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Renovation Requirement for Dairy Cattle Barns and Two Renovation Models For Existing Dairy Barns in Bursa*

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Abstract: In this study, the needs for renovation of dairy cattle barns in Bursa, Turkey were discussed and selected two tie-stall barns were converted to free-stall barns. Renovation costs were calculated and compared with new barns in similar capacity and type. In dairy cattle farm number I and II, renovation costs for barns were calculated as $ 25.060 and $ 4.993 respectively . The overall renovation costs including milking facility were determined as $ 41.460 and $ 25.050 respectively. Renovation costs per cattle were $ 1.275 and $ 520 respectively. With the renovation working, housing conditions were improved; labor requirements and difficulties in labor using were decreased.

Key Words: Renovation, dairy cattle, barns

Süt Sığırı Ahırlarının Yenilenme Gereksinimi ve Bursa İlindeki İki İşletmeye İlişkin Yenileme Örneği**

Özet: Bu çalışmada Bursa ilindeki süt sığırı ahırlarının yenilenme gereksinimi tartışılmış ve seçilen iki adet bağlı duraklı ahır serbest duraklı ahıra dönüştürülmüştür. Yenileme maliyetleri hesaplanmış ve aynı tip ve kapasitedeki yeni inşa edilmiş bir ahırın maliyetiyle karşılaştırılmıştır. Ahır iyileştirme maliyeti I nolu işletmede 25.060 $, II nolu işletmede ise 4.993 $ olarak hesaplanmıştır. Sağım yeri de dahil toplam iyileştirme maliyeti ise I nolu işletme için 41.460 $ ve II nolu işletme için 25.050 $ bulunmuştur. Sığır başına iyileştirme maliyeti ise sırasıyla 1.275 $ ve 520 $ hesaplanmıştır. Yenileme çalışması ile ineklerin barınma ortamı iyileştirilmiş, işçilik kolaylaştırılmış, işgücü gereksinimi azaltılmıştır.

Anahtar Kelimeler: Yenileme, süt sığırı, barınak

Introduction

Keeping heifers and dairy cows in uninsulated loose housing cowsheds is spreading in the cold regions of the world. It has been determined that keeping cattle in cold cowsheds is

* It was summarized from Ph.D. thesis.
** Doktora tezinden özetlenmiştir.

possible and useful even when outdoor temperatures fall as low as -34 ºC (Pajumägi et al. 2007).

In Turkey, dairy cattle barns are generally constructed as family farms in the villages. In the village centers, which have traditional collective settlement characteristics, farmstead center is small and cattle houses are generally closed tie-stall barns. Number of cattle's is too low and barns sizes are not suitable for modern dairy technology.

Recent developments in dairy cattle housing made necessary to barn size increase and modernization. But, costs and difficulties in construction of new buildings are preventing from farmer to construct new buildings.

Bursa plays an important role in Turkey's dairy cattle production. Dairy farms in Bursa have been in a transition phase to adapt modern dairy technologies, improve labor efficiency and increase in size and scale.

Most dairy producers in Turkey have tendency to converting their tie-stall barns to free-stall barns because of various reasons such as labor efficiency, providing comfortable environmental conditions for animals. Also, it has been recognized that it is imperative to reduce production costs and increase competitive power. Agricultural reforms in European Union (EU) countries didn't provide the increase in farm income. Decreasing product prices have lead EU producers to increase their farm size and scale to maintain sustainable production in current price circumstances (Pahmeyer, 1992). Essential investments in a dairy farm must be directed to efficient labor use and improved animal environment (Pahmeyer, 1992; Damm, 1994). The efficient use of old buildings significantly reduces the investment requirements for new buildings (Hilty et al., 2002).

New buildings may require an investment outlay of $ 3075 to 5000 per animal, while the renovations require expenditures of $ 575 to 2885 per animal (Brehme and Laufeld, 2001).

Bewley et al. (2001) surveyed 244 dairy cattle farms. They reported that cost per stall for remodeled free-stall barns was less than new and remodeled or new only barns ($ 534 vs. $ 980, and $ 1107; respectively).

Dairy managers must carefully evaluate existing alternatives and must select an optimal strategy (Pereira et al., 2003). Before the renovation process, existing buildings should be evaluated. Buildings must have appropriate characteristics for renovation. Therefore, prior to renovation decision, it should be determined that problems related to the facilities can be handled with renovation.

In this study, it was aimed to find some solutions for the modernization of existing dairy cattle farms in Bursa, in Turkey. To achieve this goal, two tie-stall barns selected within investigated dairy farms in Bursa region of Turkey were converted to free-stall barns. Renovation costs were calculated and compared with new barns in similar capacity and type.

Material and Methods

The study was carried out in Bursa, located on 40°15′29″ N, and 28°53′39″ E, and about 100 m above sea level (Figure 1). The local climate is temperate, summers are hot and dry, and winters are mild and rainy. According to long term meteorological data (1929-

1991), mean rainfall, temperature, and relative humidity are 696 mm, 14.6°C, and 69 %, respectively (Anonymous, 1992).

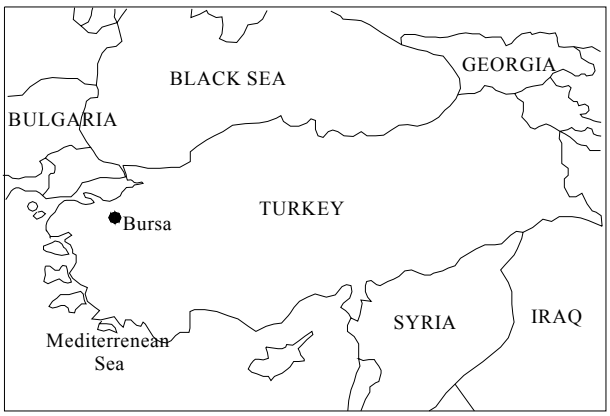

Figure 1. Study Area

In study scope, 59 dairy farms in Bursa were surveyed. Of those 59 dairy farms 33 are members of The Cattle Breeders' Association of Turkey. Two dairy farms (I and II) with 29 and 41 dairy cows were selected as study materials. In the selection of dairy farms, criteria such as farmstead layout, farmers tendency, suitability for expansion, farmstead location and distance from neighbor farms, access to major highways, manure management and access to utilities were taken into consideration.

The present values of assets were calculated with the following equation in combination with Table 1 (Chamber, 1998).

$$V_p = I_c.(1-f)^k$$

Where, V_p is the present value of an asset, I_c is the initial cost of the asset, f is the depreciation rate (2/the useful life of the asset from Table 1), and k is the age of the asset.

Table 1. Guidelines for Estimating an Asset's Useful Life (Chamber, 1998)

Type of Asset	Estimated Useful Life (in years)
Farm Buildings	20
Silos, Grain Storage	20
Barn Equipment	7
Milking Equipment	10
Other Assets	10

Detailed existing and future farmstead plans were prepared. Renovation costs for the selected options were calculated based on prices in the year 2004. Calculated renovation costs were compared to Yaslioglu's (2004) findings for same year and similar capacities.

A very important welfare factor is air distribution within the cowshed (Pajumägi et al. 2007). According to ASAE (1995), the primary definition of a ventilation system is a system for providing a desired amount of fresh air, without drafts, to all parts of the shelter. Therefore, ventilation capacities of investigated barns were analyzed.

Ventilation requirements were calculated using VENTGRAPH software package (Albright, 1990).

The speed of the air movement of the ridge outlet was studied by many scientists (Bruce, 1973, 1977; Daly, 1978; Sainsbury and Sainsbury, 1979; ASHRAE, 1981). They suggested calculating the speed of the air movement ν, $m.s^{-1}$, in the ridge outlet according to the following formula:

$$v = D.\ (H.\Delta T)^{0.5}$$

By the data of various authors, the meaning of the D coefficient is different: from 0.026 (ASHRAE, 1981) to 0.17 (Bruce, 1973).

Therefore, existing ventilation capacities were calculated using the following equation:

$$Q = 0.17.\ A_e.(H.\Delta T)^{0.5}$$

Where, Q is the ventilation capacity (m^3s^{-1}), A_e is the efficient ventilation area, H is the elevation differences between air inlet and outlet, ΔT is the temperature differences between indoor and outdoor.

Results and Discussion

Some characteristics of two operations before and after renovation were summarized in Table 2.

Table 2. Some characteristics of operation before and after renovation

Operation	BT	BC	BW (m)	BL (m)	SH (m)	RH (m)	SAW (m)	FAW (m)	VC (m^3h^{-1})
Operation I									
BR	TS	29	9.20	18.90	3.25	5.30	1.80	1.00	2740
AR	FS	33	16.15	22.25	3.90	7.45	3.00	3.00	20798
Operation II									
BR	TS	41	10.30	32.05	3.30	4.80	1.30	2.50	16453
AR	FS	48	10.30	32.05	3.30	4.80	2.50	3.00	17361

BT: Barn type; BC: Barn capacity; BW: Barn width; BL: Barn length; SH: Sidewall height; RH: Ridge height; SAW: Service alley width; FAW: Feed alley width; VC: Ventilation capacity; BR: Before renovation; AR: After renovation, TS: Tiestall; FS: Freestall.

Operation I

Operation I, a tie-stall barn with 29 dairy cattle, was established in 2000. Investment cost for this operation was $ 14903 in 2000 year and present value of farm was calculated as $ 10865. Total farmstead area is 0.47 ha.

Barn construction and structure materials were suitable for renovation. However, some barn components and equipments consequently barn sizes must be renovated.

Barn width, barn height and total windows area were insufficient windows were served as air inlet openings and its height was 2.35 m from the ground. Total windows area was 6,0 m^2 and window / floor area ratio as a natural lighting criterion was 5 %. Three chimneys with 0.60x0.40 m sizes located on the ridge were serving as air outlets. Ventilation capacity (2740 m^3h^{-1}) was lower than the minimum ventilation requirement (4644 m^3h^{-1}).

Feeding type and feed alley width (1.00 m) was not suitable for mechanical feed delivery equipment (Figure 2). Wheelbarrow was used for feed delivery. Manure was removed from the barn manually. Excessive labor use and hard working conditions were the most important problems. Time consumed for feed delivery, manure hauling and milking was two, two-half and three hours per day, respectively. Milking was performed two times per day with bucket milking systems. Figure 2. Existed Farmstead Layout for Enterprise I.

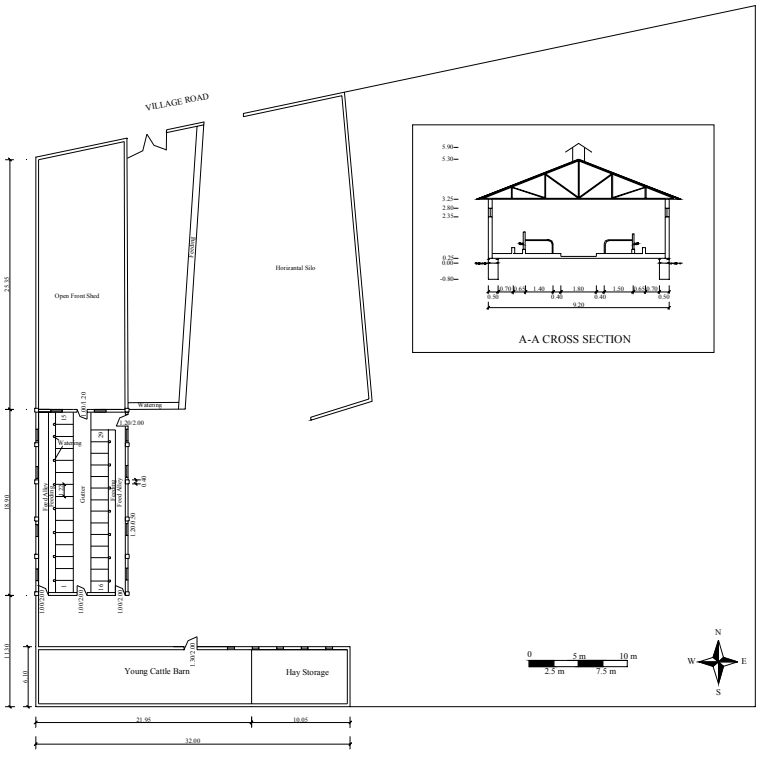

Figure 2. Existed Farmstead Layout for Enterprise I

There was no silo for silage storage. Silage was stored on the ground with covering materials. Similarly, manure was stored on the ground in a solid form.

There was no treatment and maternity pen. There was a barn with 5.50x21.35 m dimensions for young cattles.

According to the survey, it was determined that cow's udders were suffered from foot stroke and one cow was dead in 2001 due to strangulation caused by tying chain press.

To provide a better indoor environment, efficient labor use and hygienic milking operation, existing tie-stall barn converted to two-row free-stall barn with 33 dairy cattle, which is suitable for adaptation of new technologies (Figure 3).

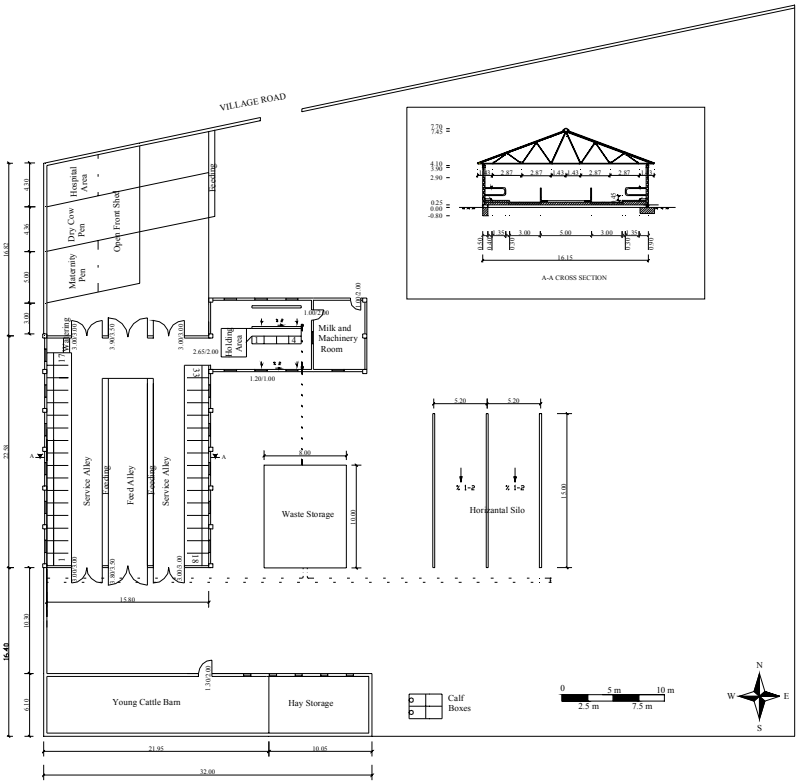

Figure 3. Renovated Farmstead Layout for Operation I

West wall of the barn was a borderline. So, whole wall of the barn except on the west side was demolished. Thus, barn width is increased from 9.20 m to 16.15 m. Barn was extended to north; therefore barn length was increased from 18.90 m to 22.25 m. To increase the natural ventilation efficiency, continuous ridge opening with 0.30 m width and continuous eave opening with 0.15 m height were designed according to Bickert and

Stowell, 1993. Sidewall and ridge height were changed to 3.90 m and 7.45 m, respectively. Thus, ventilation capacity was increased from 2740 m^3h^{-1} to 20798 m^3h^{-1}, which was higher than the minimum ventilation requirement (6050 m^3h^{-1}).

To provide sufficient lighting in remodeled design, total windows area was increased to 15.6 m^2. Distance between ground surface and bottom of the windows was also increased to 2.90 m.

To allow mechanical equipment use, feed and service alley widths are designed as a 3.80 m and 3.00 m, respectively.

Open front shed area was designed as 9.25x13.35x4.00 m. Pens for dry cows, sick animals and maternity were provided in open front shed.

Annual silage needs were calculated and silo capacity was determined based on annual silage requirements. According to the Anonymous (1997) two horizontal silos with 5.00x15.00x2.75 m were designed and located on suitable places in a farmstead.

According to the Bird and Munroe (1996) and Anonymous (1997) 8.00x10.00x2.75 m subsurface storage structure was planned for liquid manure storage.

Replacement barn and adjacent hay storage structure were not modified. Considering parturition would be extended throughout the year, it is determined that two calf boxes would be sufficient.

To provide hygienic milking conditions with ease, individual milking center with 1x4 parallel systems were designed. In the holding area 1.74 m^2 per cattle was provided.

In operation I, renovation cost for cattle barn was calculated as $ 25060 and total renovation cost including milking facility was $ 41460 (Table 3). Renovation cost per cattle is found to be $ 1275.

Operation II

Operation II was established in 1994. Barn type used in this operation was a 41-head tie-stall dairy barn (Figure 4). Farmstead area is 0.78 ha and there is a sufficient room for expansion.

Barn width, ridge height and total windows area were 10.30 m, 4.80 m and 16.32 m^2, respectively. Windows were serving as air inlet openings and the distance from the ground to the bottom of windows was 2.30 m. Total window / floor area ratio as a natural lighting criterion was 5 %. Continuous ridge opening with 0.30 m width were serving as air outlet. Ventilation capacity was calculated and it seemed to be sufficient. In winter, the barn windows closed by farmer for fear the cold weather would have an adverse effect on cattle.

Feed through and feed alleys were located in center of the barn. Feed alley width was 2.50 m. Feeding type is inappropriate for mechanical feed delivery. Position of the feed alley and use of bucket milking system made milking and manure hauling difficult and time consuming. The survey concluded that milking was performed two times per day and total time spending for milking, manure hauling and feed delivery were three hours, two hours and two hours, respectively. Calves and mature animals were sheltered in the same barn. There was no manure storage structure. Manure was stored on the ground in solid form.

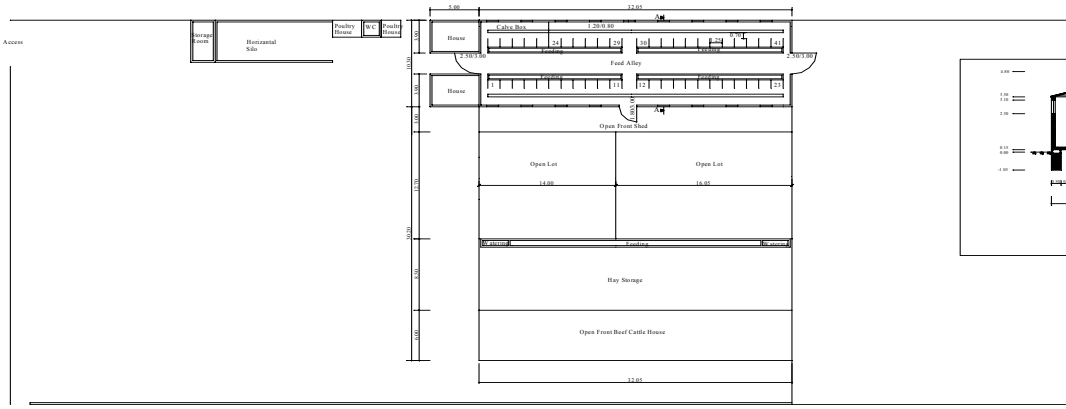

Figure 4. Existed Farmstead Layout for Operation II

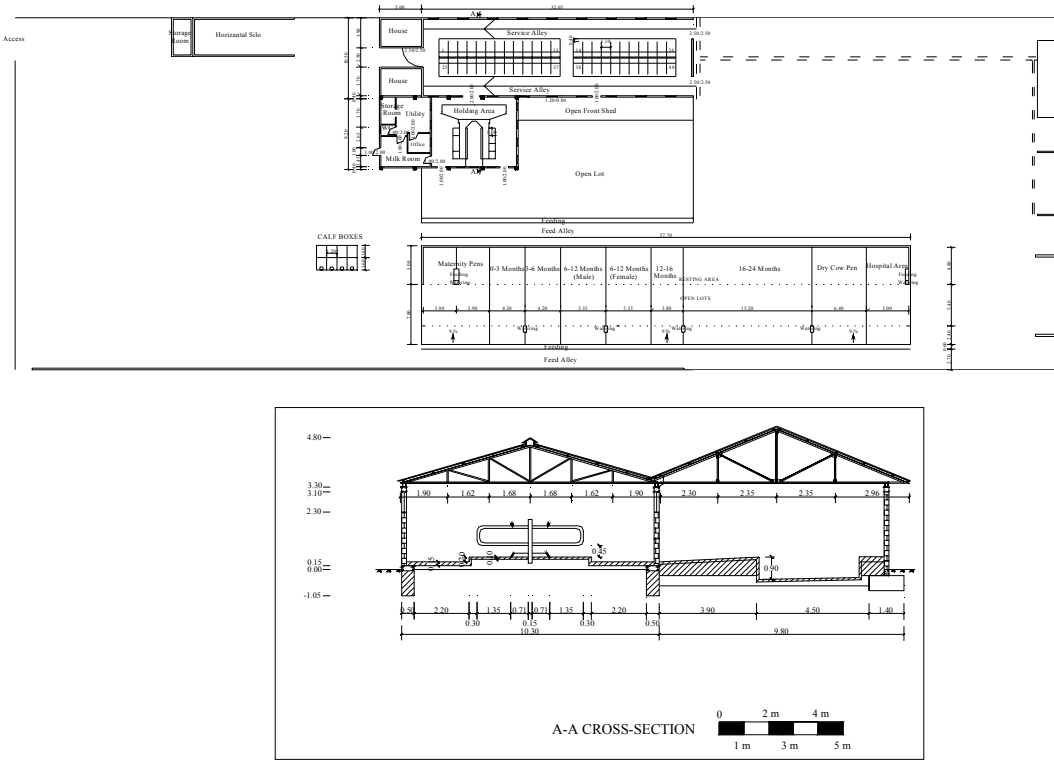

Figure 5. Renovated Farmstead Layout for Operation II

The producer managed tie-stall barn as free-stall barn with no structural arrangement. The producer pointed out that health and productivity of the cows were positively affected from this management change. However, some difficulties in performing daily works such as manure hauling, feed delivery and milking operations were observed. Therefore, existing two-row tie-stall barn with 41 dairy cattle was converted to two-row, face-to-face, free-stall barn with 48 dairy cattle capacity (Figure 5). In the new plan, feed through is placed at exercise yard.

Sidewall and ridge heights were not changed, and wall and roof system were not modified to keep the modification costs minimum. Since the existing ridge opening (0.30 m) was sufficient according to Bickert and Stowell(1993), it was not modified. Required total air inlet area was calculated based on existing total air outlet area. Vasisdas type windows were designed to prevent from direct contact of incoming air with cattles. Ventilation capacity for winter was computed as 17361 m^3h^{-1} for the design conditions. Minimum ventilation capacity was calculated as 12564 m^3h^{-1}.

Feed and manure alley widths are 3.00 m and 2.50 m, respectively. Manure hauling will be performed with automatic scraper. Existing horizontal silos with 5.00x12.00x2.00 m size was not removed, but poultry house and restroom adjacent to horizontal silo were removed.

In the new design, restroom was relocated in milking center. When compared to calculated annual silage requirements existing silo capacity was inadequate. Therefore, according to the Anonymous (1997) additional silage storage with 8.00x22.50x2.50 m size was planned and located near by the liquid manure storage so that leakage water from silage could be easily store in the liquid manure storage. The silo was constructed with 1 % base slope.

Liquid manure storage with 10.00x10.00x3.00 m size was designed considering four-month storage period (Bird and Munroe, 1996, Anonymous 1997). A solid waste storage with 10.00x15.00x3.00 m size was also designed for a 6-month storage period.

An open front shed with 5.00x57.70 m dimension for sick animals, dry cows and young cattle was designed. Since the prevailing wind direction was north, the open front shed was oriented to E-W direction.

Since the parturition would be extended throughout the year, it is determined that four calf boxes were adequate. Weaning calves will be kept in these boxes for two weeks period.

To provide easier and hygienic milking operation, 2x4 parallel milking system was designed. Thus, total milking time was reduced from 3 hours to 2 hours. In the holding area stocking rate of 1.6 m^2 per cow was provided (Anonymous, 1997).

Renovation cost for cattle barn was calculated as $ 4993 and total renovation cost including milking facility was $ 25050. Renovation cost per cattle was found to be $ 520.

Conlusions

Performed renovation studies in selected two (I and II) dairy cattle farms provide easy and fast manure hauling, milking and feed delivery. Appropriate indoor environment conditions for animals was also provided through modification in ventilation systems.

Renovation costs per cattle for operation I and II were estimated as $ 1275 and US$ 520, respectively. These findings are in agreement with Brehme and Laufeld's (2001) findings ($ 575 to 2885/animal place).

Yaslioglu (2004) has designed two free-stall barns with 20 and 50 dairy cattle for the same (Bursa, Turkey) region and estimated the construction costs per cattle for these barns as $ 2875 and US$ 2100, respectively. Renovation costs for remodeled barns were relatively lower than new one, which had similar capacity. Proportion of renovation costs to new barn construction costs are 0.44 for operation I, and 0.25 for operation II which are below to 0.5 (Chamber, 1998; Bodman and Shelton, 1996). This ratio was found as 0.48 in Wisconsin (Bewley et al., 2001) and 0.20-0.58 in Germany (Brehme and Laufeld, 2001).

Recent developments in dairy sector have lead producers to increase their farm size and scale to maintain sustainable production in current competition conditions.

According to our results renovation found to be one of the most important alternatives for the modernization and extension of existing dairy facilities in developing countries such as Turkey. Proportions of renovation costs to new barn construction costs are found to be as 0.25-0.44.

In brief, one can be said that renovation is an attractive alternative for the modernization of dairy farms in developing countries. But, existing buildings must have appropriate characteristics for renovation and problems related to the facilities can be handled with renovation.

References

Albright, L. D. 1990. Environment Control for Animals and Plants. ASABE Textbook, Technical Publications, St. Joseph, Michigan. 453 pp.

Anonymous. 1992. Meteorological Bulletin (in Turkish). General Directorate of State Meteorology Works, Prime Ministry Press, Ankara, p. 111-112.

Anonymous. 1997. Dairy Free-stall Housing and Equipment. Midwest Plan Service, MWPS-7, Iowa State University, Ames, Iowa, 136 pp.

ASAE. 1995. Design of Ventilation Systems for Poultry and Livestock Shelters. ASAE Standards (ASAE EP270.5), American Society of Agricultural Engineers, St. Joseph, MI. p: 495-512.

ASHRAE, 1981. ASHRAE Handbook of fundamentals, 1981. Atlanta, GA, USA.

Bewley, J., R. W. Palmer and D. B. Jackson-Smith. 2001. A Comparison of Free-Stall Barns Used by Modernized Wisconsin Dairies, Journal of Dairy Science, Vol. 84: 528-541.

Bickert, W. G. and R. R. Stowell. 1993. Design and Operation of Natural Ventilation Systems in Dairy Free Stall Barns. Livestock Environment IV, Fourth International Symposium, p: 970-977, July 1993, University of Warwick, Coventry, England.

Bird, N. A. ve J. A. Munroe. 1996. Manure Handling from Barn to Storage for Beef and Dairy Cattle. Canada Plan Service, M-10702, Canada. 8 p.

Bodman, R.G. and D. P. Shelton. 1996. Existing Buildings-Remodel or Abandon. (G86-825, Nebraska Cooperative Extension) University of Nebraska, 105 Ag Building, Bulletin Distribution, Lincoln, NB 68583-0918.

Brehme, U. and P. Laufeld. 2001. Suggestions of Reconstruction and Modernization from Large Stables in East Germany Dairy Farms. Proceedings of Agribuilding 2001, CIGR Congress, 31.08.-10.09.2001, Campinas, Brazil.

Bruce, J.M. 1973. Natural Ventilation by Stack Effect. Farm Building Progress, CI/SIB: 2604, Vol:17, pp 23-28.

Bruce, J.M. 1977. Natural Ventilation - Its Role and Application in the Bio-Climate System. Farm Build. R. & D. Stud. 8, p. 1–8.

Chamber, R. 1998. Planning the Livestock Farmstead for Expansion. Ontario Factsheet AGDEX711 Ministry of Agriculture, Food and Rural Affairs, Guelph, Ontario, 3 pp.

Daly, B.B. 1978. Woods Practical Guides to Fan Engineers. Woods of Colchester, 47 pp.

Damm, T. 1994. Umbau von Altgebäuden für die Tierhaltung. Eugen Ulmer GmbH & Co. Wollgrasweg 41, 70599 Stuttgart, 143 pp.

Hilty, R., R. Kauffmann and L. V. Caenegem. 2002. Building for Cattle Husbandry. Agricultural Engineering Year Book, Chapter 13, Farm Building, Landwirtschaftsverlag GmbH, Münster, p. 163-170.

Pahmeyer, L. 1992. Hat der landwirtschaftliche Betrieb in Zukunft noch eine Chance? Auswirkungen der EG-Agrarreform. Landwirtschaftskammer Westfalen-Lippe, Münster.

Pajumägi, A., I. Veermäe, J. Praks, V. Poikalainen and J. Miljan. 2007. Spatial Microclimate Patterns in Reconstructed and New Large Uninsulated Loose Housing Cowsheds, Building and Environment, Vol. 42: 113-121.

Pereira, J.M., C. J. Alvarez and M. Barrasa. 2003. Prediction of Dairy Housing Construction Costs, Journal of Dairy Science, Vol. 86: 3536-3541.

Sainsbury, D. W. B. and P. Sainsbury. 1979. Livestock health and housing. 2nd ed. Bailliere Tindall, London, UK.

Yaslioglu, E. 2004. A Research on Development of Appropriate Cold Dairy Barn Models to Dairy Cattle Production in Bursa Region (in Turkish). Unpublished Ph.D. dissertation, Uludag University, Dept. of Agricultural Structures and Irrigation, Bursa, Turkey, 173 pp.