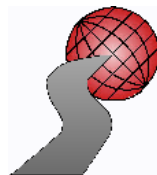


# Comparison of models and measurements for whole-farm ammonia emissions

**Tom Misselbrook, Sarah Gilhespy**  
**Daniel Sandars, Adrian Williams, Colin Burton**

**Rachel Thorman**

**Rob Pinder**



**Carnegie Mellon**

# OBJECTIVES

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- **Compare emissions from on-farm mitigated sources with experimental studies**
- **Estimate emissions using 'whole-farm models' and assess abatement scenarios**

# STRUCTURE

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- **Details of 2 study farms**
- **Emission measurement methodology**
- **Models used to estimate emissions**
- **Results**

# STUDY FARMS

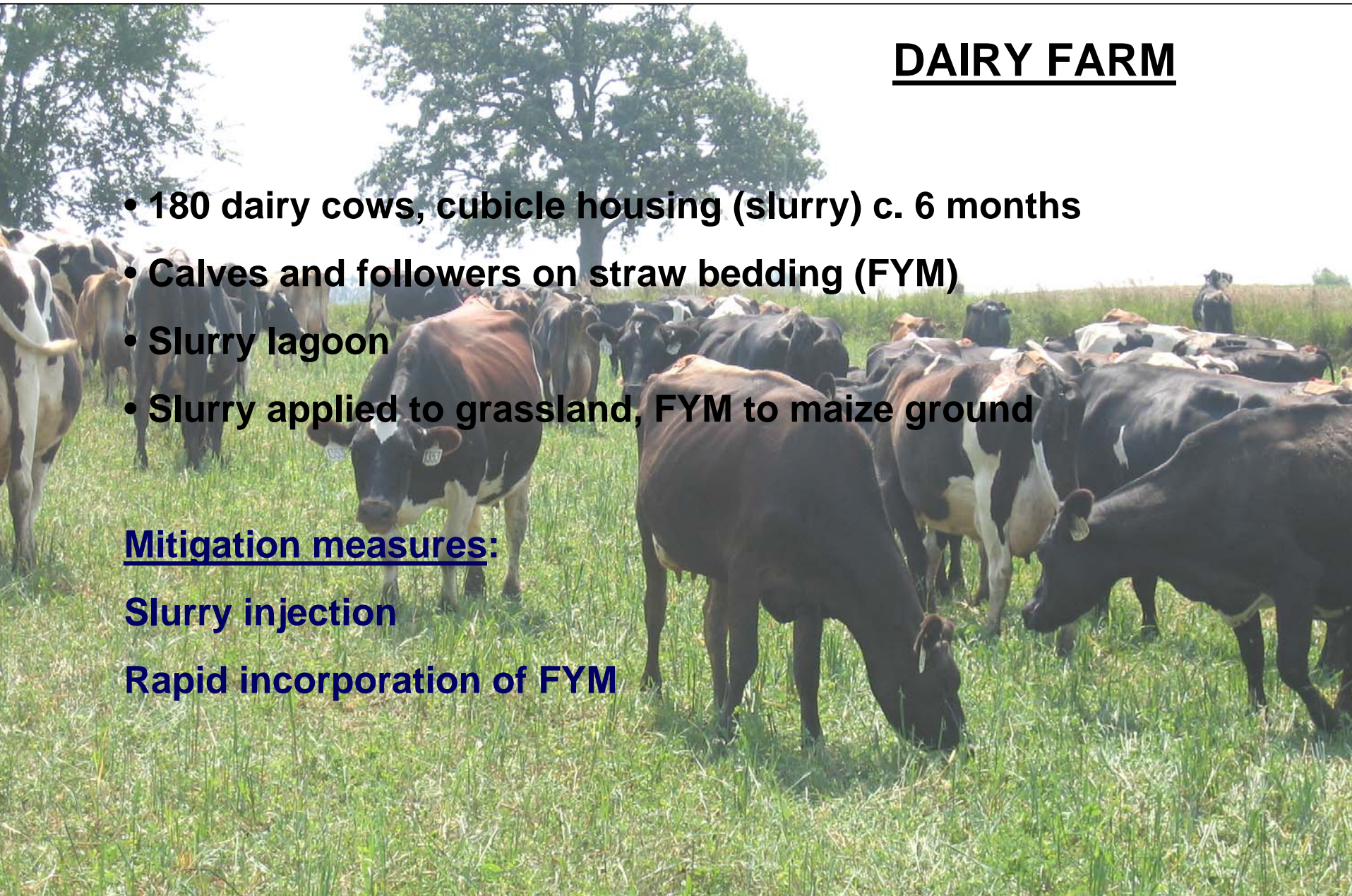
## DAIRY FARM

- 180 dairy cows, cubicle housing (slurry) c. 6 months
- Calves and followers on straw bedding (FYM)
- Slurry lagoon
- Slurry applied to grassland, FYM to maize ground

### Mitigation measures:

Slurry injection

Rapid incorporation of FYM



# STUDY FARMS

## PIG FARM

- 500 sows, 1800 finishing pigs
- Various housing types (slatted, straw-bedded, natural and mechanical ventilation)
- Slurry lagoon
- Slurry and FYM applied to arable land

### Mitigation measures:

Slurry lagoon cover

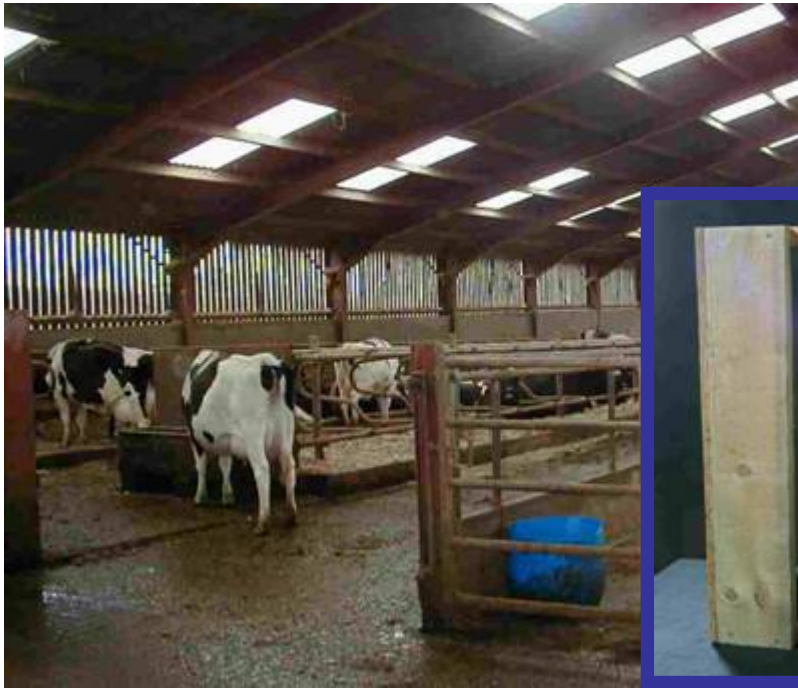
Slurry band spread

Rapid incorporation of FYM



# MEASUREMENTS

## Dairy farm



**Manure spreading**

**NOT GRAZING**

# MEASUREMENTS

Pig farm



# MODELS

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- **UK Ammonia Emissions Inventory Model UK\_AEI**
- **MAST**
- **NARSES**
- **MEASURES**
- **Farm Emissions Model (FEM)**

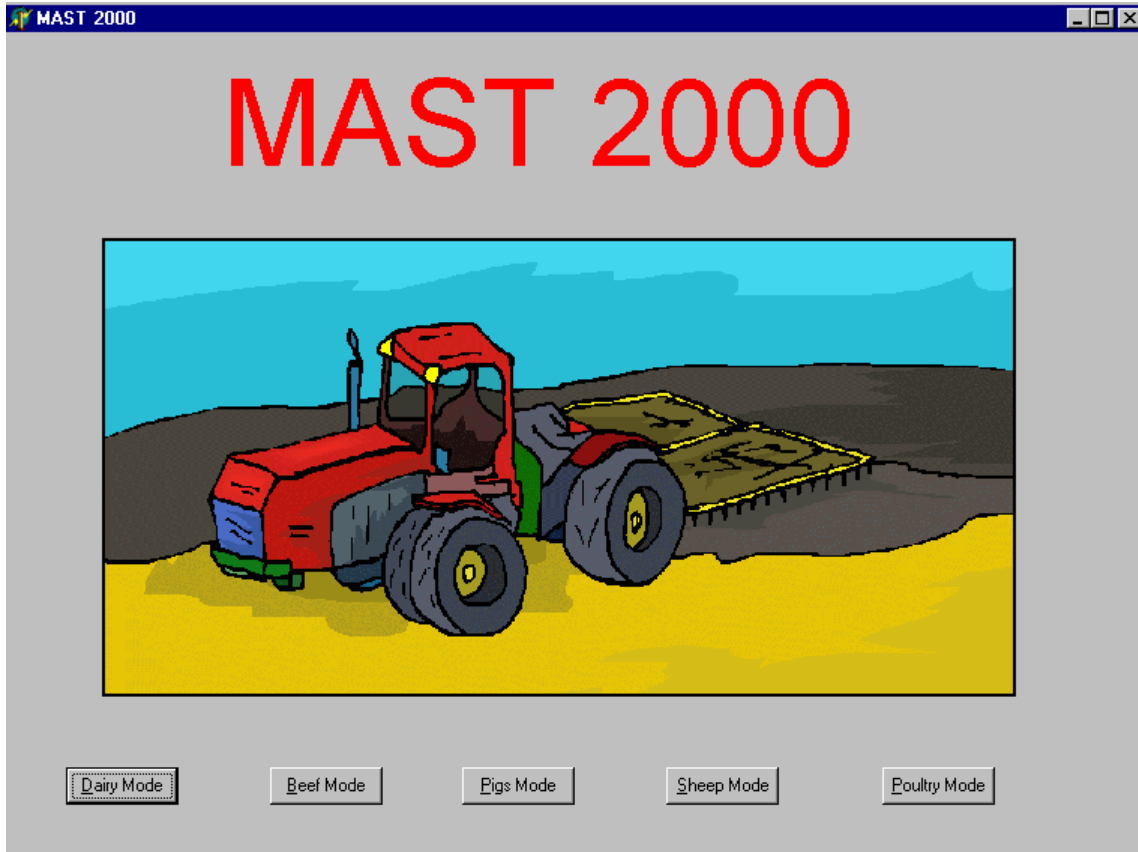


# UK Ammonia Emissions Inventory

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- **Spreadsheet model at UK-scale (not easy to use at farm scale)**
- **Detailed partial emission factors (generally expressed per animal)**
- **Detailed activity data (livestock census, manure management practices)**
- **Updated annually**
- **NOT mass-conservative or N-flow**

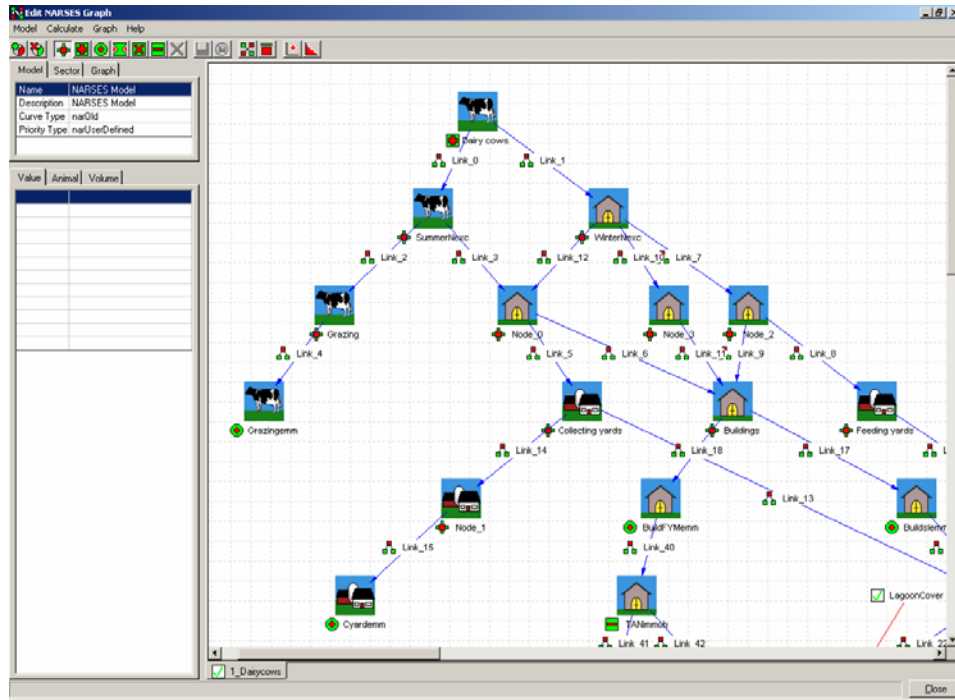
# MAST



**‘MAST’ - Model for  
Ammonia Systems  
Transfer**

- **Farm-scale model using UK\_AEI emission factors**
- **Not updated since 2000**

# NARSES



## ‘NARSES’ – National Ammonia Reduction Strategy Evaluation System

- Based on UK\_AEI structure (detailed partial EF)
- EF expressed as %TAN
- Mass-conservative N-flow model
- Includes cost-curve analysis

# MEASURES

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**'MEASURES' – Multiple Environmental outcomes from Agricultural Systems**

- **Includes many components other than ammonia**
- **Ammonia emission algorithms largely empirical – from UK emissions inventory with some revisions**



# FEM

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## 'FEM' – Farm Emissions Model

- **Specifically for slurry-based dairy farm**
- **Mass-conservative N-flow model**
- **Process-based partial emission factors**
- **Monthly emissions output**

# RESULTS

# MITIGATION

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## Dairy farm

**NONE!!!**

- **Shallow injector not used (contractor instead)**
- **Ploughing within 24h not achieved**

# MITIGATION

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## Pig farm

**Covered slurry lagoon**

**– emission almost zero**

**Band spread slurry**

**– emission 18-36% TAN applied**

**Rapid FYM incorporation**

**– emission 56% TAN applied**

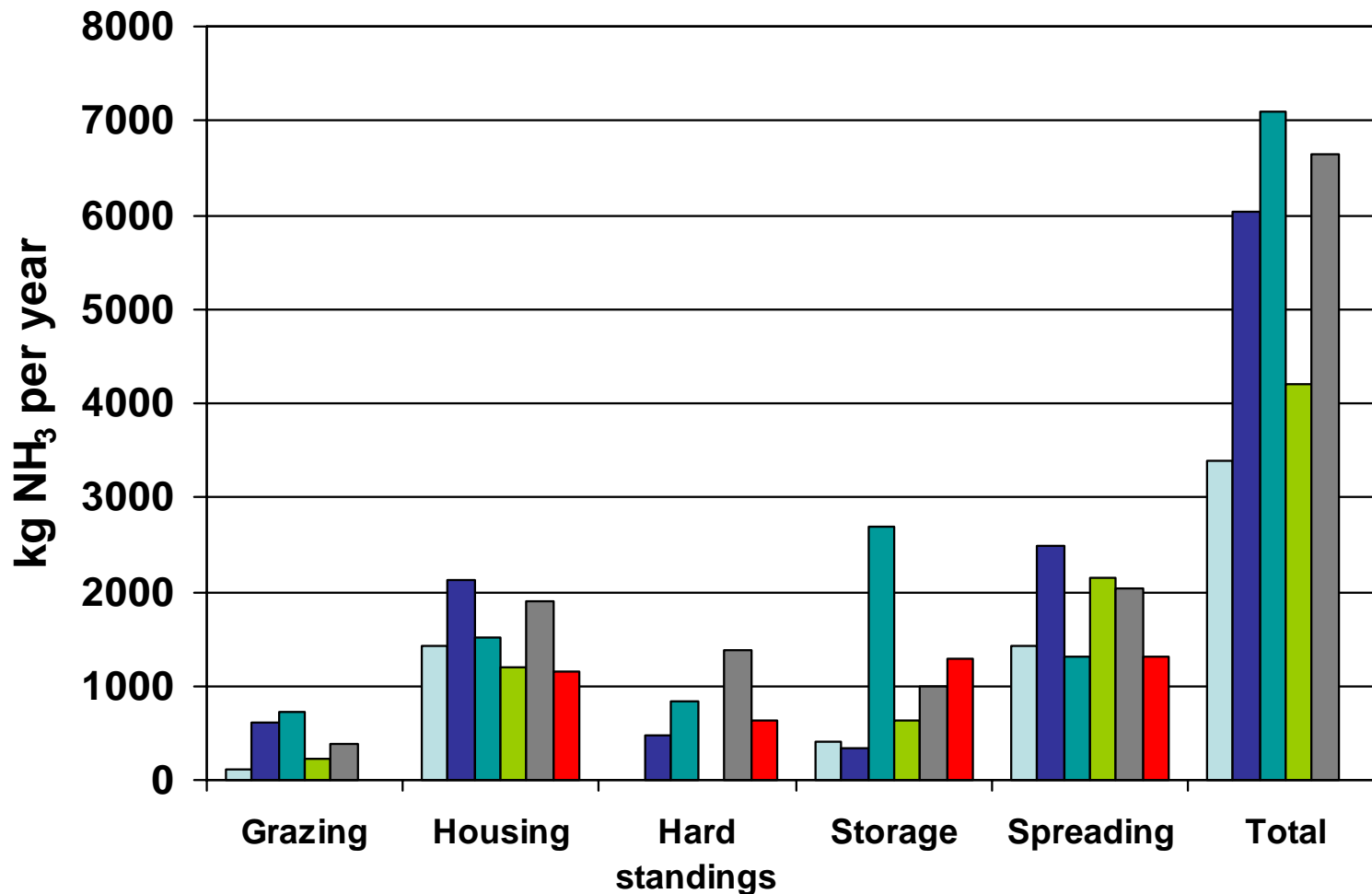
**- >80% prior to ploughing**

**Emissions agree well with experimental studies, giving confidence to emission reduction efficiencies determined in controlled experiments**



# COMPARISON OF MODELS

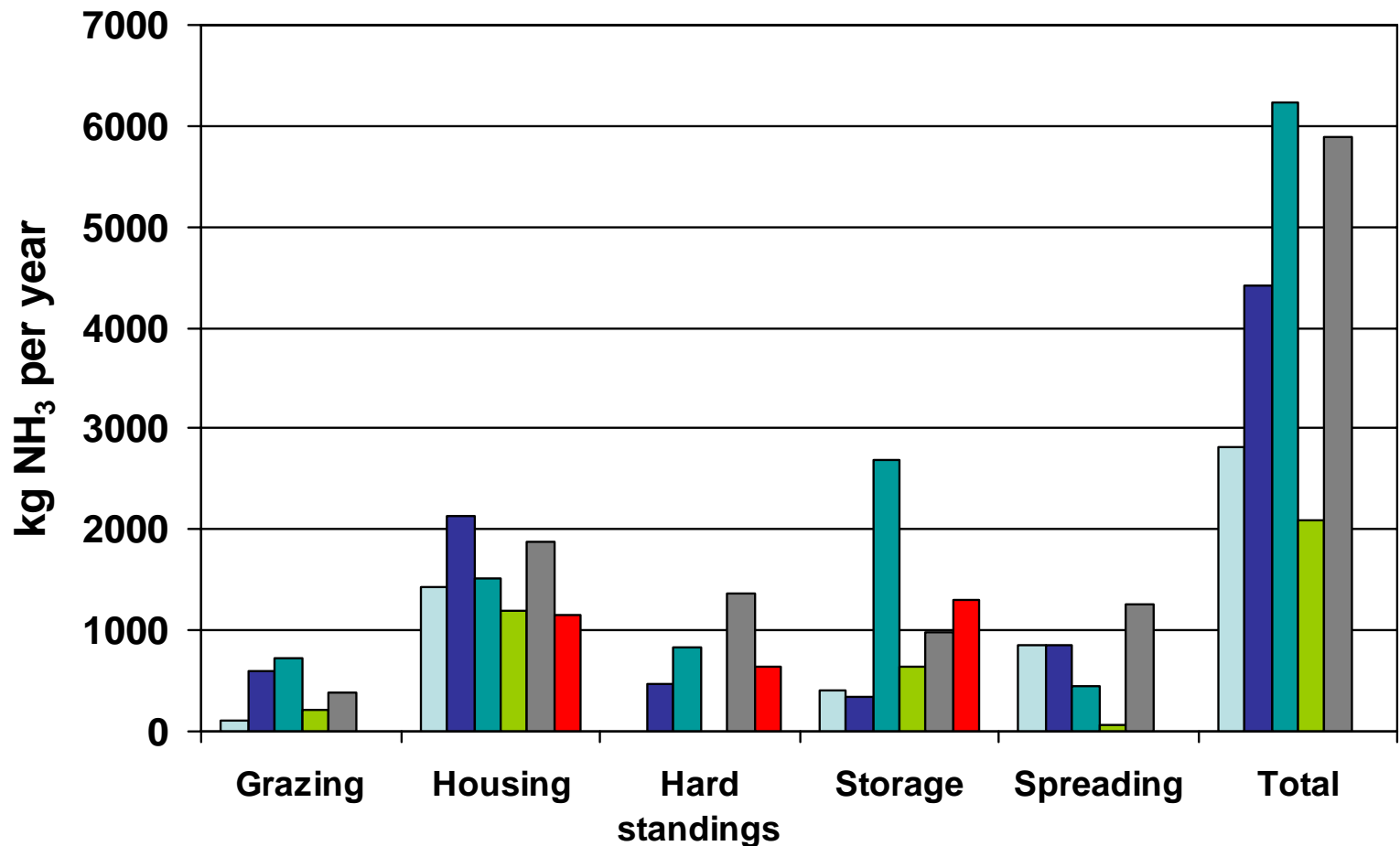
## Dairy farm – pre abatement



# COMPARISON OF MODELS

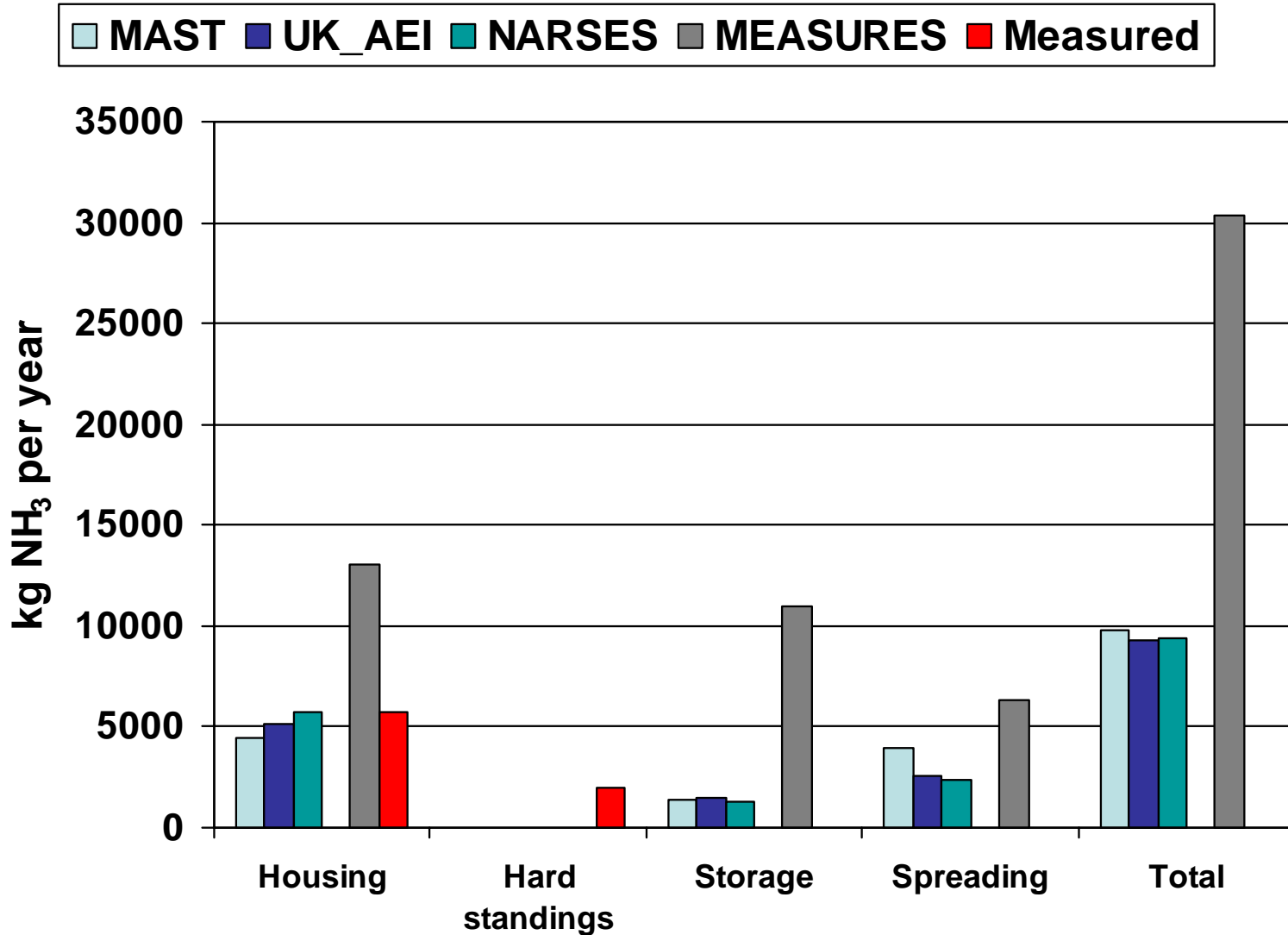
## Dairy farm – post abatement

**% reduction**    17%    27%    12%    50%    11%



# COMPARISON OF MODELS

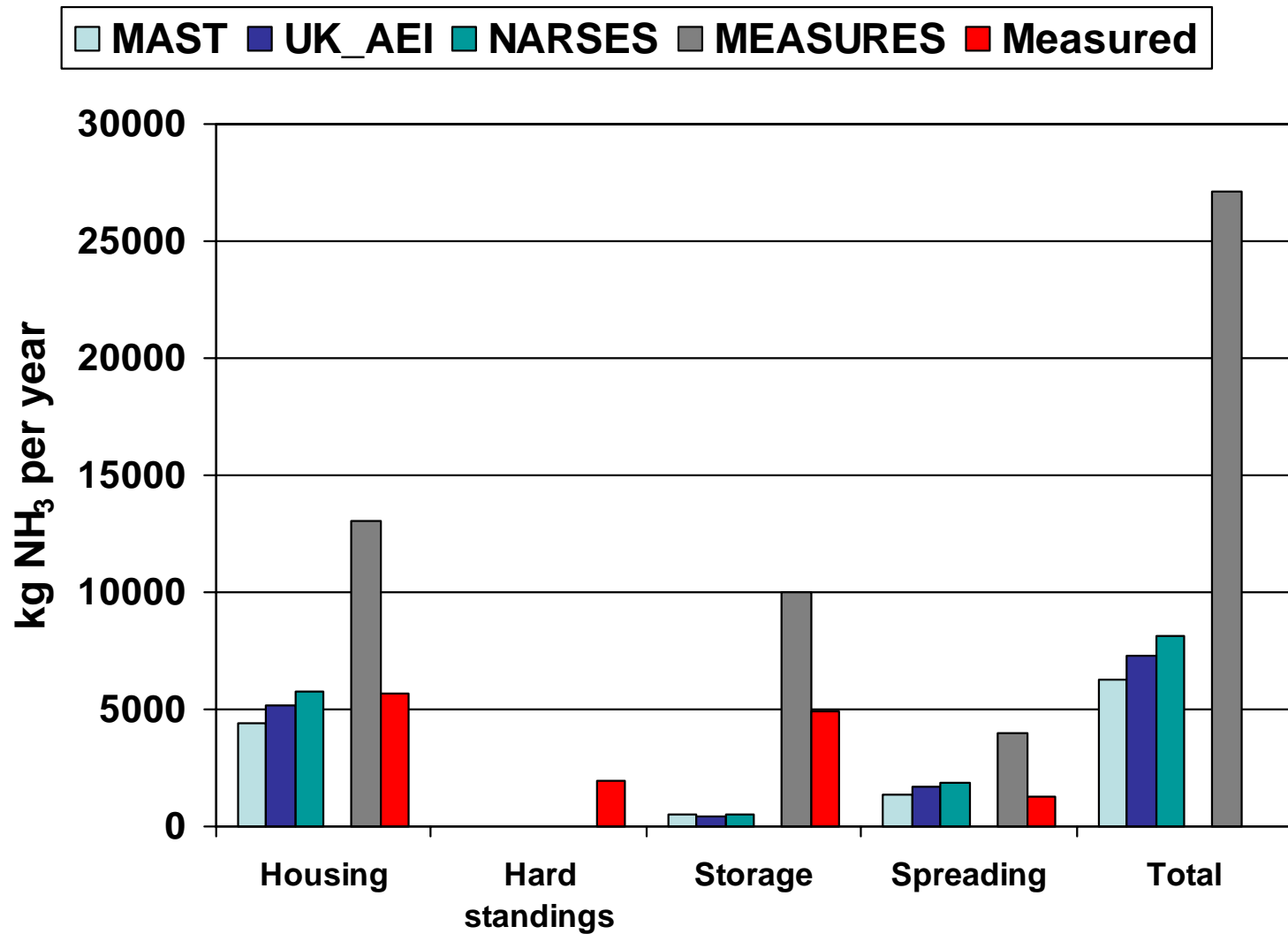
## Pig farm – pre abatement



# COMPARISON OF MODELS

## Pig farm – post abatement

**% reduction**    **36%**    **22%**    **13%**    **10%**





# CONCLUSIONS

- **Where practised (!), mitigation measures gave reductions equivalent to those from previous experiments**
- **Different models gave different totals and reductions**
  - **national vs. local scenarios**
  - **requirement for process-based models**
  - **importance of correct models for ‘pollution swapping’**

# **ACKNOWLEDGEMENTS**

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**Support and cooperation of the two farm managers is gratefully acknowledged**