OptiBarn

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# Optimised animal specific barn climatisation facing climate change

S. Hempel, B. Amon, C. Ammon, S. Pinto, W. Pauw, J. Heinicke,
G. Hoffmann, C. Menz, G. Zhang, I. Halachmi, A. del Prado,
F. Estelles, W. Berg, R. Brunsch, T. Amon

**EAAP Annual Meeting 2015 - session 01**
**Warsaw, 31st August 2015**

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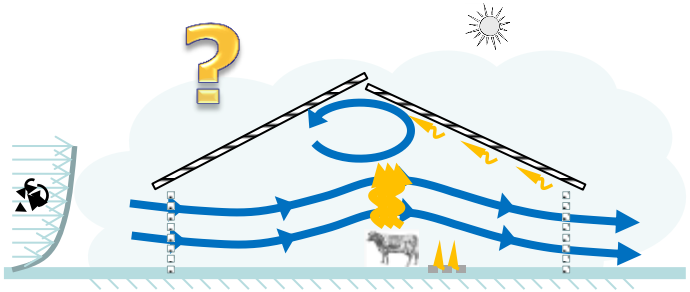
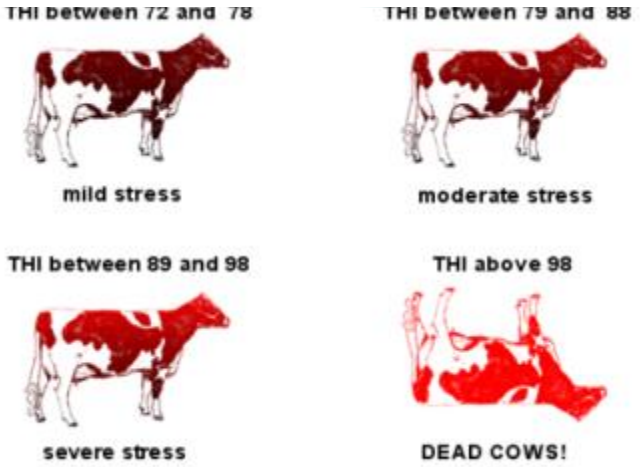
# Motivation

Climate in naturally ventilated barns depends directly on the outdoor conditions




Barn climate affects animals (welfare) and vise versa (heat release)

more weather extremes and increased variability are expected




Climate change affects economy (productivity) and environment (emissions)

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# The OptiBarn project

- FACCE ERA-NET+ Initiative
  „Climate Smart Agriculture“


- Consortium: 6 institutes from 4 countries

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PIK

AARHUS UNIVERSITY

bc3

+ 1 associated partner from Australia

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USQ UNIVERSITY OF SOUTHERN QUEENSLAND

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# Companies and Stakeholders

- Danish Exergy Technology A/S DXT (DK)
- PLF Agritech EU Ltd (GB)
- Agrotel GmbH (DE)
- Bauförderung Landwirtschaft e.V. BFL (DE)
- Wolf System GmbH (AT)
- Afimilk Ltd. (IL)
- Sächsische Landesanstalt für Umwelt, Landwirtschaft und Geologie (DE)
- Gut Dummerstorf/Landesanstalt für Landwirtschaft und Fischerei Mecklenburg-Vorpommern (DE)

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# Central Questions - Work Packages

How does the climate in the stable depends on climatic boundary conditions? (WP1)

What may smart naturally ventilated barns look like? (WP2)


How may results be communicated efficiently? (WP5)

How does the barn climate affect animal welfare? (WP3)

How effective and practical are the optimisation approaches? (WP4)

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# Tasks - Work Packages 1

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**1.1. Modelling through- and inflow of NVB in a boundary layer wind tunnel and numerically (S. Hempel, ATB)**

**1.2. Deduction of potential risks factors (C. Menz, PIK)**

**1.3. Region-specific cross-validation (L. Rong, AU)**

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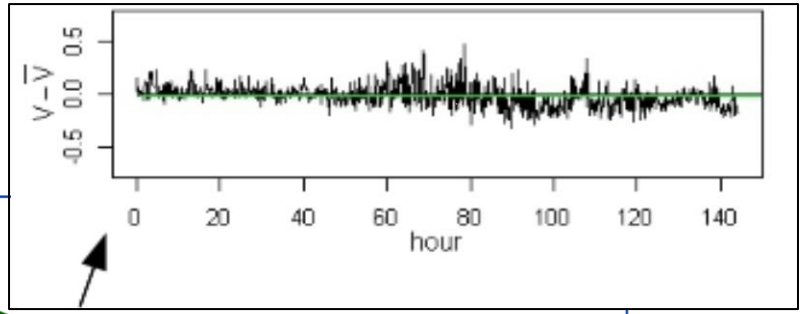
# Longterm air flow measurements …

- Complex On-Farm data have limited temporal and spatial resolution and fluctuating boundary conditions







→ spatially heterogeneous and not stationary air flow patterns

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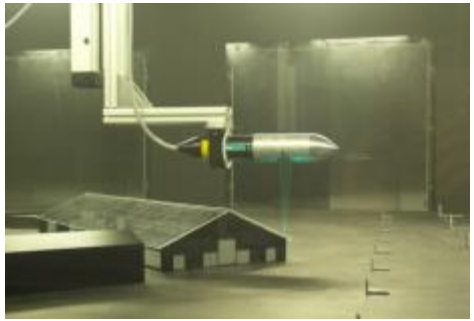
# … physical modeling

- Model and measure turbulent flow in a boundary layer wind tunnel



→ investigate in- and throw-flow characteristics of naturally ventilated barns (realistic atmospheric boundary layer)

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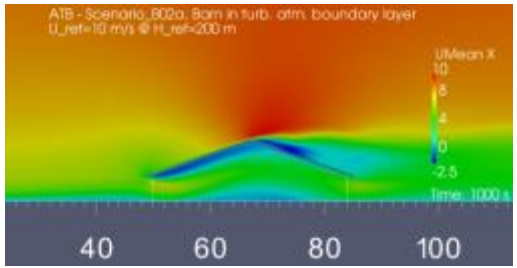
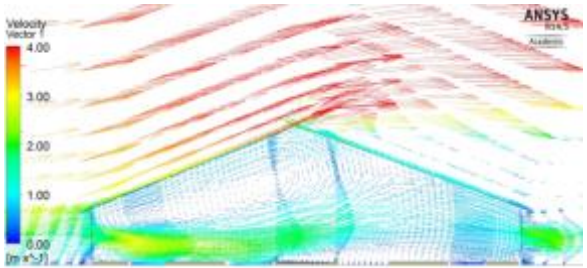
# … and numeric simulation (CFD)

## Tools




- Open Source - Open FOAM
- Commercial - ANSYS

## Modeling




- Navier-Stokes Equations on a high resolution grid
- Turbulence model: RANS & LES
- Different types of heat sources and barn geometries
- **Couple with climate and emission source model**

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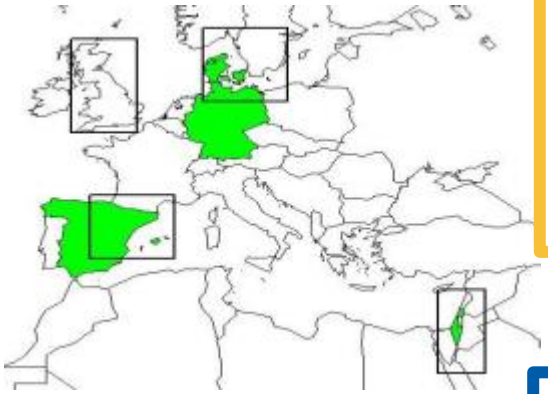
# Adaption potentials and needs

relate observed outdoor climate to indoor climate and animal welfare → deduce resulting climate risk factors

assess climate condition classes

cross-validation of model coupling and determination of model uncertainty



climate projections today & 2050
(PIK + CORDEX- Europe )
→ determine projection uncertainty with ensemble approach

uncertainty estimation from model and projection uncertainty

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ATB, ARO, PIK  PIK

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# Cross-validation - selected barns

← Israel

**Sound cross-validation requires common experimental plan**

↑ Spain

← Germany

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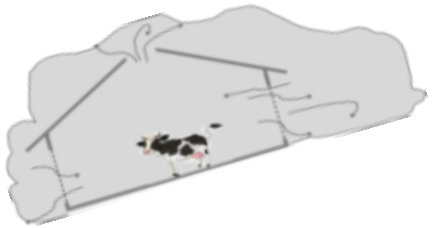
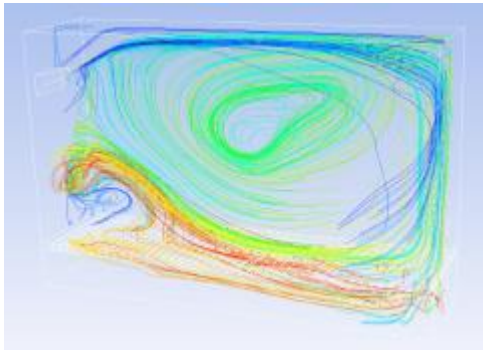
# Tasks - Work Packages 2



**2.1. Integrated sensing method development (G. Zhang, AU)**

**2.2. Precision zone ventilation 1 –**

**AOZ climate control (L. Rong, AU)**



**2.3. Precision zone ventilation 2 –**

**Emission zone exhaust control (L. Rong, AU)**

**2.4. Effectiveness and feasibility assessment**

**(I. Halachmi, ARO)**

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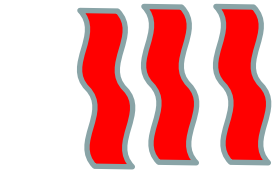
# Thermal sensing

- Find one parameter to represent convection, radiation and latent heat release of cow at varied thermal conditions



- Experiments & CFD to estimate parameters difficult to achieve by measurements

- Artificial animal models with surface temperature regulation to estimate heat loss depending on air velocities and air temperatures

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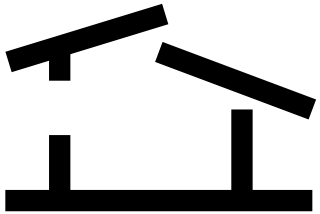
# Zone ventilation and its impact

- Experiments & numeric modelling
  - Zone air speed & temperature control [2.2]
    - Partial mechanical ventilation
    - Earth - Air heat exchange
  - Optimal indoor air quality & minimum emission [2.3]
    - Exhaust location
    - building configuration



- Stakeholders' estimations and opinions (advisory board) & animal responses

→ assess building design and ventilation concepts
(heat stress, productivity and working environment, costs) [2.4]

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# Tasks - Work Packages 3

**3.1. Building a setup for evaluation animal stress based on sensor selection (I. Halachmi, ARO)**

**3.2. Case studies on animal-individual stress, using the setup (T. Amon, ATB)**

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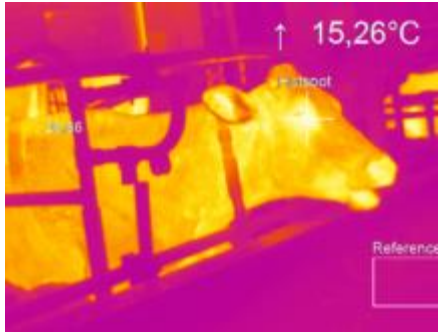
# Heat stress scale

- What do dairy cows show under heat stress?

→ define sensors that indicate heat stress (lab + barn)

- Under hot conditions:
  search for significant differences in

- Heart rate variability
- Respiration
- Body temperature
- Surface temperature
- activity

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# Behavioral adaptation

morning

afternoon

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# Animal individual stress

- Under which conditions are individual dairy cows in heat stress?

→ identify stress under various conditions

- Use the proven sensors to test sensibility of cows to:
  - temperature, humidity and wind,
  - under individual stages of pregancy, lactation

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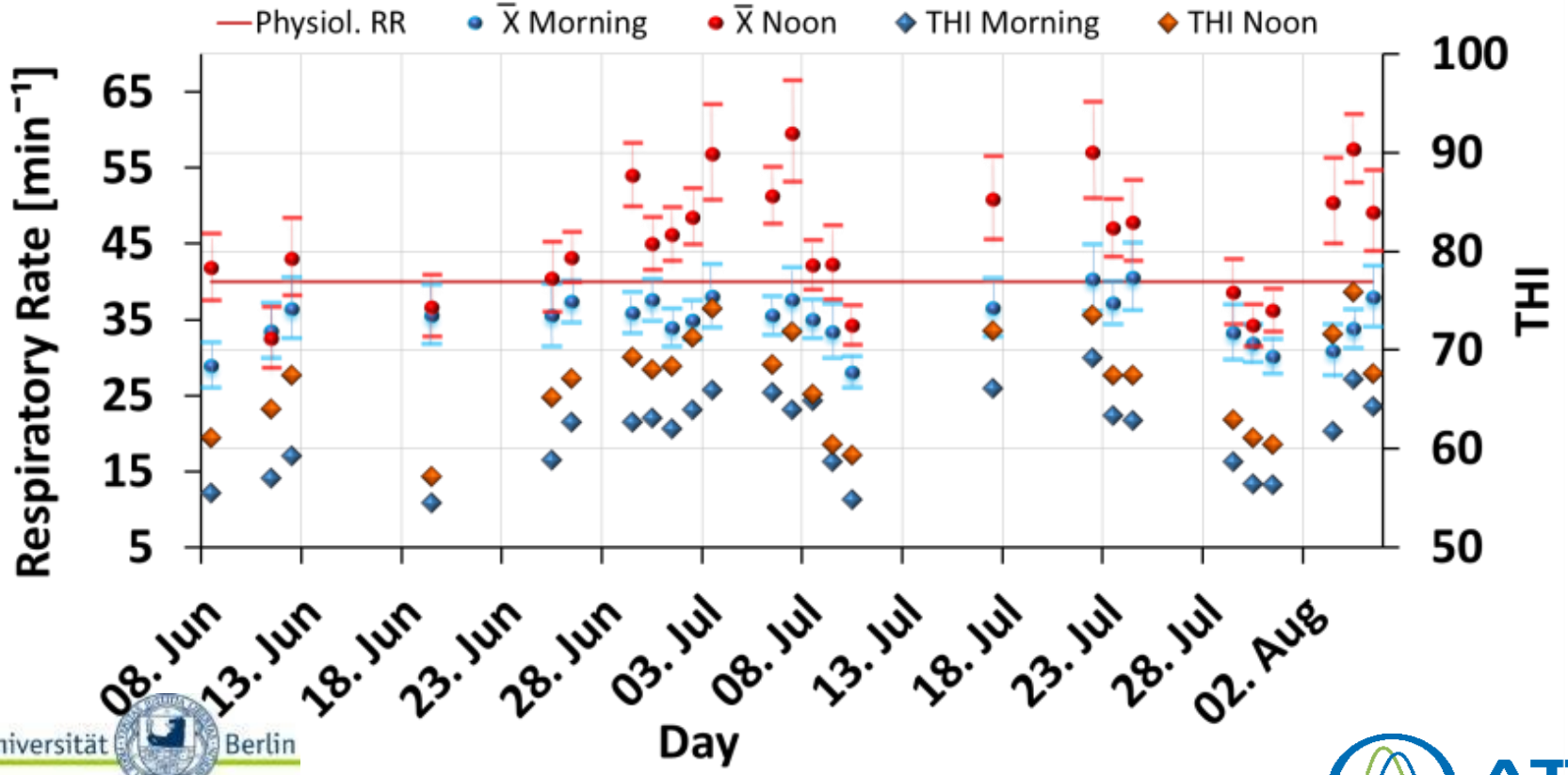
# Respiratory Rate - adaption strategie to heat stress

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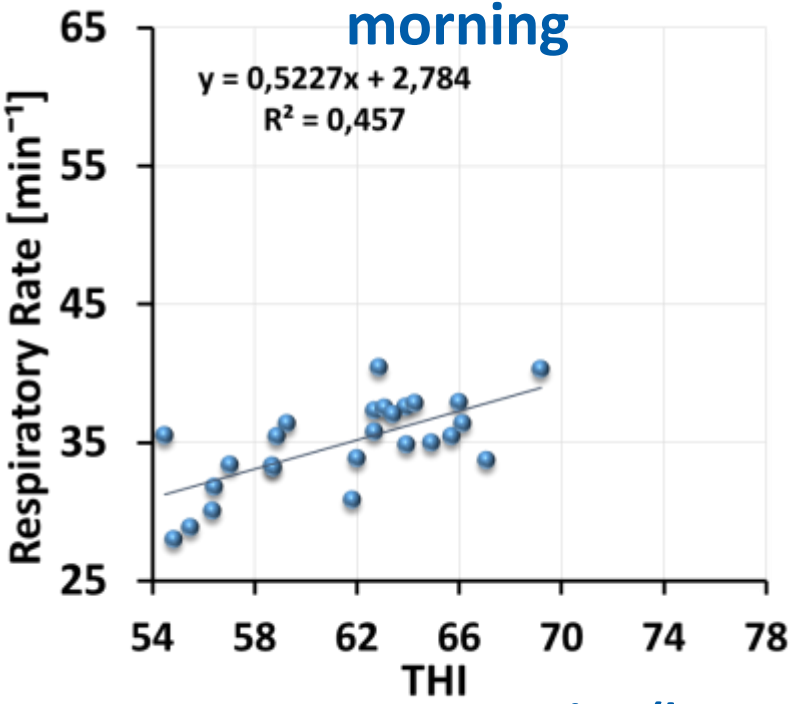
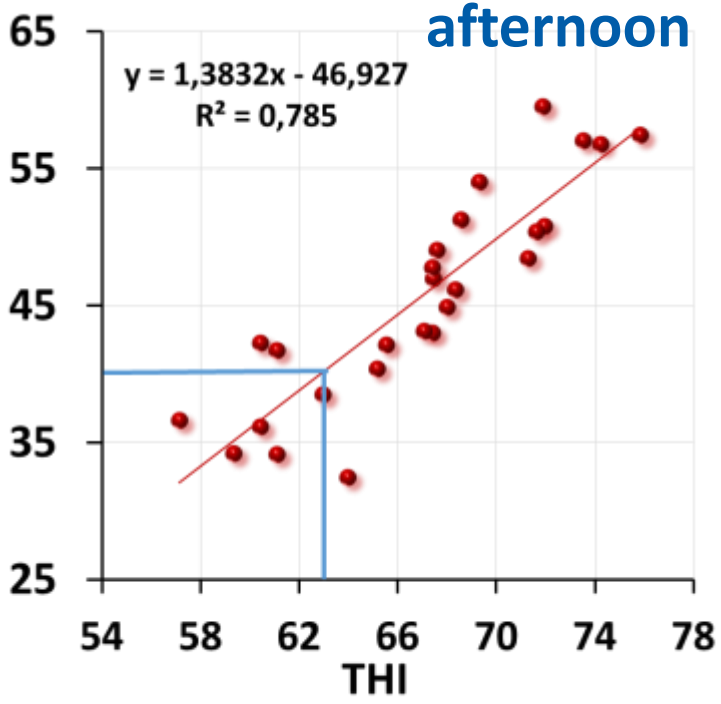
# Correlations: THI – RR



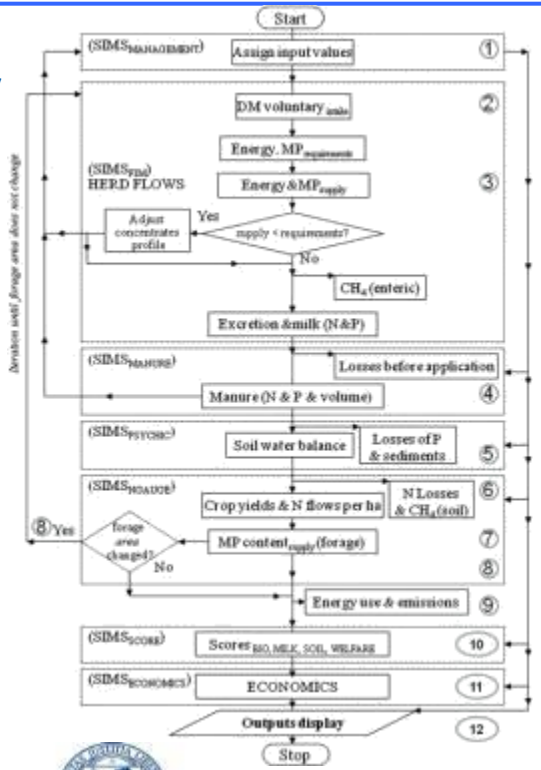




Morning (low THI): hardly correlations

Afternoon: high correlations

# Tasks - Work Packages 4

SIMS$_{Dairy}$




## 3.1. Evaluation of expected environmental impacts

**(A. del Prado, BC3)**

## 3.2. Evaluation of expected economic impacts and risk management options

**(F. Estelles, UPV)**

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# Tasks - Work Packages 5

## 5.1. Internal project communication

## 5.2. Workshop organisation

## 5.3. External project communication

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# External commitees

**Industry panel**

- Companies that wrote letter of intent

**Scientific panel**

- Thomas Banhazi (NCEA, AU)
- Tom Misselbrook (Rothamsted Research, UK)
- Nico Ogink (Wageningen UR, NL)
- Melinda Hassouna (INRA, FR)

**Advisory board**

**Biannual strategic evaluation based on monthly status reports**

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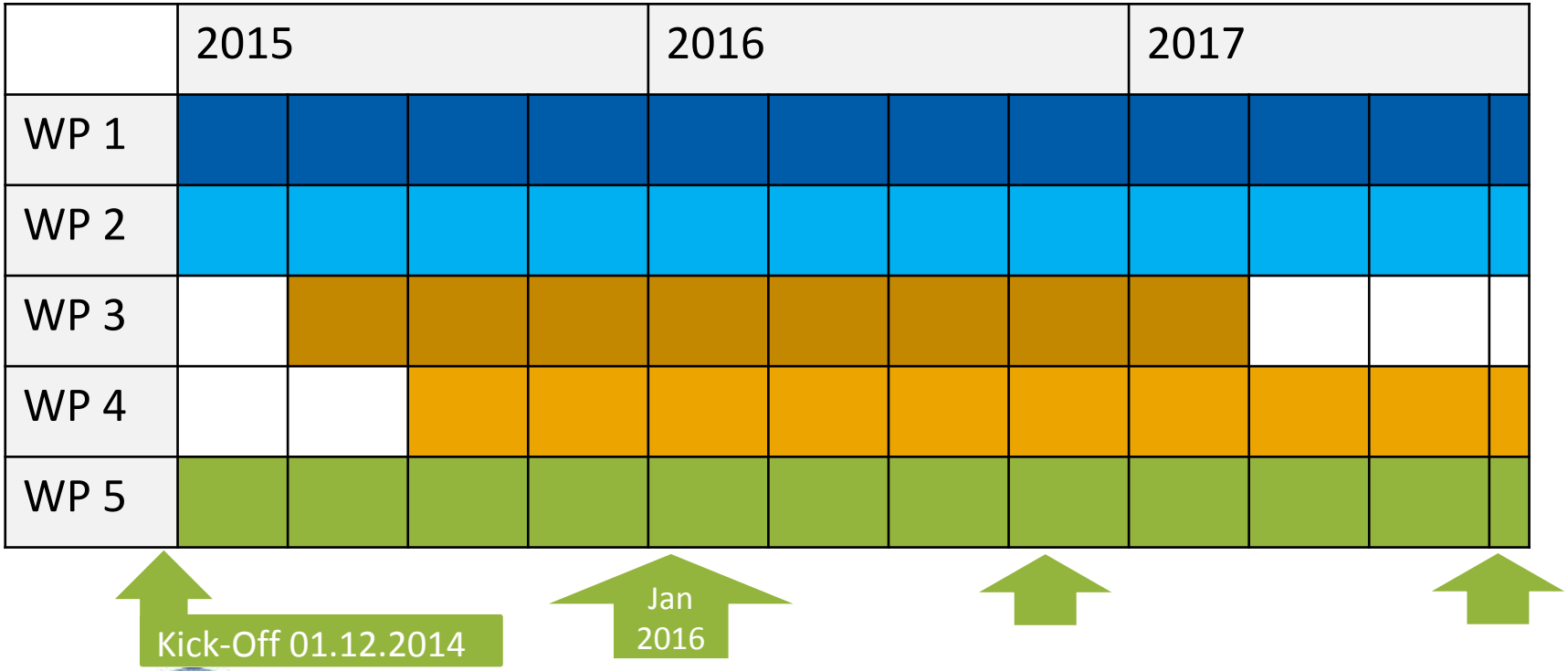
# Timeline

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# Summary

- Naturally ventilated barns will be affected by climate change

  → interdisciplinary approach to quantify adaption potentials and needs

  (region-specific and animal-individual)

- Cooperation with international companies and stakeholders

  + scientific advisory board

  → evaluation of results by experts and fast dissemination

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