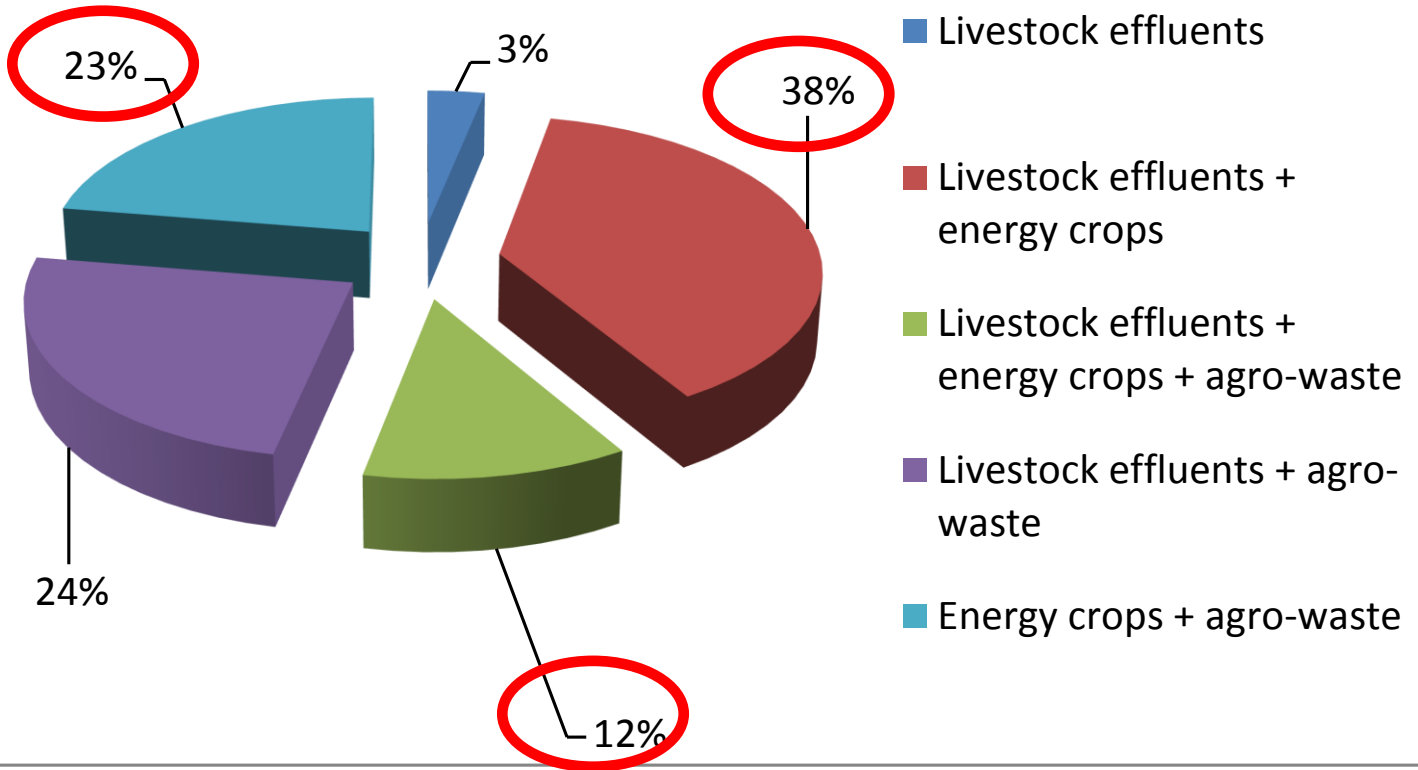




# The role of energy crops



## Power production in farm AD plants



**70% of produced power is originated from AD plants using energy crops in the feedstock**



**Maize**



**Sorghum**



Typical energy crops (EC)  
grown in the Po valley



**Triticale**



## Figures for the Italian scenario for maize silage

- ❑ Yield up to 40-45 tons/ha
- ❑ Cost of some 25-30 Euros per tonne

However, the massive demand for these substrates determined an increase in costs (>60 euros/tonne in 2013) and upset the original business plan ....

Therefore, **agro-waste** are now particularly requested ....





Other substrates (agro-waste from food crops processing) can be used for the purpose of renewable energy production



**Sweet corn**



**Beans**



**Tomato peel**



**Peas**







**Salad**



**Potatoes**



**Onions**



**Fruit marc**





Seasonal, but covering the whole year  
(in the Mediterranean Region)

|                     | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Tomatoes            |     |     |     |     |     |     |     | ■   | ■   | ■   |     |     |
| Peas, beans, maize  |     |     |     |     | ■   | ■   | ■   | ■   | ■   |     |     |     |
| Apples, pears       | ■   | ■   |     |     |     |     |     |     |     | ■   | ■   | ■   |
| Apricots, peaches   |     |     |     |     |     | ■   | ■   | ■   |     |     |     |     |
| Fruit marc          | ■   | ■   | ■   | ■   |     |     |     |     |     |     | ■   | ■   |
| Vinasses            |     |     | ■   | ■   |     |     |     |     |     | ■   | ■   | ■   |
| Livestock effluents | ■   | ■   | ■   | ■   | ■   | ■   | ■   | ■   | ■   | ■   | ■   | ■   |

**Please, note that this means different stock areas and tanks in the plant + different loading systems**







## With similar characteristics and biogas potential of Energy Crops (EC)

| Parameters                 | Total solids (TS) | Total volatile solids (TVS) | TVS/TS | COD       | N        | P         |
|----------------------------|-------------------|-----------------------------|--------|-----------|----------|-----------|
| Substrates                 | g/kg              | g/kg                        | %      | g/kg dm   | mg/kg dm | mg/kg dm  |
| Dairy manure (solid)       | 260-350           | 250-315                     | 78-84  | 880-930   | 34-49    | 6.0-7.8   |
| Dairy manure (liquid)      | 89-97             | 69-76                       | 76-89  | 910-1020  | 31-41    | 7.6-8.1   |
| Piggery                    | 60-90             | 47-76                       | 66-83  | 860-965   | 18-42    | 4.2-8.5   |
| Poultry (litter)           | 467-688           | 397-530                     | 72-87  | 751-1000  | 27-47    | 11.8-20.1 |
| Duck (liquid)              | 124-190           | 105-155                     | 81-88  | 802-871   | 27-39    | 10.7-11.6 |
| Rabbit manure              | 192-255           | 154-213                     | 80-84  | 803-970   | 19-21    | 8.0-10.7  |
| Maize silage               | 272-453           | 262-440                     | 89-96  | 545-1170  | 11-17    | 2.2-3.1   |
| Triticale silage           | 190-315           | 167-282                     | 87-95  | 990-1160  | 13-19    | 1.1-4.8   |
| Fruit marc                 | 220-255           | 210-230                     | 96-98  | 1120-1250 | 25-35    | 1.2-3-2   |
| Potatoes                   | 157-192           | 167-180                     | 92-94  | 980-1050  | 20-26    | 2.2-3-9   |
| Onions                     | 103-130           | 96-104                      | 91-94  | 880-996   | 20-34    | 3.0-3.3   |
| Vegetables (e.g., lettuce) | 40-80             | 31-70                       | 80-91  | 765-1050  | 21-36    | 6.4-7.7   |





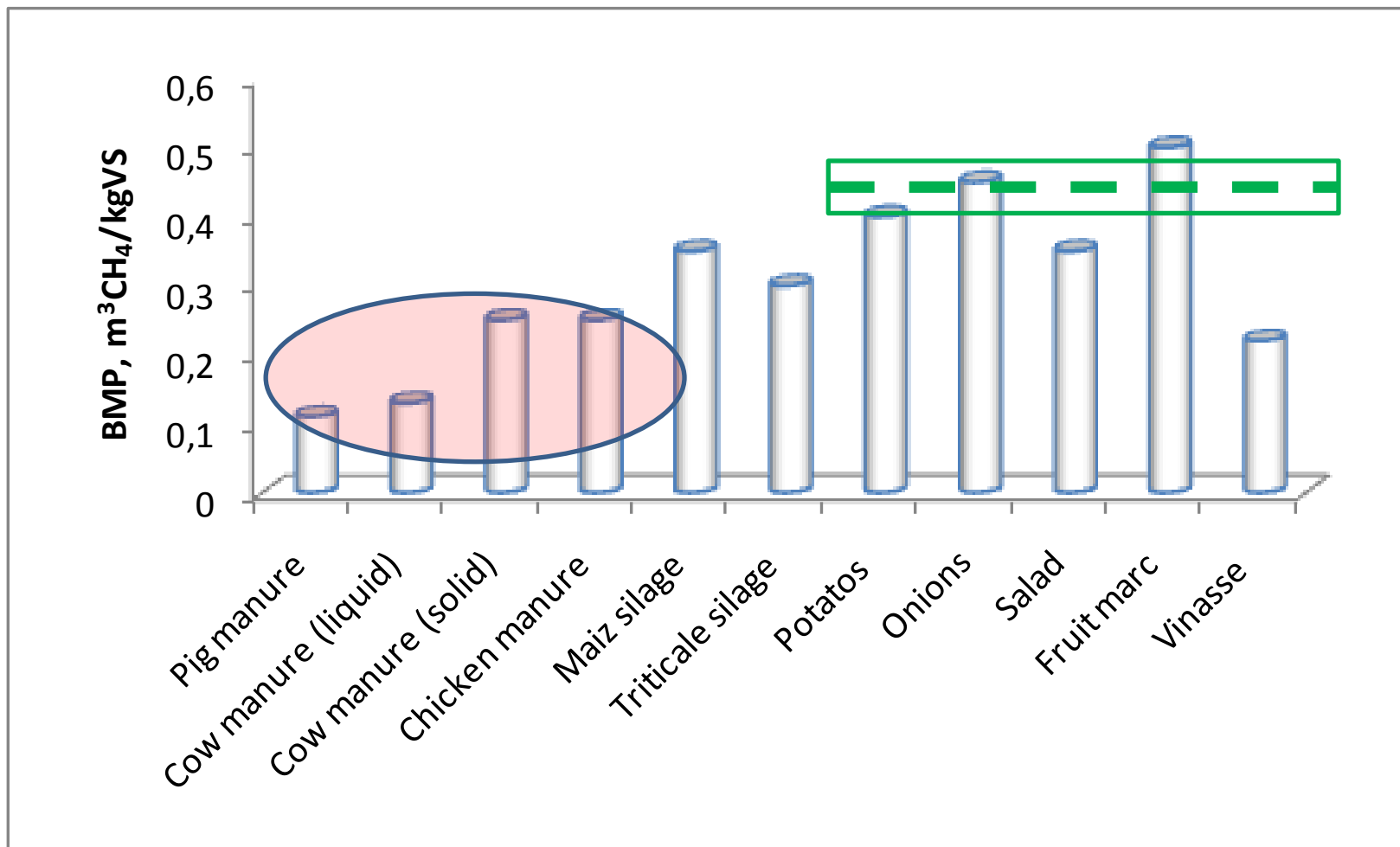
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# How to produce 1 MWh (12,000 m<sup>3</sup> biogas per day) ? Biogas potential for different substrates



## Future perspective

The decree of July 6th 2012 changed the scenario and improved the help for small farm AD plants: livestock effluents are the main feedstock !



| Power (kW <sub>e</sub> ) | Years | Tariff (€/MWh) | Efficient energy prod (€/MWh) | Nitrogen recovery or removal (€/MWh) |
|--------------------------|-------|----------------|-------------------------------|--------------------------------------|
| 1 < P ≤ 300              | 20    | 180            | 40                            | 30 ÷ 20 ÷ 15                         |
| 300 < P ≤ 600            | 20    | 160            | 40                            | 30 ÷ 20 ÷ 15                         |
| 600 < P ≤ 1.000          | 20    | 140            | 40                            | 30 ÷ 20 ÷ 15                         |