Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

The Challenges of Estimating Optimal Nutrient Allowances in Growing-Finishing Pigs and the Future of the Swine Industry

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Canada

Introduction

Pork producers' challenges

- **Current sector challenges**:
  - Changing international trade rules,
  - Limited agricultural resources availability given the growing world population,
  - Governments gradually reducing sector support, and
  - Increasing animal welfare and environmental standards.

- **To stay competitive the producers need to**:
  - Increase cost efficiency of their operations,
  - Produce safe high quality food, and
  - Comply with the highest environmental and animal welfare standards.

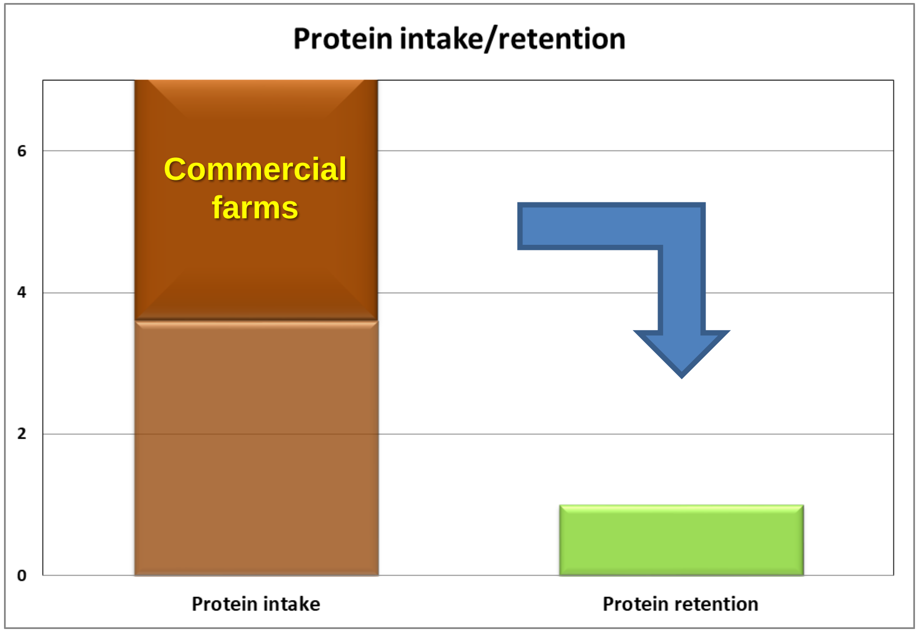



Introduction

Pork producers' challenges

To face producers' challenges (*improve the protein share, stay competitive and comply with the highest environmental*) **the livestock industry need to**,

- **Improve nutrient efficiency**
- **Use alternative feed ingredients**



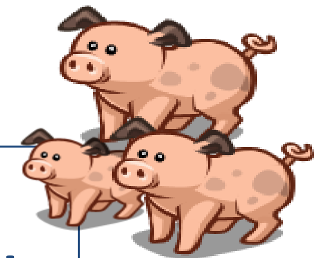
Dourmad et al., 1999, Shirali et al. 2011, Flachowsky and Kamphues, 2012

Introduction

Essential elements for improving nutrient utilization in livestock animals

Nutrient Supply

Nutrient Requirements



Feeding Program: feed composition and distribution (feeding phases)

Profitability

Pork Quality

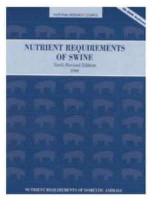
Sustainability

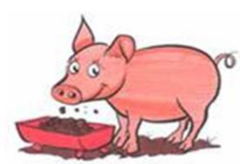
Nutrient Requirements

The concept

But, what **nutrient requirements** means

- ✓ Body growth results from the net synthesis of muscle, adipose tissue, bone, hair, skin and other body components and depends on an adequate supply of nutrients
- ✓ Nutrients must be provided in adequate amounts and in forms that are palatable and efficiently utilized for optimal growth





Nutrient Requirements
The concept

✓ **For one individual animal at a given time**

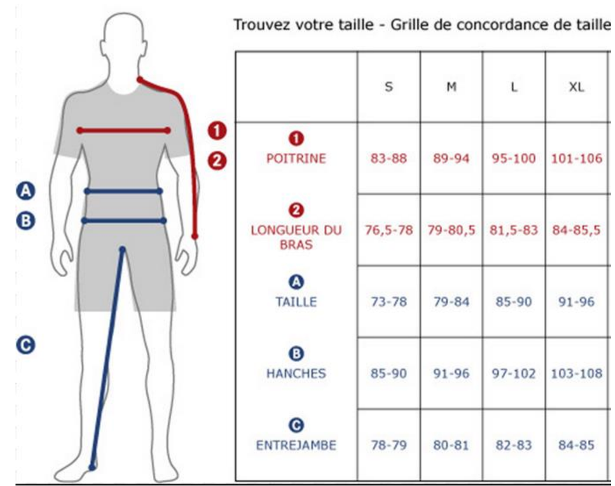
- For a given nutrient (e.g., Lys), and when all other nutrients are provided at adequate levels, nutrient requirements can be defined as **the amount of this nutrient that will allow this individual animal to perform its natural functions in a normal manner**

Fuller, 2004; Noblet and Quiniou, 1999

Nutrient Requirements
The concept

✓ <u>**For one individual animal at a given time**</u>

- Only one diet (one size), which composition can be estimated as the sum of the requirements for **maintenance** and **production** (e.g., growth).



Trouvez votre taille - Grille de concordance de taille

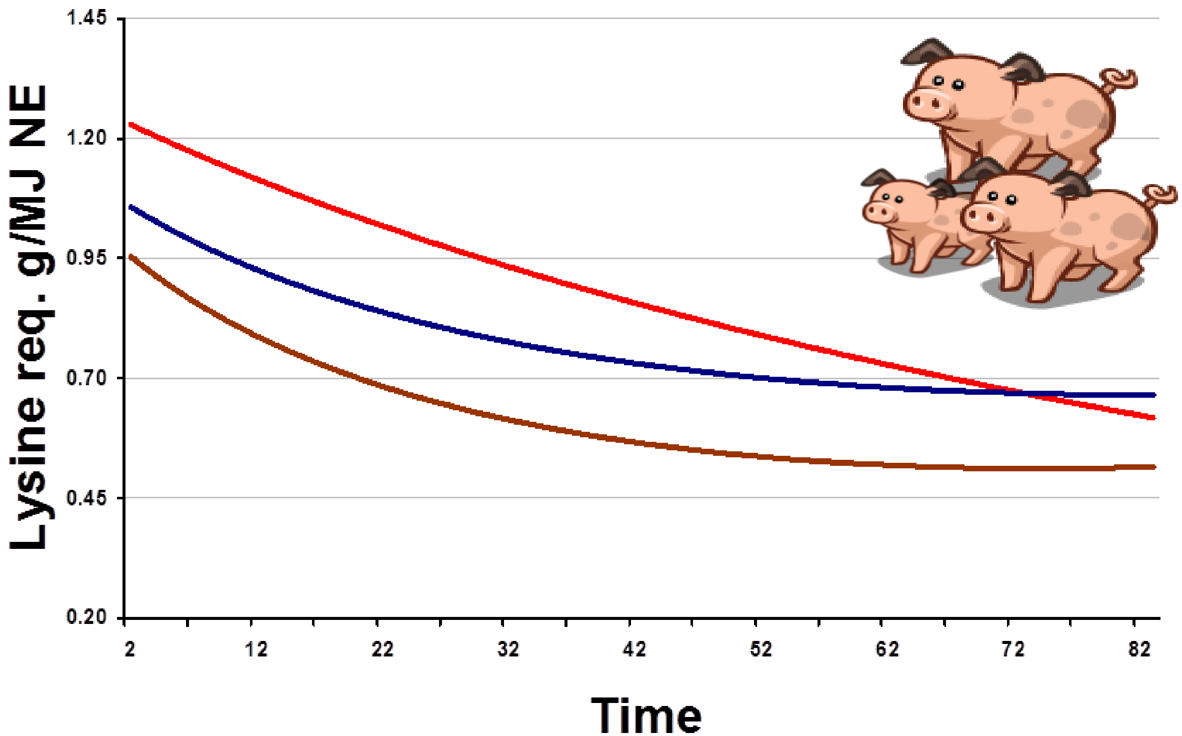
	S	M	L	XL
❶ POITRINE	83-88	89-94	95-100	101-106
❷ LONGUEUR DU BRAS	76,5-78	79-80,5	81,5-83	84-85,5
Ⓐ TAILLE	73-78	79-84	85-90	91-96
Ⓑ HANCHES	85-90	91-96	97-102	103-108
Ⓒ ENTREJAMBE	78-79	80-81	82-83	84-85

Nutrient Requirements

First challenge (differentiate individual and population requirements)

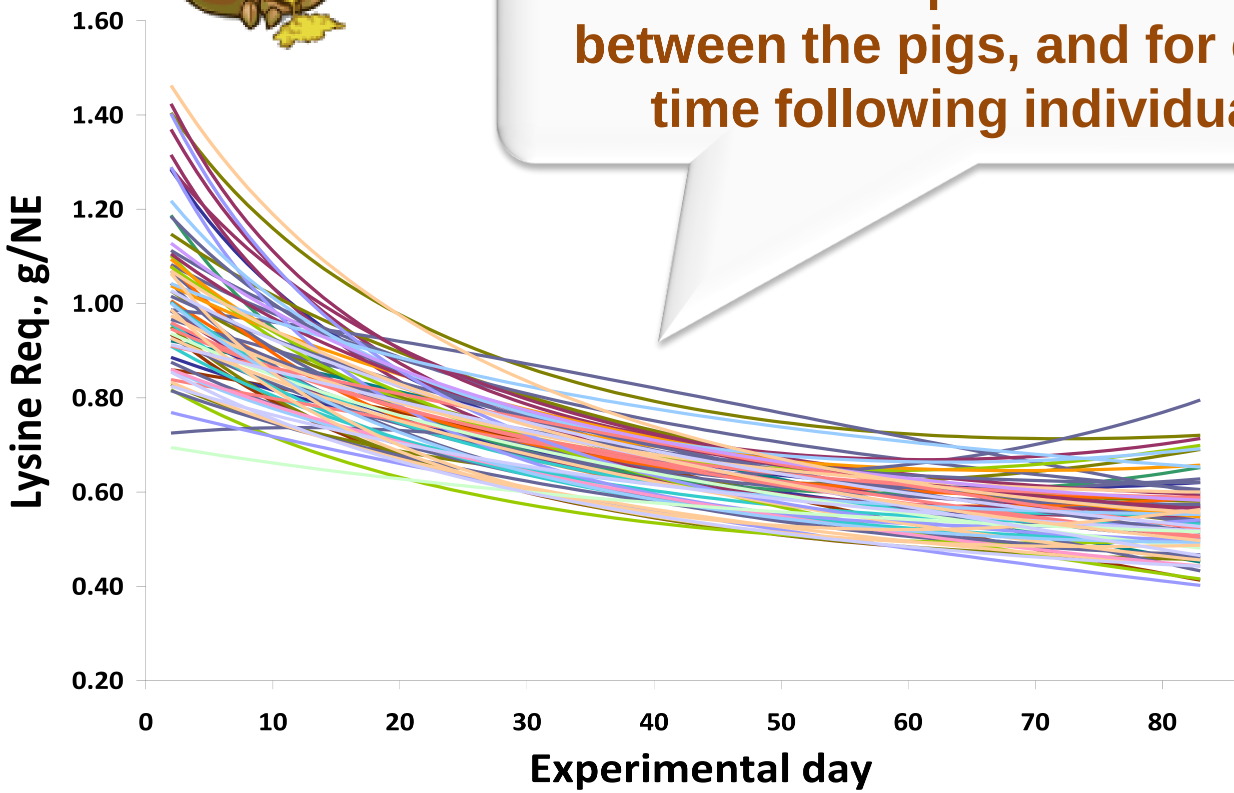
✓ **<u>For one individual animal at a given time</u>**

- For a given nutrient (e.g., Lys), and when all other nutrients are provided at adequate levels, nutrient requirements can be defined as **the amount of this nutrient that will allow this individual animal to perform its natural functions in a normal manner**



Nutrient Requirements

First challenge (differentiate individual and population requirements)



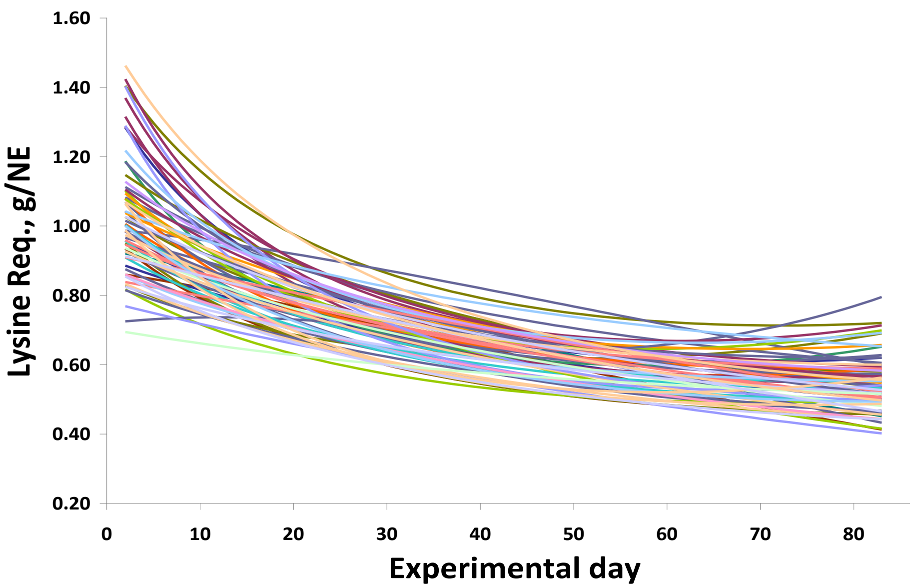
Nutrient requirements vary greatly between the pigs, and for each pig over time following individual patterns

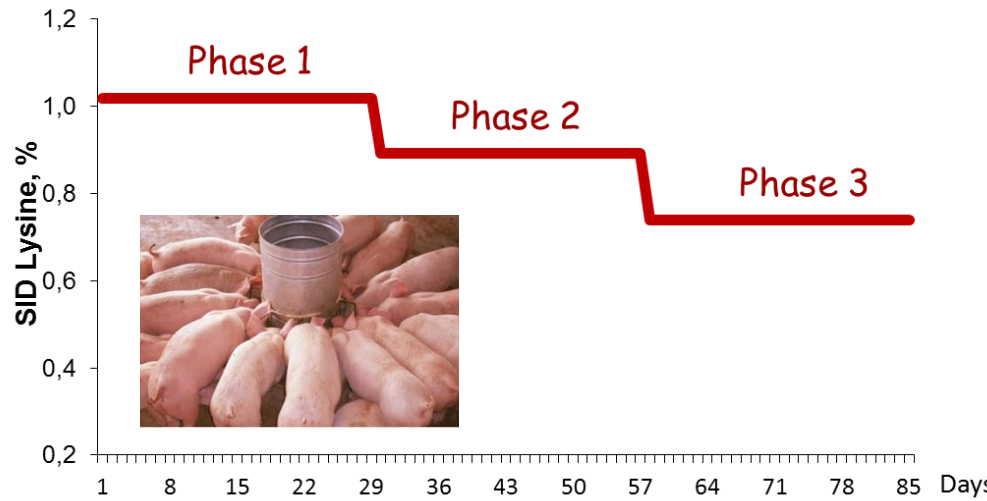
Hauschild et al., 2010

Nutrient Requirements

First challenge (differentiate individual and population requirements)

- **The big question !**
  How can we estimate the optimal level of nutrients to be provided to all the animals for optimal population growth at minimal cost?



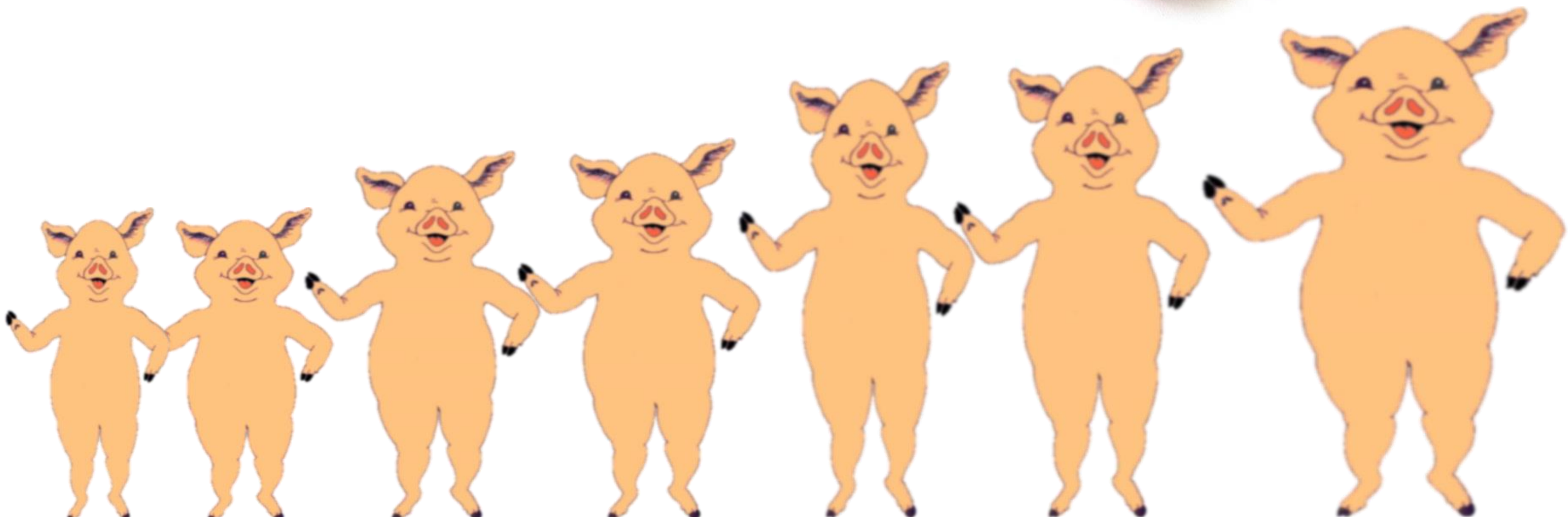


Nutrient Requirements

First challenge (differentiate individual and population requirements)

✓ **For a group of (heterogeneous) animals**

- One feed to all pigs (one size fits all)
- For a given period of time

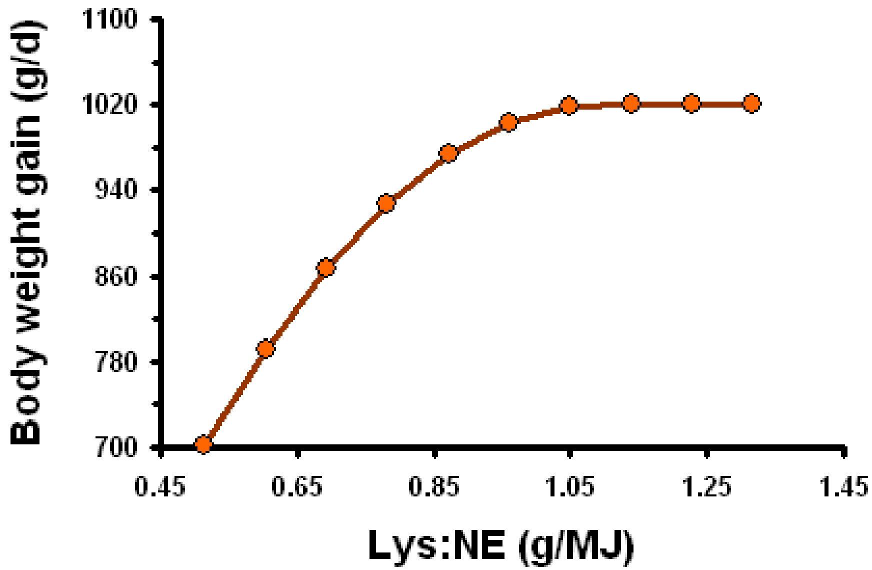


Nutrient Requirements

First challenge (differentiate individual and population requirements)

✓ **For a group of (**heterogeneous**) animals**

- For most nutrients, **underfed** animals will exhibit reduced performance while the **overfed** ones will exhibit near optimal performance



Nutrient Requirements

First challenge (differentiate individual and population requirements)

✓ **For a group of (heterogeneous) animals**

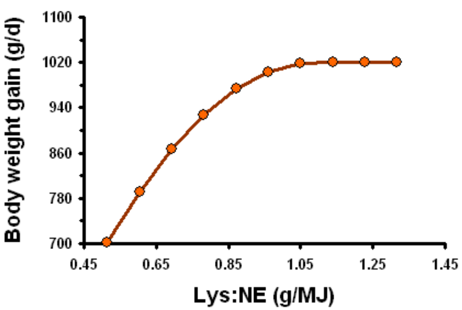
- One feed to all pigs (one size fits all)

Nutrient Requirements

First challenge (differentiate individual and population requirements)

✓ **For a group of (**heterogeneous**) animals**

- Population nutrient requirements should be seen as **the optimal balance between the proportion of pigs that are going to be overfeed and underfeed**



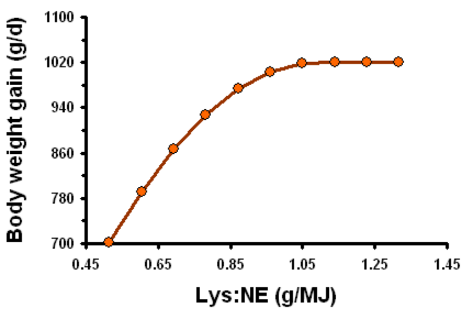
Pomar et al. 2014

Nutrient Requirements

First challenge (differentiate individual and population requirements)

When using a **factorial method** (*e.g., NRC 2012 model*) to estimate the requirements of a population we have to identify,

- **Which is the parameter to optimize (ADG, FC, feed cost)?**
- **To obtain this optimal response, who is the best representative of this population?**



Pomar et al. 2014 & 2017

Nutrient Requirements

First challenge (differentiate individual and population requirements)

- **Which is the parameter to optimize (ADG, FC, feed cost) and who is the best representative of the population?**

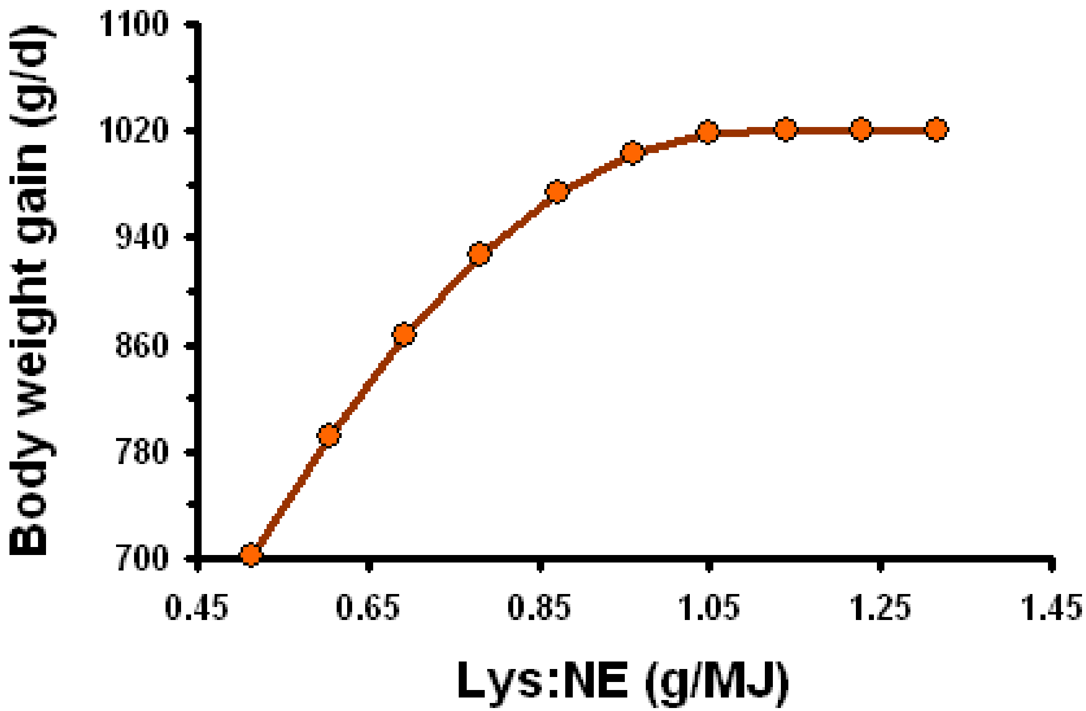
  For a 25 kg BW pig population,

  - maximal population response was obtained at **114% for ADG**, **104% for FC** and **100% for feed cost** of the average pig Lys requirements (*Hauschild et al., 2010; Brosssard et at al., 2009 & 2014 suggested to oversupply the average pig by 15% for optimal ADG*).

  - We have to be cautious when using factorial methods (e.g., NRC, 2012) given that they had been calibrated for maximal responses when using average population values

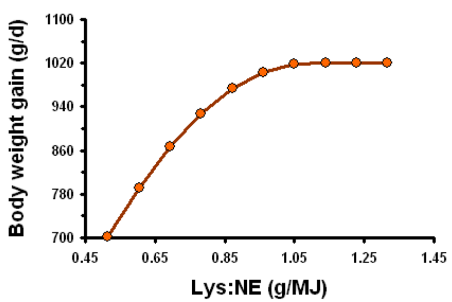
Nutrient Requirements
New challenge (integrate animal variation)

- We indicated before that for most nutrients, **underfed** animals will exhibit reduced performance while the **overfed** ones exhibit near optimal performance.



Nutrient Requirements
New challenge (integrate animal variation)

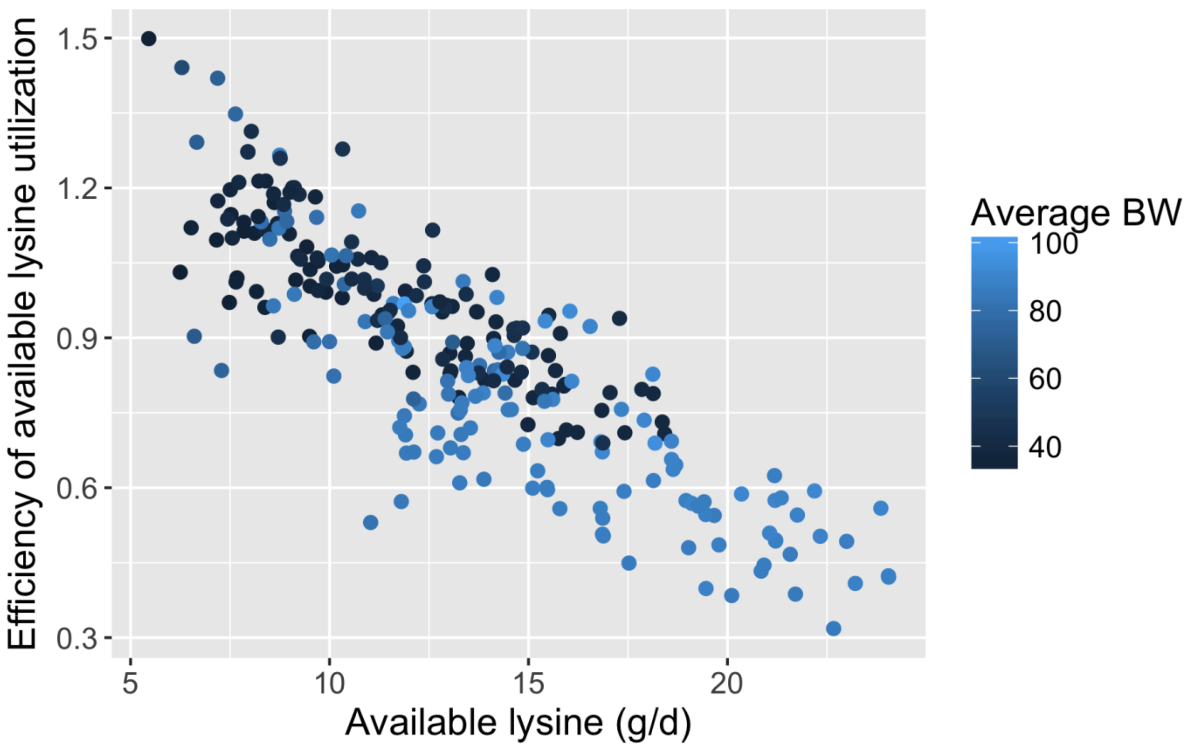
- This assumption is based in the principles that, for many nutrients, in particular for amino acids,
  - Utilization efficiency is **constant** (e.g., 72% for Lys), this across animals and ages
  - Body protein amino acid concentration is **constant** across animals and ages (e.g., 7% for Lys)
  - Amino acids are retained following the **ideal protein** profile



Nutrient Requirements
New challenge (integrate animal variation)

However, these principles are weak

- **Nutrient efficiency is not constant** across animals and is affected by production conditions

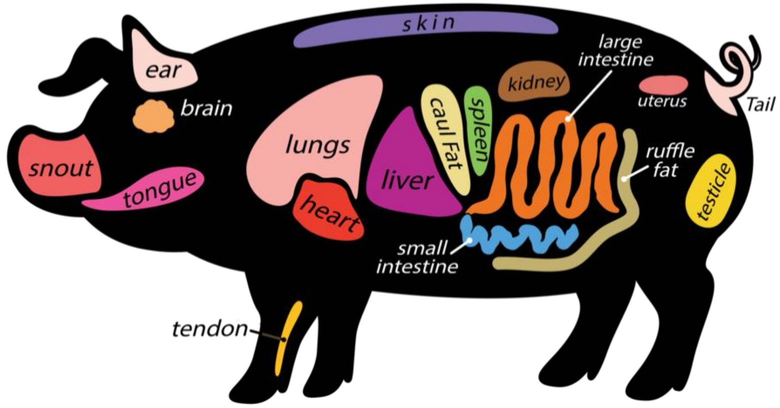


Ghimire et al., unpublished results

Nutrient Requirements
New challenge (integrate animal variation)

However, these principles are weak

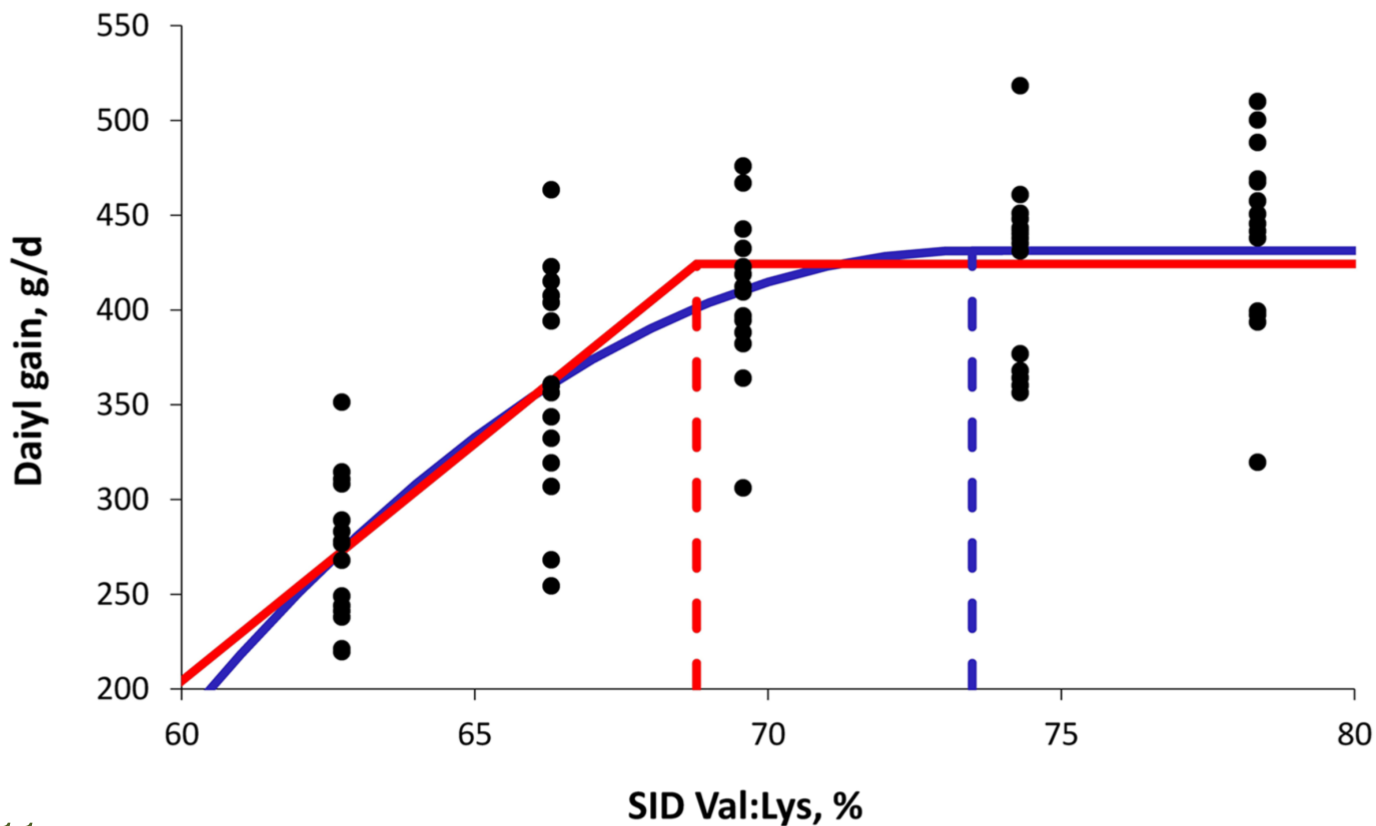
- **AA supply affects the amino acid composition of body protein and different body proteins are affected differently**
  - ✓ The splanchnic tissues are less affected than carcass muscles (Conde-Aguilera et al. 2010; Conde-Aguilera et al. 2016a; Conde-Aguilera et al. 2016b; Remus et al, unpublished data)
  - ✓ Different muscles respond differently to dietary AA supply (Conde-Aguilera et al., 2016b; Remus et al, unpublished data)



Nutrient Requirements
New challenge (integrate animal variation)

However, these principles are weak

- **The ideal protein concept does need to be reviewed**



Gloaguen et al. 2011

Nutrient Requirements
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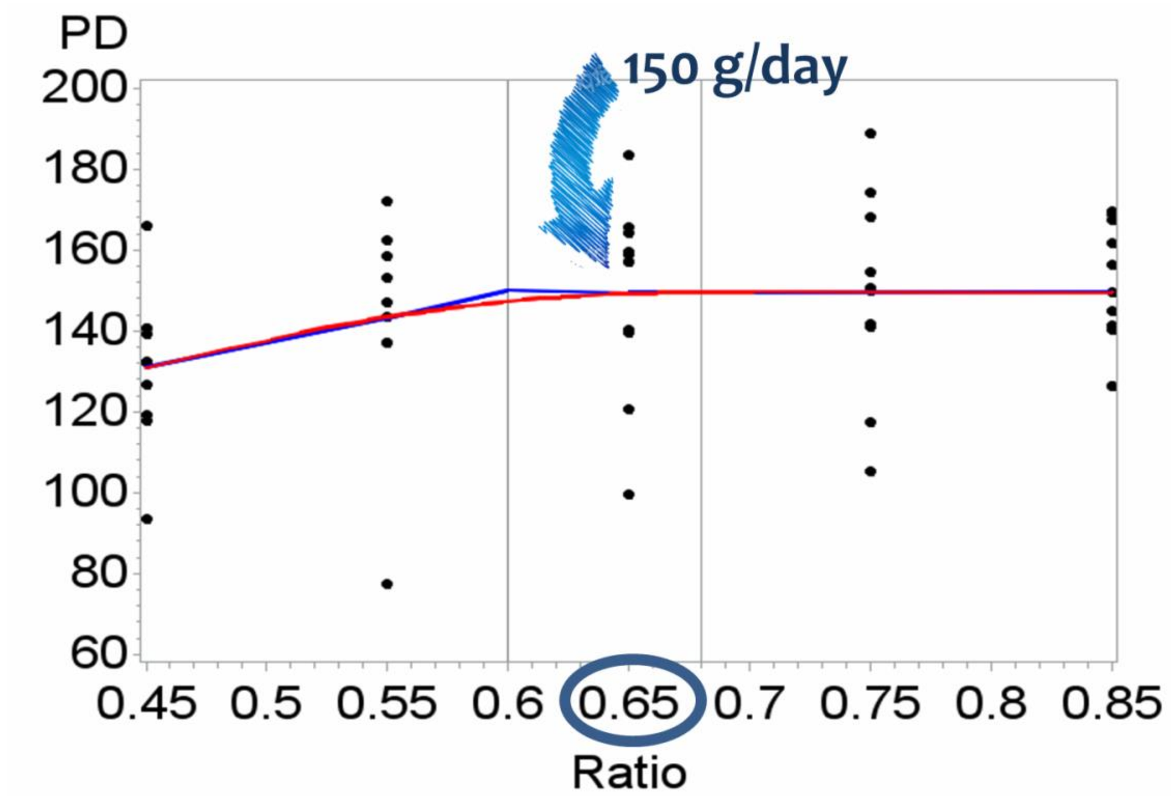
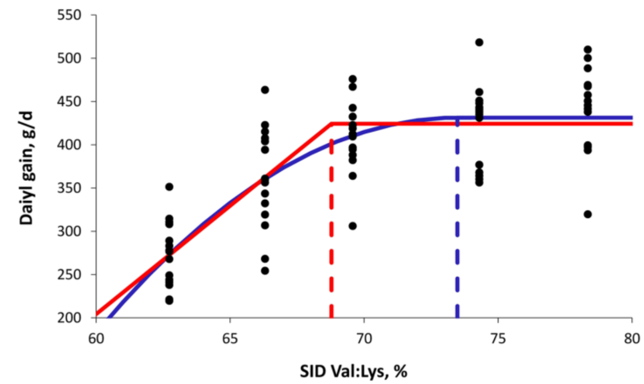


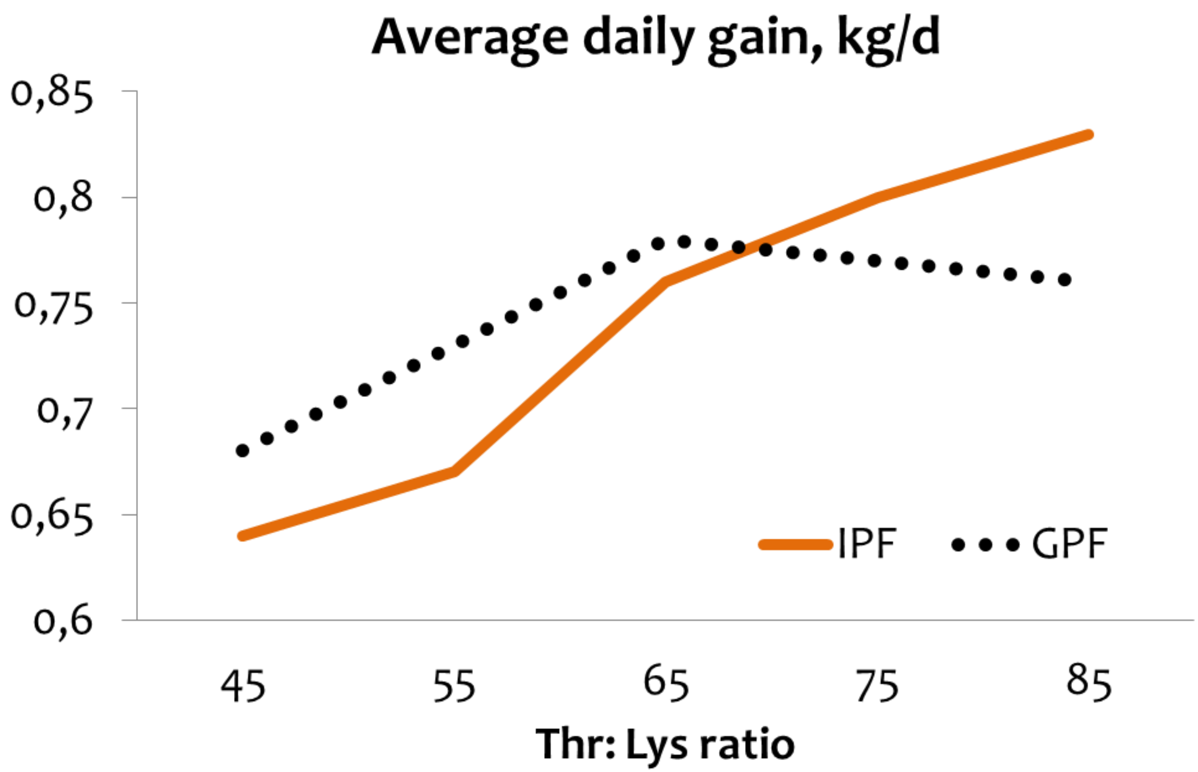
Remus et al., unpublished results



Gloaguen et al. 2011

Nutrient requirements
Future challenges

The ideal protein concept needs to be reviewed for precision feeding

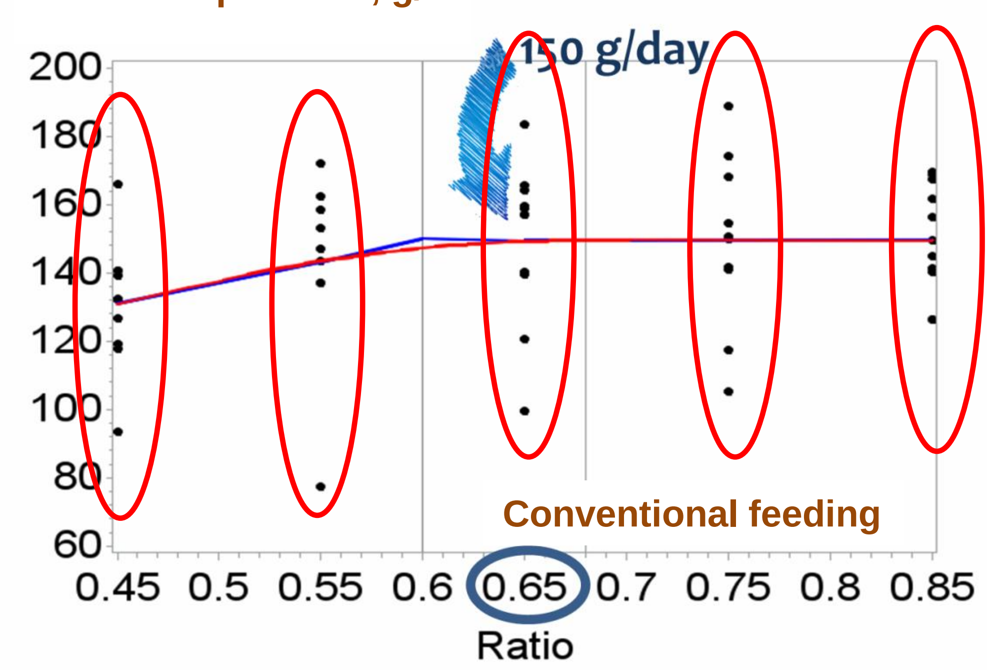


Remus et al., unpublished results

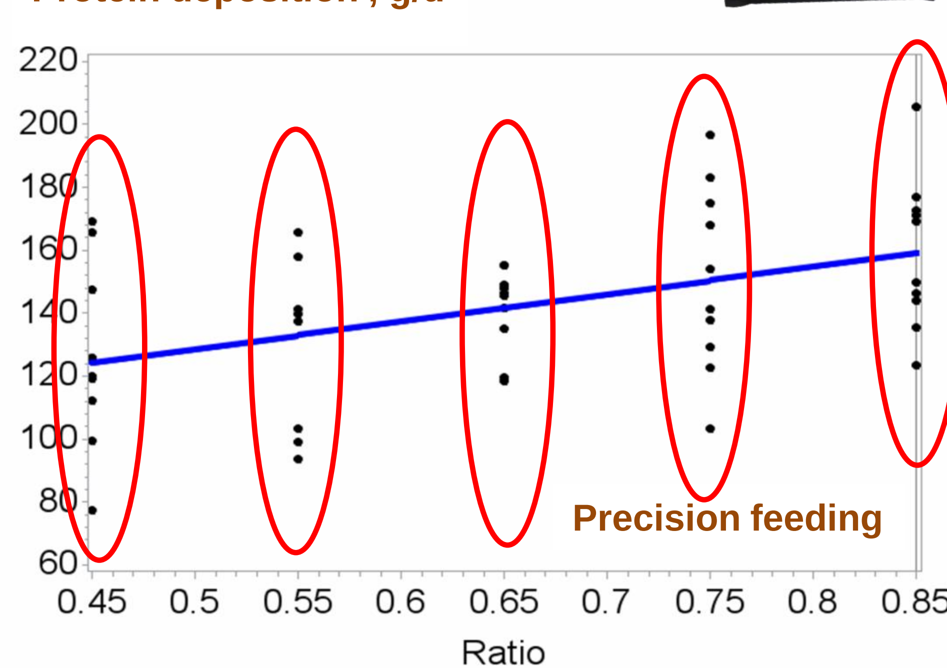
Nutrient requirements
Future challenges

The ideal protein concept needs to be reviewed for precision feeding

Protein deposition , g/d



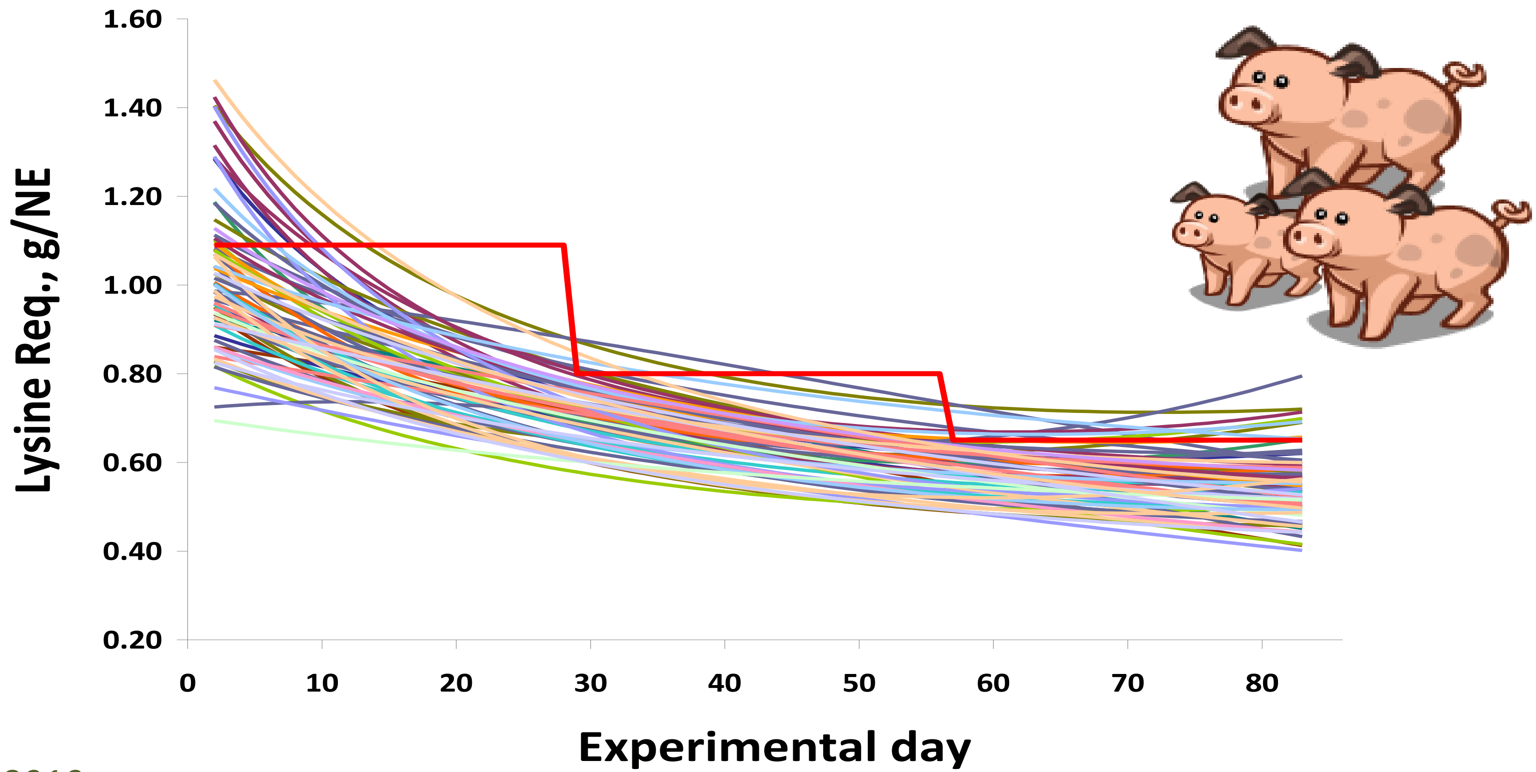
Protein deposition , g/d



Remus et al., unpublished results

Precision feeding
The concept

- ✓ Given that pigs are raised in groups, and there is large variation between animals, **it is difficult to further improve nutrient efficiency** in conventional production systems



Hauschild et al., 2010

Nutrient requirements
The concept

✓ **In conventional feeding**

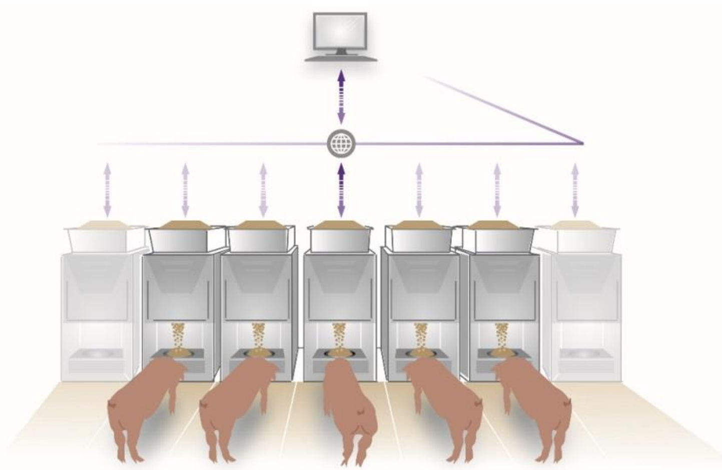
- One feed to all pigs (one size fits all)

Precision feeding
The concept

✓ **Precision farming** and precision agriculture is an agricultural concept that relies on the existence of ***in-field variability***

✓ **Precision feeding** involves the use of feeding techniques that allow

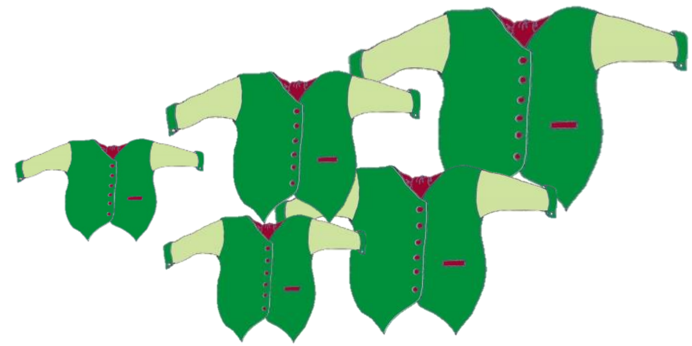
- the ***right amount*** of feed
- with the ***right composition***
- to be provided ***at the right time***
- to ***each animal*** of the herd



Precision feeding
The concept

✓ **With precision feeding**

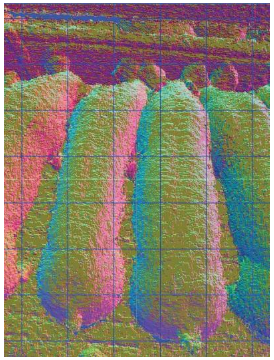
- Each pig is fed with a diet tailored daily for him



Precision feeding
The concept

- For **precision feeding**, feeds and feeding, are among the most important control elements

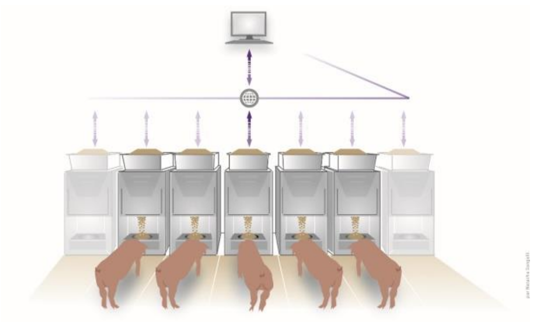
- For the efficient application of precision feeding we need:
  - **Measuring devices** (e.g., scales for body weight and feed measurements)
  - **Numerical methods** (e.g., mathematical models estimating real-time nutrient requirements)
  - **Control devices** (e.g., automatic feeders)



Precision feeding
Development

Feeding growing pigs **individually with daily tailored diets** required the development of

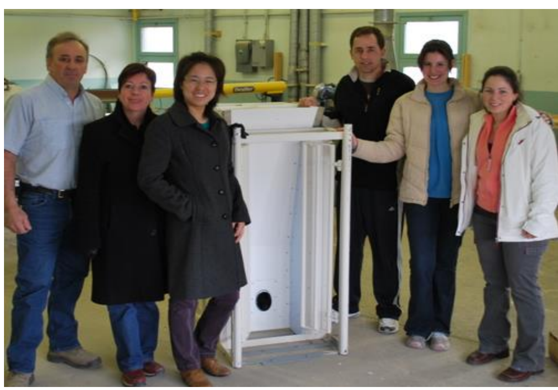
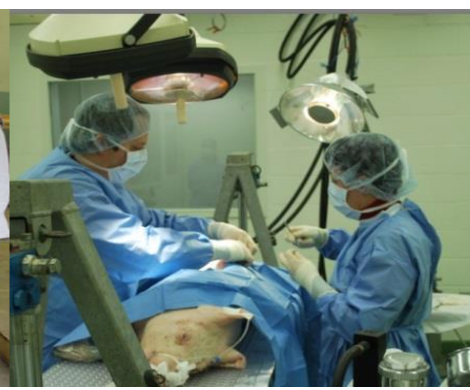
- **New feeding systems**
- **New nutritional concepts**
  a. To feed individual pigs with daily tailored diets based on their own real-time patterns of feed intake and growth (**completed**)
  b. Introducing some sources of animal variation (**ongoing**)
  c. Better understanding the animals' metabolism (**future developments**)



Precision feeding
Development

Many animal trials and many others dealing with the numerical procedures

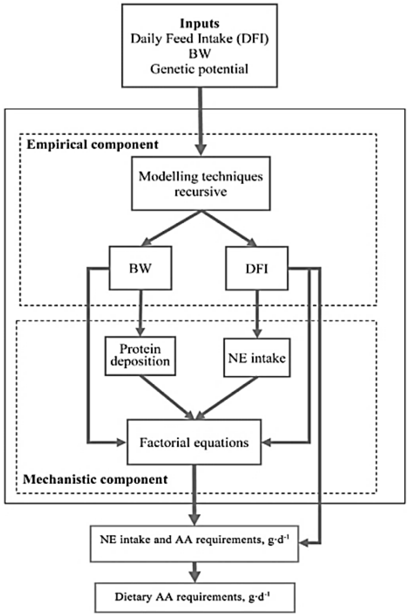


Precision feeding
Real-time estimation of nutrient requirements

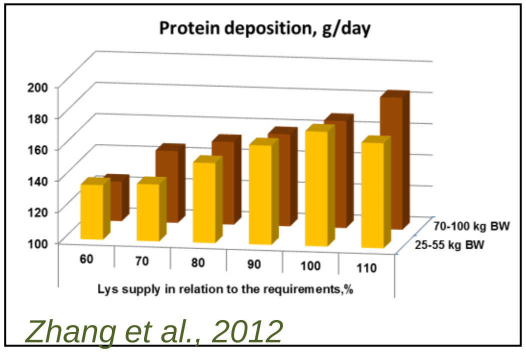
Daily lysine requirements

Estimated for each pig in real-time

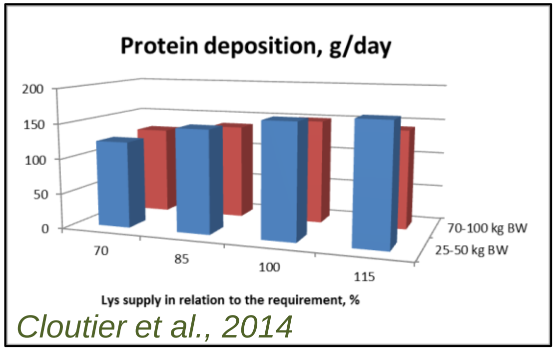


Hauschild et al., 2012

Parameters previously calibrated in two projects



Zhang et al., 2012



Cloutier et al., 2014

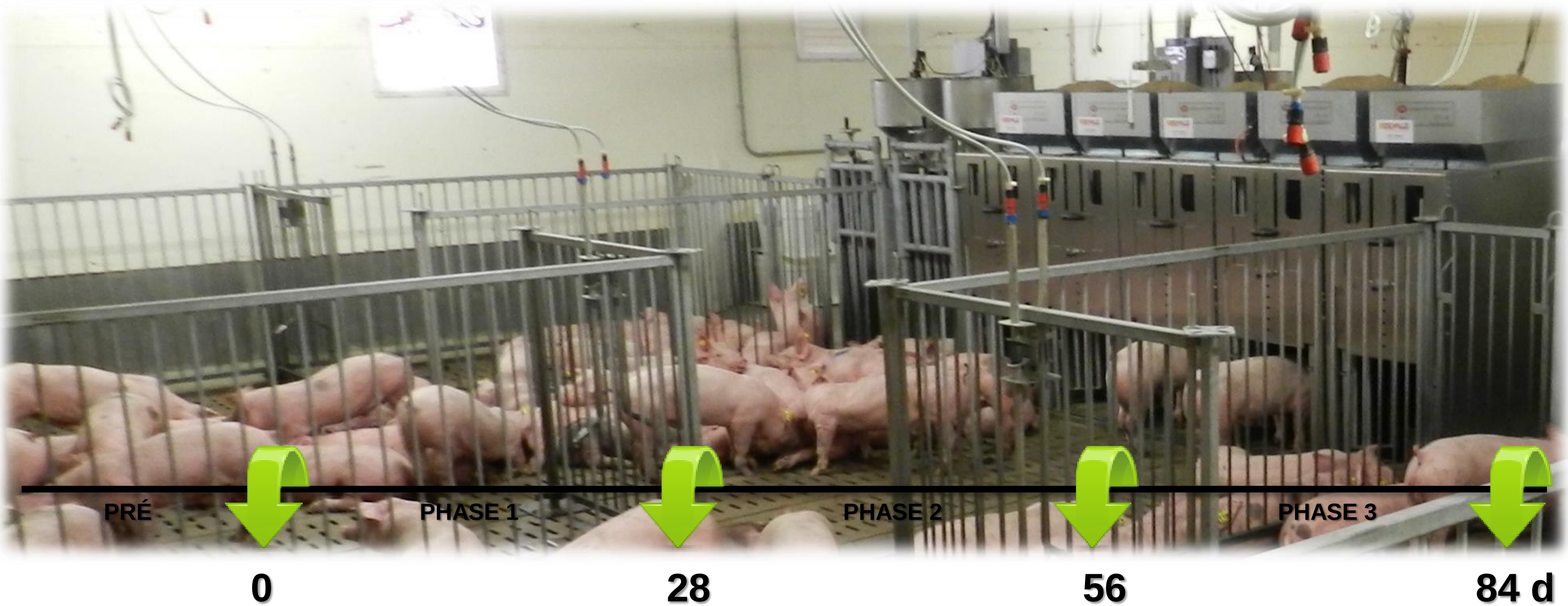
12 trials

6 prototypes

Precision feeding
Validation

Trial 1 :
60 castrated males
41,2 ± 3,9 kg

Trial 2 :
35 females and 35 castrated males
30,4 ± 2,2 kg



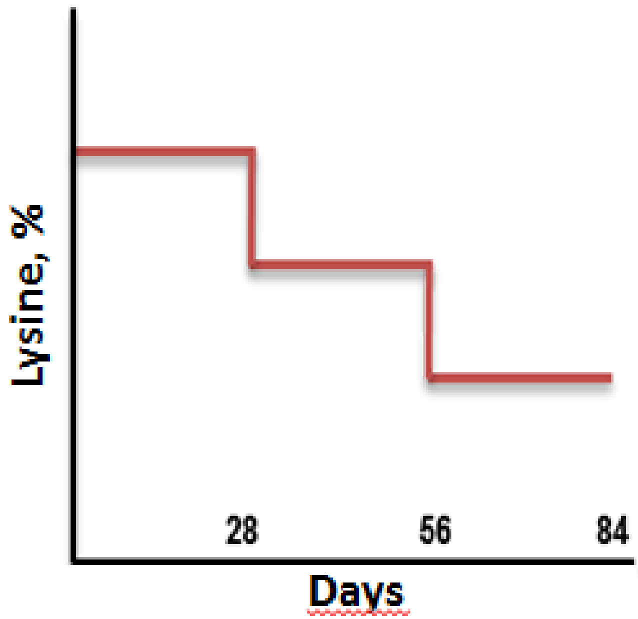
Andretta et al. 2014; 2016

Precision feeding
Validation

Trial 1 & 2 : feeding programs

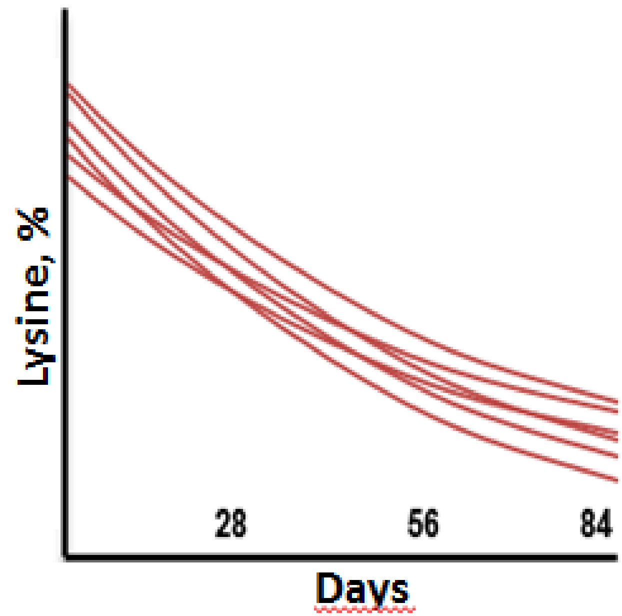
Three-phase feeding (3P)

Providing within each phase received a fixed blend of premixes A and B satisfying the lysine requirement of the 80th percentile pig



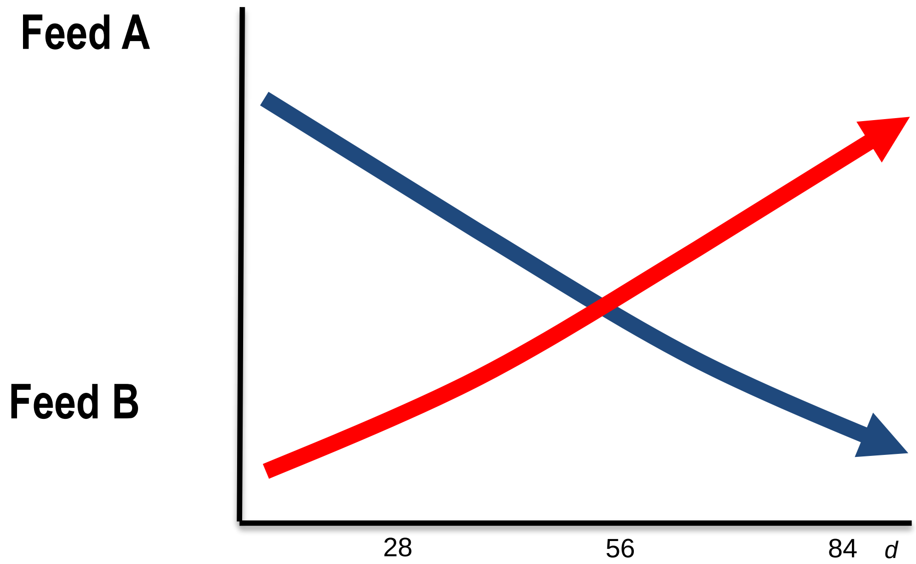
Precision feeding (PF)

Each pigs received daily a blend of premixes A and B satisfying its specific lysine requirements



Andretta et al. 2014; 2016

Precision feeding
Validation



Andretta et al. 2014; 2016

Precision feeding
Validation

PRÉ

0 28 56 84 d

Protein and lipid composition were obtained by transforming the lean and fat values from dual-energy X-ray densitometry to their chemical equivalents

Nitrogen excretion: ratio between retention and intake

Andretta et al. 2014; 2016 *Pomar et Rivest, 1996*

Precision feeding
Validation

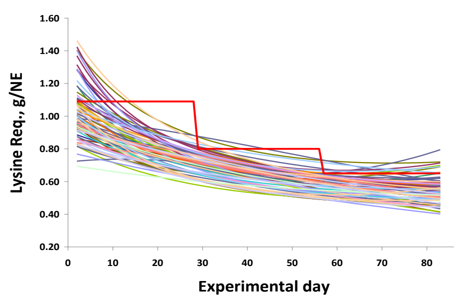
Variable	Precision *vs.* Conventional feeding Trial 1	Trial 2
Feed intake	n.s.	n.s.
Weight gain	n.s.	n.s.
Protein deposition	n.s.	n.s.
Lipid deposition	n.s.	n.s.
Protein intake	**< 16%**	**< 16%**
Lysine intake	**< 27%**	**< 26%**
Nitrogen excretion	**< 22%**	**< 30%**
Feeding cost, $/pig	**< 8%**	**< 10%**

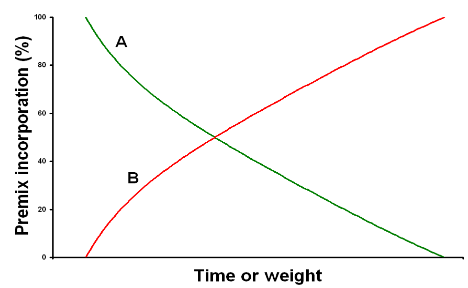
Andretta et al. 2014; 2016

Precision feeding
Implications

Individual precision feeding allows:

- ✓ **Reducing by 5-10% feeding costs** by reducing the expensive excess supply of nutrients (protein, P, etc.)
- ✓ **Reducing by 2-3% feed fabrication costs,** storage, management and shipping by using the same two or more premixes on all farms
- ✓ **Reducing by more than 40% the excretion of N, P** and other polluting constituents of manure and the amount of soil required for manure application





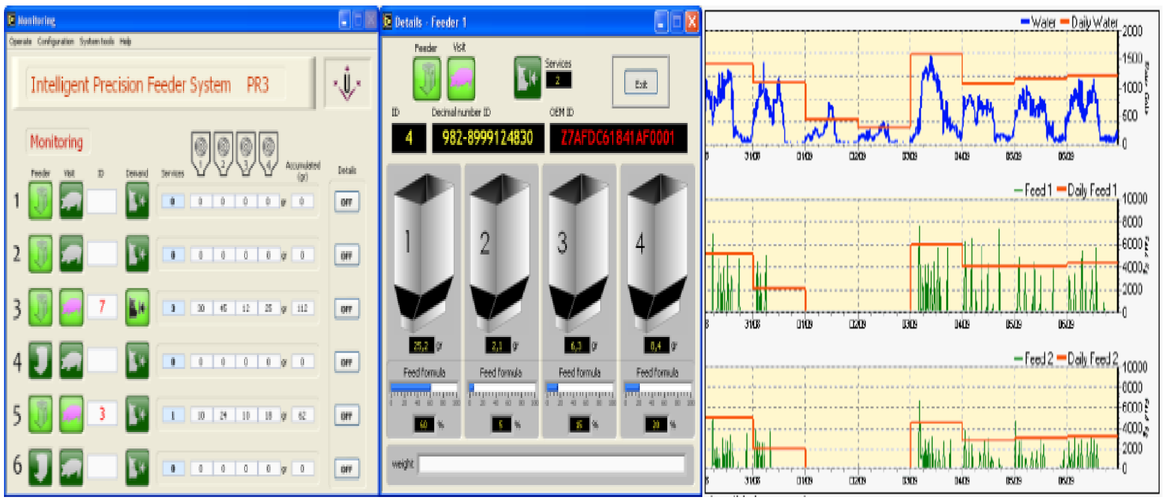
Precision feeding

Implications

Intelligent management of feeds and animals with advanced computerized technologies allows:

- ✓ **Real-time off-farm monitoring** of feeds and animals for improved economic efficiency

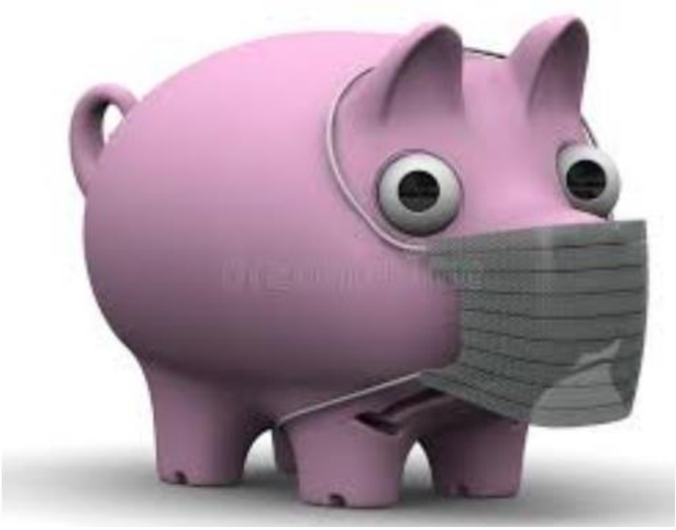
- ✓ **Reducing labor requirements** and costs through the automatic monitoring and management of feeds and animals



Precision feeding
Implications

Easy application of dietary treatments facilitates:

- ✓ **Early identification of diseases** by monitoring individual feed intake patterns and other animal parameters
- ✓ **Reducing antibiotic use** by the precise application of individual veterinary treatments, resulting in improved herd performance and lower veterinary cost

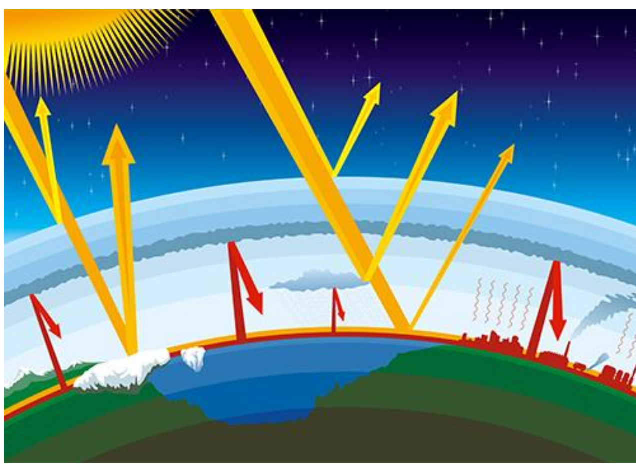


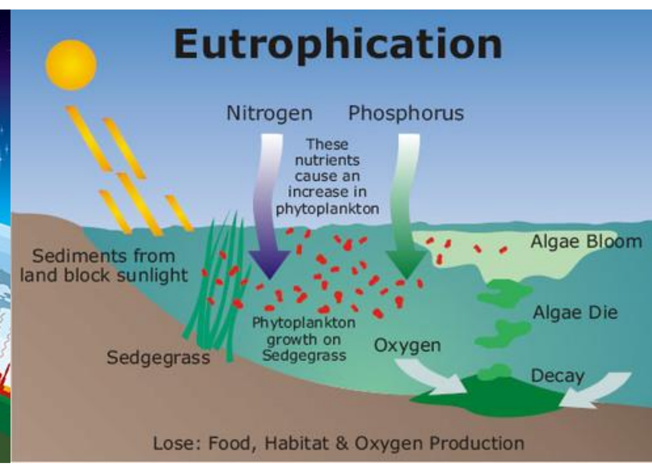
Precision feeding
Implications

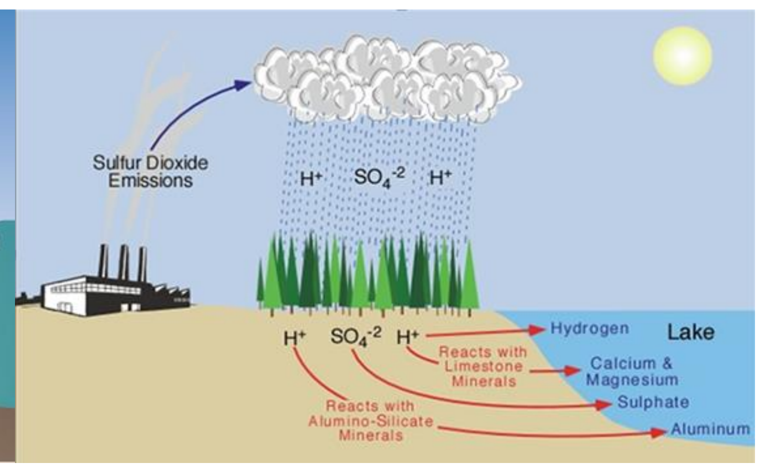
Precision feeding allows:

✓ In relation to conventional group feeding systems

- **Reducing** by **6%** climate change (*kg CO2-eq*) impact, and
- **Reducing** up to **5%** eutrophication and acidification (*kg PO4-eq and SO2-eq*) impact



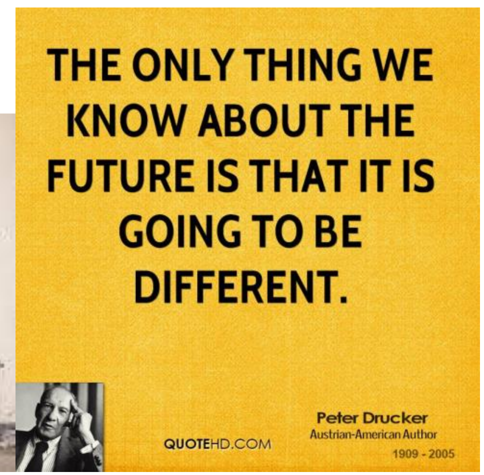




Smart farming

The future of the swine industry

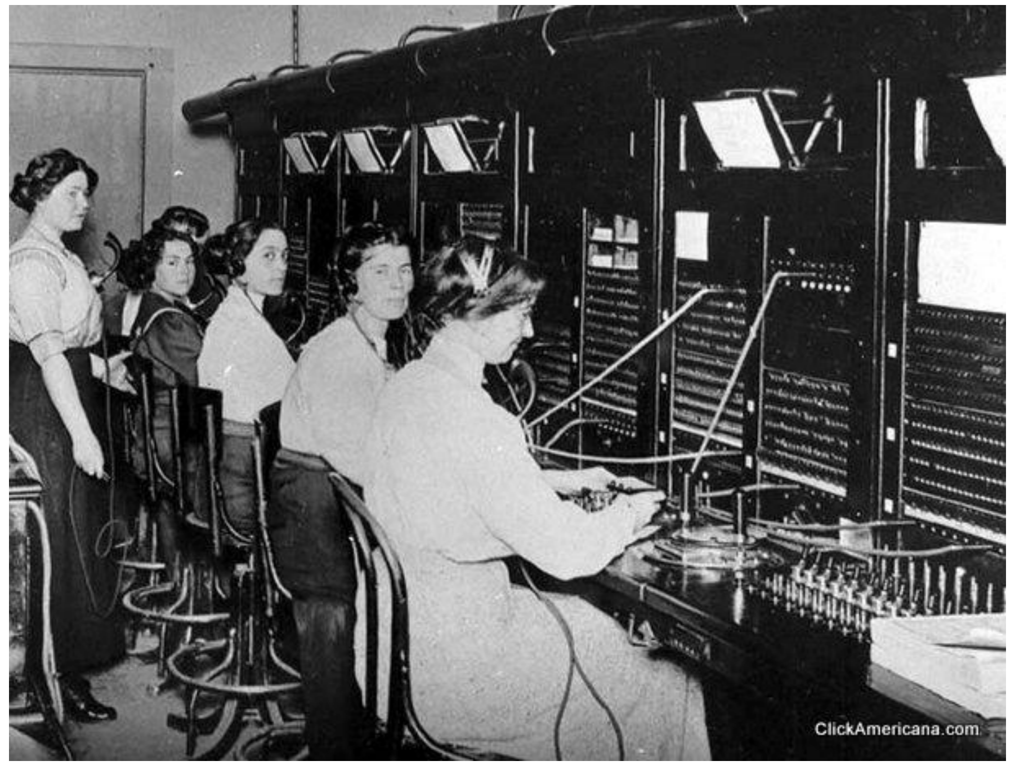
✓ **Will precision farming change the way we are feeding and raising domestic animals?**



Smart farming

The future of the swine industry

Jobs that NO LONGER EXIST… because of technological developments



Smart farming

The future of the swine industry

Jobs that ARE DESAPEARING (or dramatically changing)… because of technological developments

5. Travel Agent: **$31,800**

9. Librarian: **$54,500**

Smart farming

The future of the swine industry

Will your job still exist in 2025?

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50% of today occupations will be redundant by 2025!

By JENNY AWFORD FOR MAILONLINE

PUBLISHED: 14:31 GMT, 8 November 2014 | **UPDATED:** 15:55 GMT, 8 November 2014

- Experts believe half of today's jobs will be completely redundant by 2025
- Artificial intelligence will mean that many jobs will be done by computers
- Customer work, process work and middle management will 'disappear'
- Report states that workspaces with rows of desks will no longer exist

Smart farming

The future of the swine industry

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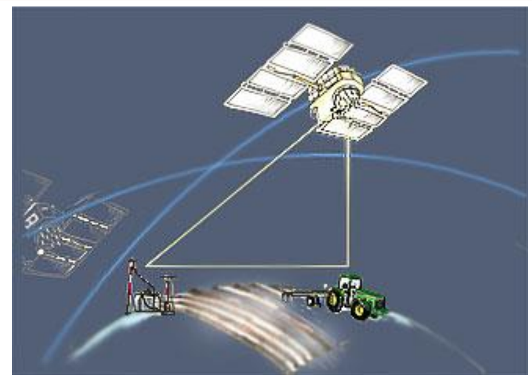

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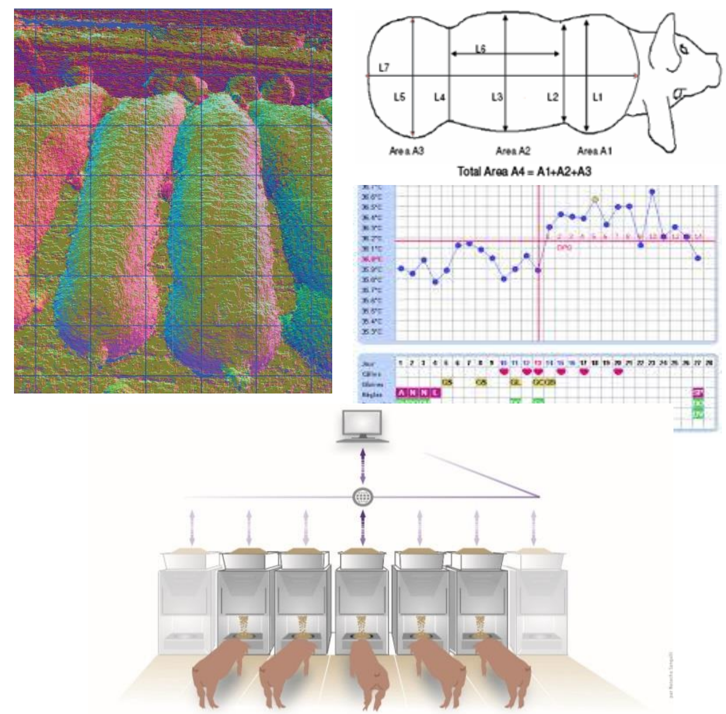
FARM activities that will change in the next 5-10 Years

From the **manual handling** of animals and feeds and
from the **feeding in groups** with one feed given during long periods of time to
the **automatic and personalized daily feeding and measuring**



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FARM activities that will change in the next 5-10 Years

From the **manual** estimation to

the **individual automatic real-time** estimation of nutrient requirements

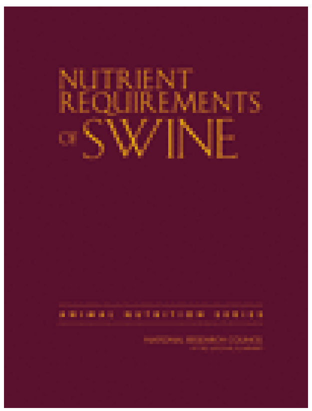
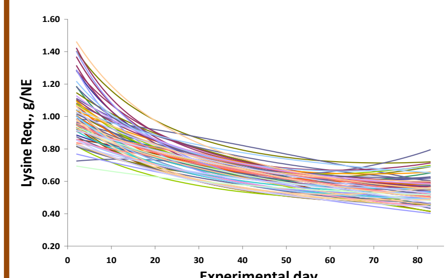
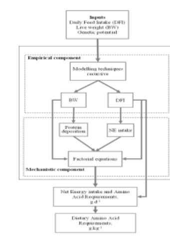


Table 1. Amino Acid Requirements of Growing Pigs*

	Amino acid requirements	
	Maintenance	Protein gain
Lysine	36 mg/kg $BW^{0.75}$	12 g/ 100 g PD[2]
Methionine	28[1]	27
Met+Cystine	123	55
Threonine	151	60
Tryptophan	26	18
Isoleucine	75	54
Valine	67	68
Nitrogen	*not estimated*	*not estimated*

[1]Ratio to lysine
[2]Protein deposition (PD)
National Research Council, 1998





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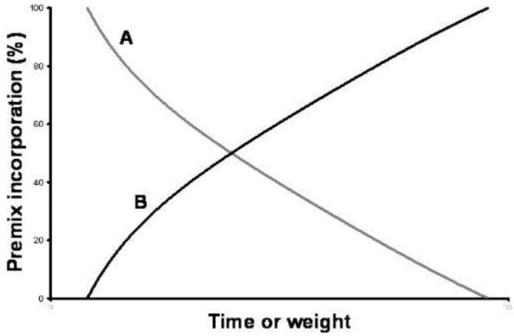
FARM activities that will change in the next 5-10 Years

From **customized feed formulation** and fabrication to
the **automatic on-farm blend** fabrication



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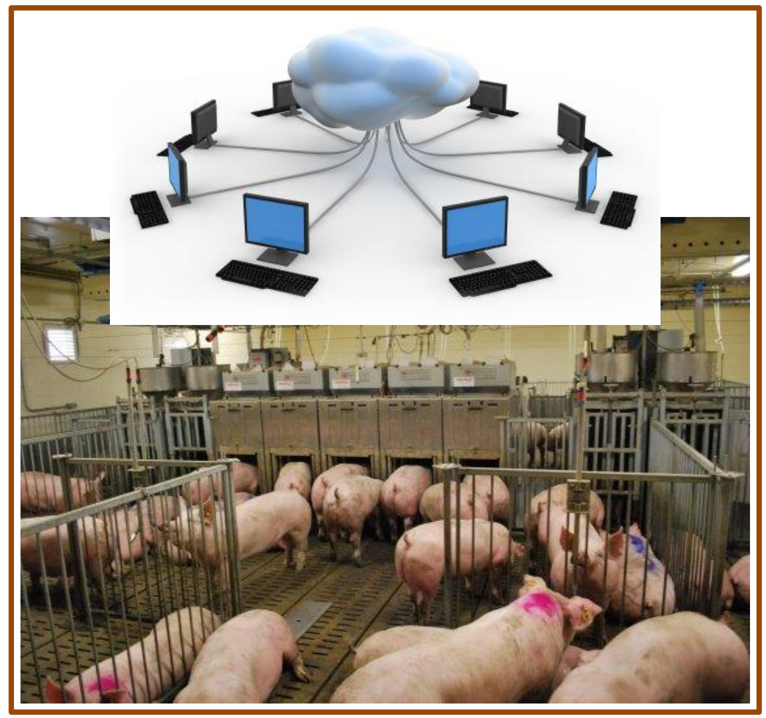
<u>FARM</u> activities that will change in the next 5-10 Years

From a **herd management of diseases** to

the use of individual real-time feed, water and behavioural information for **early identification of individual animal health disorders** and **individual management of diseases**



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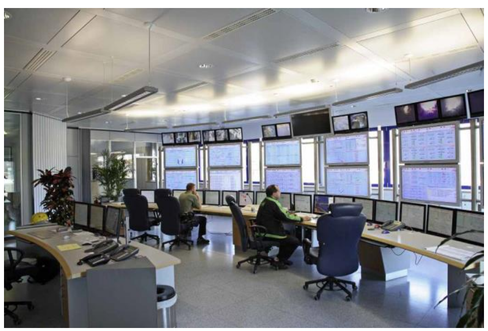
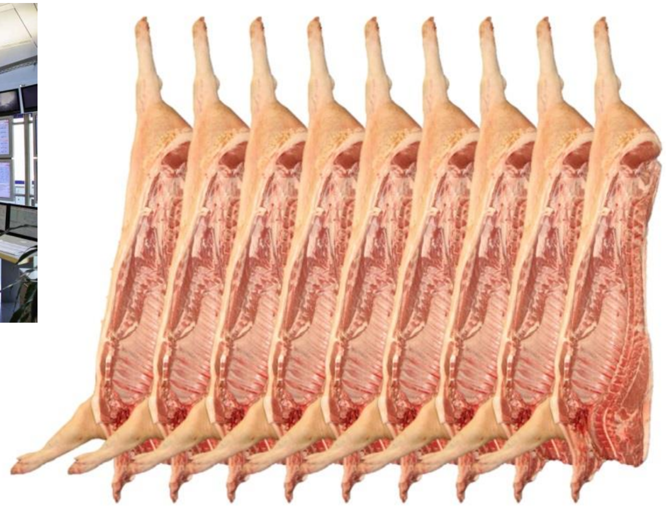
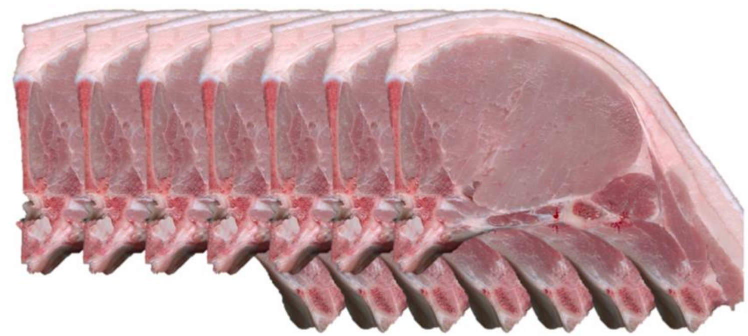
In a near future (5-10 years), pigs will be raised and feed not to optimize growth at minimal (feed) costs,

but to achieve each pig optimal bodyweight gain (i.e., reducing heterogeneity) **and carcass leanness** (i.e., maximal carcass value) **at minimal feeding costs** (i.e., $/kg produced meat) **and optimal nutrient efficiency** (i.e., reducing environmental load)







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In a near future (5-10 years) pigs will be raised in a fully monitored and off-farm managed farms where,

- **Smart sensors** and devices will produce big amounts of data that will provide unprecedented decision-making capabilities
- Incorporating **Big Data** analysis and the **Internet of Things (IoT)** will provide a new edge for innovation, productivity and competition
- **Smart Farming**

Manyika, 2011; Wolfert et al., 2017

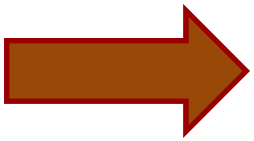
Smart farming

Final remarks

In a near future (5-10 years), pigs will be raised to achieve each pig optimal bodyweight gain and carcass leanness at minimal feeding costs and optimal nutrient efficiency

But,

- Is this production approach, affordable, achievable, etc.?
- **How much the feeders will cost?**
- **How long will take to pay the equipment?**



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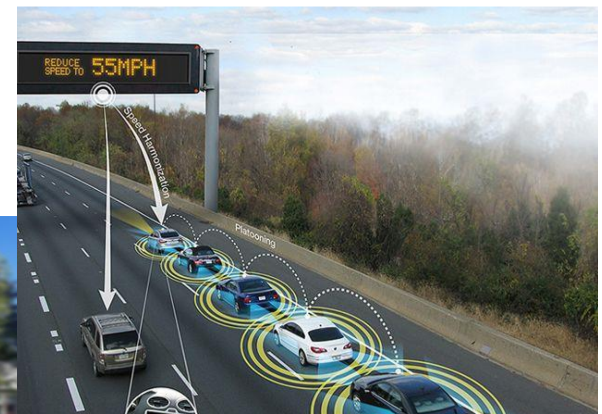

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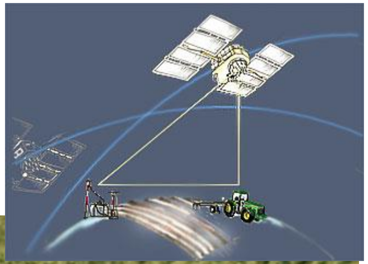

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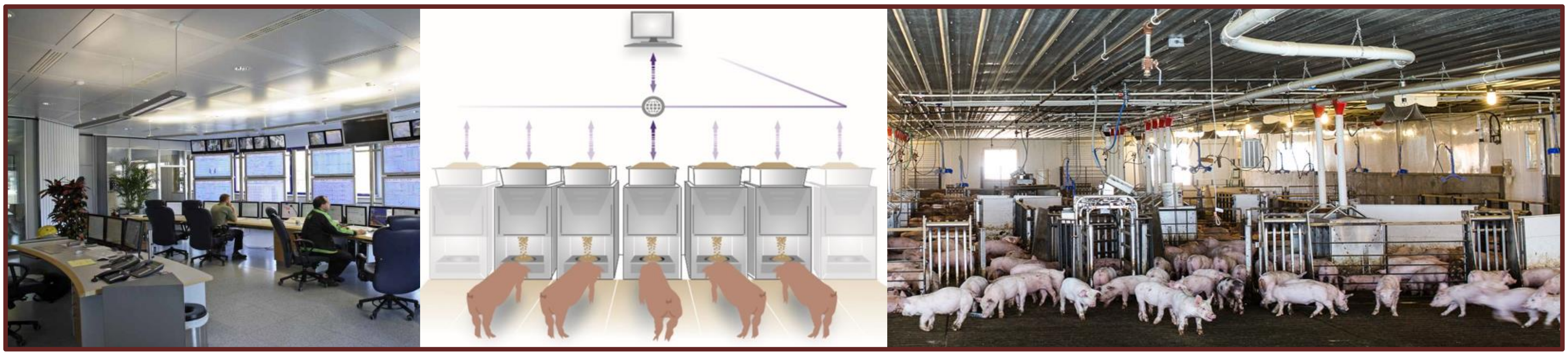
Final remarks

- Smart farming, **not just a question of technology**, but a successful marriage between knowledge and technology
- There is a **strong need for coordination** and involvement of different experts and stakeholders in the development and implementation of smart farming (*researchers, engineers, technology providers, economists, farmers, consumers and citizens*)



Acknowledgements

Many of the projects were funded by Swine Innovation Porc within the Swine Cluster 1 & 2. : Driving Results Through Innovation research program. Funding is provided by Agriculture and Agri-Food Canada through the AgriInnovation Program, provincial producer organizations and industry partners

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Agriculture and Agri-Food Canada

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Thank you

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