Large Dairy Farm Designs

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Components of a Large Dairy Farm System

1. Cow Housing and Management
   - Milking Cows
   - Dry Cows
   - Transition Cows
2. Milking Center and Management
3. Feed Storage and Management
4. Manure Storage and Management
5. Calf Housing and Management
6. Heifer Housing and Management
7. Labor Management
“Facilities are tools to implement a management plan”

Components of a Large Dairy Farm System

- Lactating Cow Barns
- Sand Separation
- Dry Cow Barn
- Milking Center
- Transition Cow Barn
- Calf Hutches
- Feed Storage
- Methane Digester
- Clean Water
- Manure Storage

DVM Gordy Jones
Dairy Planning and Design Principles

- Implement the dairy cow management plan
  - Optimize cow comfort
  - Optimize cow genetic potential (productivity)
  - Optimize cow dry matter intake
- Provide worker safety and health
- Labor efficient
- Consider flow of cows, feed, manure, and people
- Protect the environment
  - Land
  - Water
- Use proven technology and design
Dairy Design Team

1. Owner
2. Herd Manager
3. Farm Manager(s)
4. Consultant(s)
   - Veterinarian
   - Nutritionist
   - Lender
   - Builder
   - Dairy Designer
   - Agricultural Engineer
The Farmstead Design Process

- Develop the dairy animal management plan
- Investigate and develop alternative designs
- Evaluate design decisions
  - Develop design decisions into a system
- Choose the “best” farmstead design
  - Consider how design decisions in one system will affect other systems
- Evaluate the farmstead design
  - Consider implications on flow of air, water, cows, manure, feed, and people
  - Benefits/Limitations
- Review and troubleshoot farmstead design

Iterate Plan
Change Management Plan
Develop a Dairy Animal Management Plan

- Determine the herd size
- Define the management groups
  - Herd Table
    - Number of animals in each group
- List Needs of Dairy Animal
- List Needs (and wants) of the Owner
- Determine facility features that meet these needs and (wants)
- Develop management protocols to achieve the plan
- Adjust the management plan as necessary to meet the farm goals
- Prioritize the facility features to help make budget decisions
Dairy Animal Management Group

A group of animals that has similar needs such as:

- Nutrition
- Health
- Housing
- Environment
### Dairy Animal Management Groups

<table>
<thead>
<tr>
<th>Cow Groups</th>
<th>Calf Groups</th>
<th>Heifer Groups</th>
<th>Bull/Steer Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Far off dry cows</td>
<td>✓ Wet calf group (birth – 2 months)</td>
<td>✓ 6-8 months</td>
<td>✓ 2nd and later lactation cows</td>
</tr>
<tr>
<td>✓ Thin</td>
<td>✓ Weaned calf group (3-5 months)</td>
<td>✓ 9-12 months</td>
<td>✓ Slow milking cows</td>
</tr>
<tr>
<td>✓ Fat</td>
<td></td>
<td>✓ 13-15 months (breeding age)</td>
<td>✓ Treated cows</td>
</tr>
<tr>
<td>✓ Transition cows (closeup cows)</td>
<td>✓ Wet calf group (birth – 2 months)</td>
<td>✓ 16-23 months (bred)</td>
<td>✓ Hospital cows</td>
</tr>
<tr>
<td>✓ Transition heifers (closeup heifers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Maternity cows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Lactating cow groups (7-8 pens)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Fresh cows/heifers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ First lactation cows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ 2nd and later lactation cows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Slow milking cows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Treated cows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Hospital cows</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Group Size Design Values

<table>
<thead>
<tr>
<th>Animal Group</th>
<th>Design 1000 Cows</th>
<th>Design 3000 Cows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,200</td>
<td>3,600</td>
</tr>
<tr>
<td>Lactating Cows</td>
<td>1,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Pen Size (8 pens)</td>
<td>125</td>
<td>375</td>
</tr>
<tr>
<td>Dry Cows (first 40 days)</td>
<td>134</td>
<td>400</td>
</tr>
<tr>
<td>Closeup Cows + Heifers (3 weeks before calving)</td>
<td>66 + 34 = 100</td>
<td>200 + 100 = 300</td>
</tr>
<tr>
<td>Maternity (1 day)</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Fresh Cows + Heifers (3 weeks after calving)</td>
<td>66 + 34 = 100</td>
<td>200 + 100 = 300</td>
</tr>
<tr>
<td>Calves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>340</td>
<td>1,000</td>
</tr>
<tr>
<td>Birth - 2 months</td>
<td>136</td>
<td>400</td>
</tr>
<tr>
<td>3-5 months</td>
<td>204</td>
<td>600</td>
</tr>
<tr>
<td>Heifers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,224</td>
<td>3,600</td>
</tr>
<tr>
<td>6-8 months</td>
<td>204</td>
<td>600</td>
</tr>
<tr>
<td>9-12 months</td>
<td>272</td>
<td>800</td>
</tr>
<tr>
<td>13-15 months (breeding)</td>
<td>204</td>
<td>600</td>
</tr>
<tr>
<td>16-23 months (bred)</td>
<td>544</td>
<td>1,600</td>
</tr>
</tbody>
</table>
Dairy Animal Management Plan

“Needs of the cow”

- The cow is number one priority
  - Provide an environment that can express the genetic potential of the cow
- Provide adequate space for all management groups
- Provide optimal cow comfort
  - Provide fresh air by ventilation
  - Adequate space for resting, eating and drinking
  - Clean & dry resting space
  - Adequate space to move to feed and water
  - Minimize social and environmental stress
  - Safe from injury
  - Manage Temperature extremes
    - Cow Cooling in warm season
    - Manure management in cold season
Cow Comfort

- Adequate Neck Rail Height
- Stall Loop Divider
- Low Brisket Locator
- Curb
- Adequate Sand Base
Dairy Animal Management Plan

“Needs of the owner and workers”

• Effectively utilize a farm’s resources
  ✓ Land
  ✓ Capital
  ✓ Labor
  ✓ Genetic potential of herd

• Safe & Labor efficient
  ✓ Milking
  ✓ Feeding
  ✓ Manure Handling
  ✓ Cow movement

• Environmentally friendly
Worker Safety
Natural Ventilation
Design Principles
370 meters
315 meters
Total Area
27.0 acres
11.25 hectares
90 cows/ha

Cow Barn and Parlor
6.0 Acres
2.4 hectares

Feed Storage
3.2 acres
1.3 hectares

Manure Storage
5.4 acres
2.25 hectares

Total Area
27.0 acres
11.25 hectares
90 cows/ha

Natural Ventilation Design Site Plan
Natural Ventilation Design

• Benefits
  ✓ Good design in temperate climate
  ✓ Natural ventilation adequate most of the year
  ✓ Energy dependant only in hot weather
  ✓ Natural lighting supplemented with artificial light
  ✓ Stall bedding can be affected by air velocity
  ✓ Can allow for exercise lots adjacent to the cow pens

• Limitations
  ✓ Space needed between barns for access to wind for ventilation
  ✓ East West Barn Orientation to minimize solar penetration
  ✓ If North South barn orientation then no freestall rows on east or west side (head to head stall arrangement)
  ✓ Natural ventilation dependant on wind direction and velocity
  ✓ Supplemental artificial lighting
  ✓ Supplemental velocity fans necessary in hot weather
Mechanical Tunnel Ventilation
Design Principles
Baffles
Manure Storage
5.5 acres
2.2 hectares

Feed Storage
15.5 acres
6 hectares

Cow Barn and Parlor
14 acres
5.7 hectares

Methane Digester

Total Area
116 acres
47 hectares
96 cows/ha

Mechanical Tunnel
Ventilation Design
Site Plan

Clean Water

North
Mechanical Tunnel Ventilation Design

- **Benefits**
  - Space footprint for barns can be reduced as compared to naturally ventilated barns
  - Option to naturally ventilate in cold and mild weather
  - Option to environmentally control air velocity in hot weather
  - Can be retrofit into naturally ventilated barns

- **Limitations**
  - Ventilation is energy dependant in hot weather
  - Dependent on artificial lighting
  - Stall bedding choice affected by air velocity
  - Baffles needed
  - Minimal air flow in cold weather may compromise animal health
Mechanical Cross Ventilation
Design Principles
Baffles
Clean Water

Manure Storage
17 acres
7 hectares

Cow Barn and Parlor
32 acres
13 hectares

Feed Storage
8 acres
3 hectares

Feed Storage
17 acres
7 hectares

Manure Storage
4.0 acres
1.5 hectares

Feed Storage
4.3 acres
1.8 hectares

Total Area
116 acres
47 hectares
8000 cows
170 cows/ha

812 meters

North
Mechanical Cross Ventilation Design

Benefits
- Space footprint for barns can be reduced as compared to naturally ventilated barns
- Any barn orientation possible
- Environmentally controlled air velocity all seasons
- Reduce heat stress in hot weather
- Improve feed efficiency in cold weather
- Evaporative pad/mist cooling option

Limitations
- Ventilation is energy dependent all seasons
- Dependent on artificial lighting
- Stall bedding choice affected by air velocity
- Baffles needed
- Feed can be contaminated with bedding
- Minimal air flow in cold weather may compromise animal health
Milking Center
Milking Pen Size Depends on Milking Parlor Capacity
Milking Parlor Capacity and Efficiency
## Milking Parlor and Pen Sizing

<table>
<thead>
<tr>
<th>Parlor Size</th>
<th>Number People in Operator area</th>
<th>Theoretical Parlor Capacity Cows per hour (cph)</th>
<th>Theoretical Pen Size @ 3x milking 45 minutes per pen*</th>
<th>Theoretical Milking Herd Capacity @ 3x milking 8 pens (groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Side by Side Parlor 4 Turns/hr</td>
<td>Rotary Parlor 7.5 Turns/hr</td>
<td>Side by Side Parlor</td>
</tr>
<tr>
<td>16 on a side</td>
<td>2</td>
<td>128</td>
<td>NA</td>
<td>96</td>
</tr>
<tr>
<td>32 on a side</td>
<td>4</td>
<td>256</td>
<td>NA</td>
<td>192</td>
</tr>
<tr>
<td>48 on a side</td>
<td>6</td>
<td>384</td>
<td>NA</td>
<td>288</td>
</tr>
<tr>
<td>60 rotary</td>
<td>3 - 4</td>
<td>NA</td>
<td>450</td>
<td>NA</td>
</tr>
<tr>
<td>80 rotary</td>
<td>3 - 4</td>
<td>NA</td>
<td>600</td>
<td>NA</td>
</tr>
</tbody>
</table>

* Pen size rounded to a multiple of parlor stall capacity
Components of a Large Dairy Farm System
Bunker Silo Feed Storage
Silage Pile Feed Storage
Silage Bag Feed Storage
Leachate Collection
Manure Storage
Manure Digester
Manure Solids
Dairy Farmstead Planning Numbers

- **Land**
  - **Site**
    - 1 hectare per 100-150 cows
  - **Cropland for feed**
    - 0.7 hectares/cow
  - **Manure Nutrients**
    - 0.4 - 0.6 hectares/cow based on N
    - 1.0 - 1.6 hectares/cow based on P
  - **Wisconsin Land Price**
    - Average $4,320/acre
    - Range $1700-$5400/acre

- **Water**
  - **Cows Drinking water**
    - 95 liters/cow
  - **Wastewater**
    - 27 liters/cow
  - **Total farmstead**
    - 114 liters/cow
    - 17 liters/liter milk produced
  - **Well flow rate**
    - 75 - 114 lpm preferred
  - **Plate cooler water**
    - 2-3 liters water per liter milk
    - Used to water cows and wash parlor

These estimates are based on USA experience and practices. 1 animal unit (AU) = 454 kg,
Assumes 1 cow = 636 kg = 1.4 AU
Dairy Farmstead Planning Numbers

- **Feed Storage (20% losses)**
  - Forage per cow per year
    - 5900 kg/cow-year
  - Grain per cow per year
    - 3300 kg/cow-year

- **Manure Storage**
  - 2-3 liter manure/waste per liter milk produced
  - 95 -114 liter per cow per day
  - 3.8 million liters per 100 cows per year

- **Labor**
  - 70-100 cows per FTE
  - FTE = 2500-3000 hours per year
  - 341,000-450,000 kg milk per FTE year

- **Energy Used**
  - 800 - 1200 kWh/cow-yr

- **Energy Generated from Biogas**
  - 3-7 kWh/cow-day
Facility Costs in Wisconsin

- Housing Cost
  ✓ $2,000-$3,000/ cow
- Milking Center Cost
  ✓ $20,000 - $25,000/ milking stall
  ✓ Double 16 parlor cost - $640,000 - $800,000
- Feed Storage
  ✓ $500/ cow
- Manure Storage
  ✓ $700/ cow
- Total Capital Cost
  $8,000-$10,000/Cow

- Calf Housing Cost
  ✓ $750/ calf
- Heifer Housing Cost
  ✓ $1,000 - $1,500/ animal
- Bio Gas Generation
  ✓ Plug Flow - $1100/cow
  ✓ Mixed Flow - $900/cow
- Sand Separation $125/cow
- Solid Separation $125/cow
- Freestall Bedding Cost
  ✓ Sand @ $11/ Mton
    ✓ 23 kg/cow-day = $.25/cow-day
  ✓ Wood Shavings @ $110/Mton
    ✓ 7 kg/cow-day = $.75/cow-day
  ✓ Biogas solids @ $33/Mton
    ✓ 10kg/cow-day = $.33/cow-day
Facility Design should:

- Allow the implementation of the management plan
- Allow the cow to express its genetic potential
- Provide:
  - Cow Comfort
    - Clean dry environment for cows
    - Adequate fresh air, feed, and water
- Be:
  - Labor efficient
  - Safe for both workers and cows
  - Environmentally friendly
- Produce:
  - Quality Food
  - Profitable Dairy Business
Goodbye!
Cow Barn and Parlor
22 acres
9 hectares

Feed Storage
8 acres
3 hectares

Manure Storage
12 acres
5 hectares

Manure Storage
16 acres
6 hectares

Total Area
160 acres
65 hectares