Gestation

Meeting the nutrient demands of both the gestating sow and developing fetus can be achieved in many different ways. This factsheet will focus on energy, amino acid, and vitamin and mineral considerations for a gestating sow nutritional program.

Energy

Determining Energy Requirement

Energy requirements for gestating sows include maintenance, maternal growth including protein and fat deposition, conceptus (fetus + placenta and fluids + uterus), and mammary tissue (NRC, 2012). Dietary energy for maternal maintenance, conceptus products, and mammary gland development is prioritized and, if excess energy is available, partitioned for maternal gain (NRC, 2012; Figure 1).

The gestating sow basal maintenance requirement (kcal/d) can be expressed as $100 \times BW^{0.75}$ where BW is body weight in kg (NRC, 2012). Thus, with increasing bodyweight, maintenance energy requirements increase. Environmental conditions such as temperature influence maintenance energy requirements (NRC, 2012). Because gestating sows are restrictively fed to control weight gain, body heat production is low. However, at temperatures below 68°F, for every 1° decrease in temperature, feed allowances should be increased by 0.05 lb.

Setting Feed Allowances

Feed allowances must be adjusted based on BW to meet maternal maintenance and conceptus energy requirements. Once those requirements are met, any extra energy will be directed towards gain. Gilts require less energy for maintenance and more for gain as they have not yet reached mature body weight. Older parity sows' maintenance requirement increases with increasing bodyweight, but less energy is required for gain (Figures 2 and 3). To establish the proper feed allowance for gestating sows, an objective measure should be used to maintain sows in proper body condition. Sows should be identified as thin, ideal, or over conditioned. Feed allowance should then be adjusted accordingly. Variation in feed drop accuracy can occur based on different types of feed drops, bulk density of the diet and how they are mounted on feed lines (Schneider et al., 2008). Thus, the feeding system should be calibrated for accurate daily feed delivery.

Energy Requirements in Late Gestation

Fetal development changes dramatically during the gestation period. In early to mid-gestation, energy is primarily used for maternal maintenance and protein deposition. At approximately d 70 of gestation, energy retention is shifted more towards the growing demands for conceptus development (McPherson et al., 2004). Mammary development accelerates at approximately d 80 of gestation further shifting energy retention away from maternal growth (Kim et al., 2013). Feeding additional energy and amino acids through increasing feed allowances has been a common practice to meet the shifting late term gestating sow energy demands in an attempt to increase birth weight. While research data indicates increasing feed allowances will increase sow weight gain and backfat depth, the impact on birth weight is modest with negative impacts on lactation feed intake and stillbirth rate. Therefore, providing extra feed during late gestation does not appear to be necessary and in many instances not economically justified.

Fiber

Restricting feed intake can potentially lead to aggressive behaviors due to unfulfilled feeding motivation and satiety (Meunier-Salaün et al., 2001). Feeding dietary fiber can increase satiety and reduce aggressive behaviors, but the influence on reproductive performance is inconclusive at this time (McGlone and Fullwood, 2001; Holt et al., 2006). However, providing fiber in a restricted-fed gestation diet shows no evidence for negative effects on reproductive performance (Wilson et al., 2003; Holt et al., 2006; Guillemet et al., 2007).

When feeding fiber in gestating sow diets, some considerations exist. First, the energy value of the fibrous ingredient should be accurately estimated. The net energy and bulk density of most fibrous ingredients is lower than corn. Because fibrous ingredients lower the energy density and increase the bulkiness, feed allowances must be increased. The increase in feed allowance potentially could offset a lower diet cost. Volumetric feed delivery should be adjusted as diet bulk density can affect the amount of feed being delivered. Finally, pelleting diets can negate dietary fiber benefits on satiety during restricted feed intake as it can improve the digestibility of nutrients (De Vries et al., 2012).

The economic value of higher fiber ingredients is generally greater in gestation diets as it can potentially lower diet costs and has no evidence for a negative impact on reproductive performance.

Amino Acids

Determining AA Requirements

Time- and energy-dependent maternal protein deposition for weight gain are the tissue pools that require the greatest amount of amino acids (Figure 4). Time-dependent protein deposition for maternal gain is greatest in the early part of gestation and this best represents the time that body protein reserves can be replenished from losses during lactation. Energy-dependent maternal protein deposition represents the relationship between energy intake and protein deposition. This type of maternal protein deposition can vary with parity as gilts will deposit more protein with increased energy intake as they have yet to reach mature body weight. This relationship will essentially be 0 in parity 4+ sows (Dourmad, 2008). Furthermore, fetal and mammary tissue growth are the next greatest need for amino acids. Amino acid requirements for these tissues begin to increase from d 60 until the end of gestation.

AA Requirements

Daily amino acid requirements can be calculated from these determinants and should be expressed on a g/d basis. From the desired feed allowances in gestation, amino acid levels can be set in diet formulation to meet the g/day requirement.

Limited research has focused on gestating sow amino acid nutrition. From this limited research, lysine has been the most extensively evaluated amino acid. The lysine requirement of gestating sows changes based on parity and stage of gestation. Gilts and younger parity sows will have greater lysine needs to support maternal gain to achieve mature weight but this requirement decreases with older parity sows (Samuel et al., 2012). Furthermore, the lysine requirement increases from early to late gestation and this change is due to the demands required for fetal growth and mammary development. Providing increased dietary lysine in late gestation has the potential to positively influence sow performance and pig birth weight. From this data, it is recommended that gestating gilts and sows receive 11 to 13 g/d of SID lysine (Goncalves et al., 2016; Thomas et al., 2018).

After lysine levels are set, other amino acids relative to lysine can be calculated. Compared to lysine, limited research exists on other amino acid requirements and these recommendations are mostly based on modeling of amino acid use (Leveseque et al., 2011; Franco et al., 2014).

Because research has shown that amino acid requirements increase in late gestation, the concepts of phase-feeding and parity-segregated feeding have been proposed (Moehn and Ball, 2013). These concepts require the blending of 2 diets or increased movement of animals within the gestation barn to segregate by parity. Due to facility and logistical constraints, this can be difficult to implement. Therefore, most production systems will provide a single diet throughout gestation. (Table 1).

Vitamins and Minerals

Ca and P

The phosphorous requirement for gestating sows is determined by requirements for maternal maintenance to replace minimum urinary and basal endogenous losses, maternal phosphorous retention for growth, and development of the conceptus and mammary glands (Bikker and Blok, 2017). Similar to energy and amino acids, the phosphorous requirement for gestating sows increase in late gestation to meet the demands for conceptus development and growth (Mahan et al., 2009). Parity can also dictate the phosphorous requirement as gilts and younger parity sows will require greater amounts of phosphorous on a daily basis to support growth as they have not yet reached mature bodyweight. Older parity sows will require less phosphorous to maintain bodyweight and body reserves. Calcium requirements increase in a similar manner as phosphorous in late gestation to support fetal development (Mahan et al., 2009). The relationship between calcium and phosphorous must be considered as both minerals are essential for development of the skeletal system, but excessive dietary Ca can inhibit P retention and absorption in the body (Létourneau-Montminy et al., 2012). Limited data exists on the calcium and phosphorous requirements for gestating sows. Research has shown that low calcium and phosphorous intake can result in lameness, while providing increased amounts of calcium and phosphorous has no effect on reproductive performance or structural soundness (Giesemann et al., 1998; Tan et al., 2016). It is recommended that gestating gilts and sows be provided 11.3 g/d of STTD phosphorous and 14.3 g/d of STTD calcium. These recommendations are above NRC (2012) levels to provide a margin of safety. Furthermore, the use of phytase in gestating sow diets can improve the digestibility and retention of calcium and phosphorus (Lee et al., 2018). Therefore, phytase is recommended for use in gestating sow diets. Calcium and phosphorous release values should be applied in diet formulation when using phytase.

Trace Minerals

Because of variability in concentrations as well as bio-availability, copper, zinc, iron, iodine, manganese, chromium, and selenium are typically supplemented to gestation and lactation diets. Increased supplementation above these recommended levels and effect on reproductive performance is inconclusive and not recommended (Chen et al., 2016; Van Riet et al., 2018). Furthermore, organic sources of trace minerals in gestating sows have been researched, but results are inconclusive versus inorganic sources (Peters and Mahan, 2008; Bradley, 2010; Novais et al., 2016).

Vitamins

A standard practice is to provide additional vitamins that are not included in growing pig diets which include biotin, folic acid, pyridoxine and choline. Also carnitine, a vitamin like compound, is often included. In the KSU sow add pack, vitamin A and E are also provided to achieve higher levels than required by growing pigs. Providing these extra vitamins can be achieved by using a sow add pack or separate vitamin premix designed for sows only.

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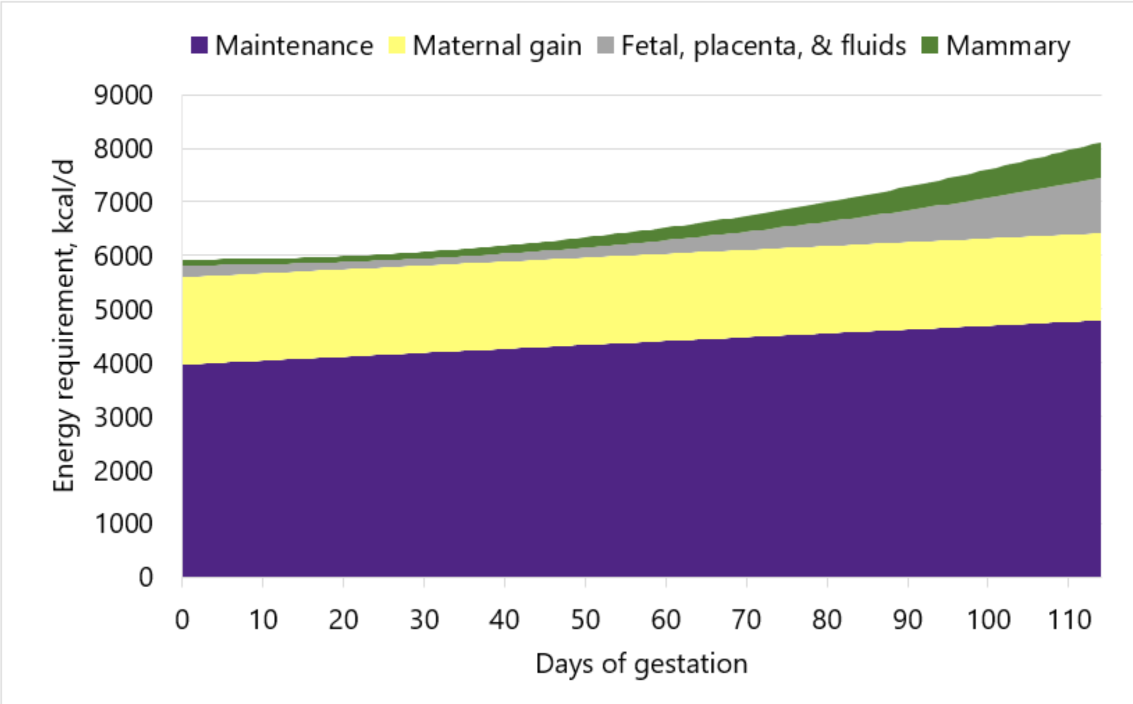

Figure 1. Energy needs of gilts during gestation based different body tissues (Adapted from NRC, 2012).

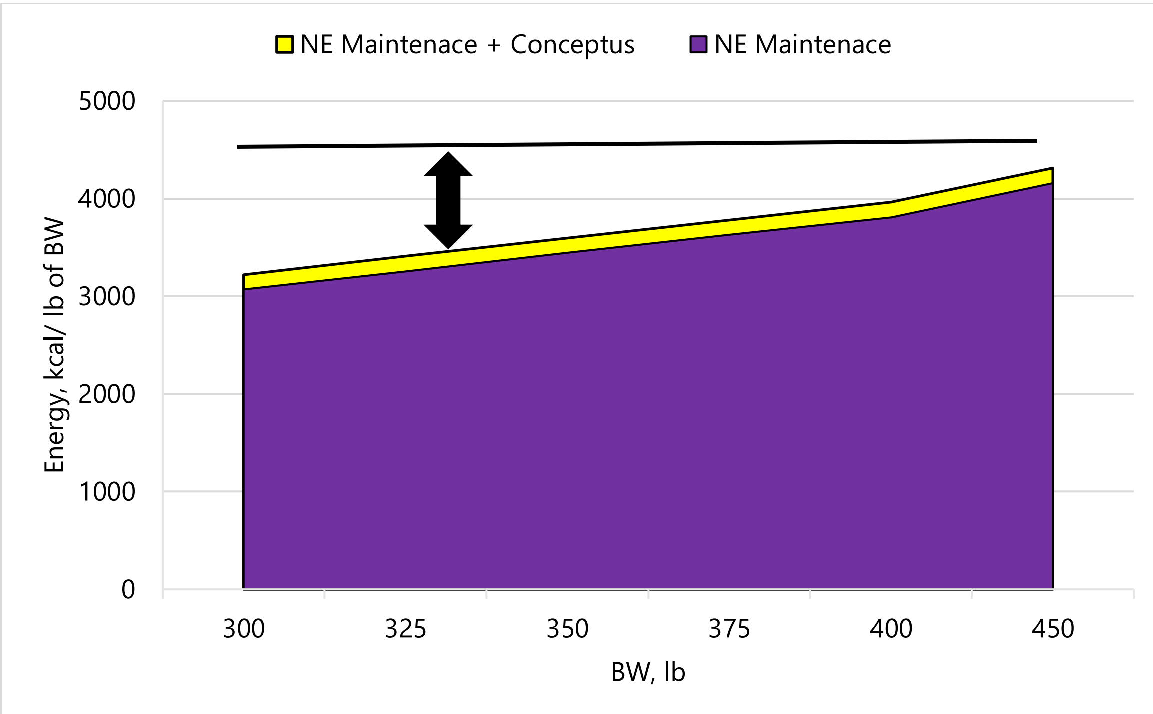

Figure 2. Estimated maintenance and maintenance plus conceptus energy (NE) requirements for gilts based on BW. Bold line indicates energy provided from a 4 lb feed allowance of a corn-soybean meal diet containing 1,123 kcal of NE/lb. Arrow indicates energy remaining that is available for maternal gain.

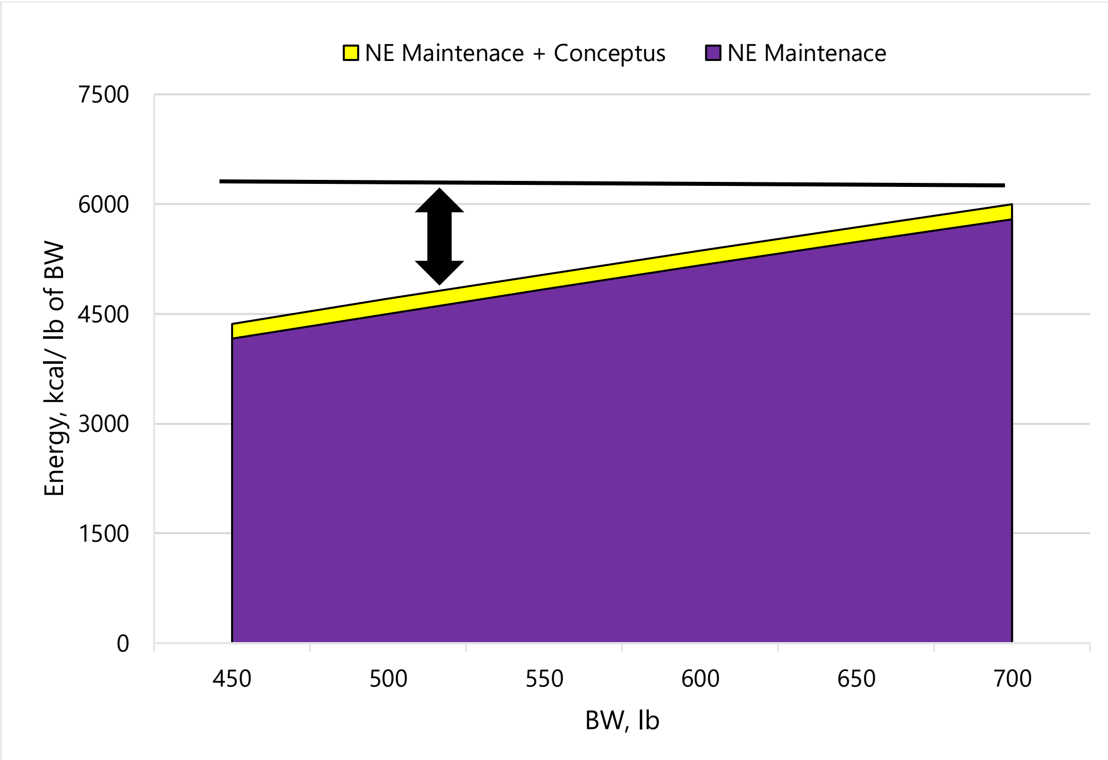

Figure 3. Estimated maintenance and maintenance plus conceptus energy (NE) requirements for parity 1+ sows based on BW. Bold line indicates energy provided from a 5.5 lb feed allowance of a corn-soybean meal diet containing 1,123 kcal of NE/lb. Arrow indicates energy remaining that is available for maternal gain.

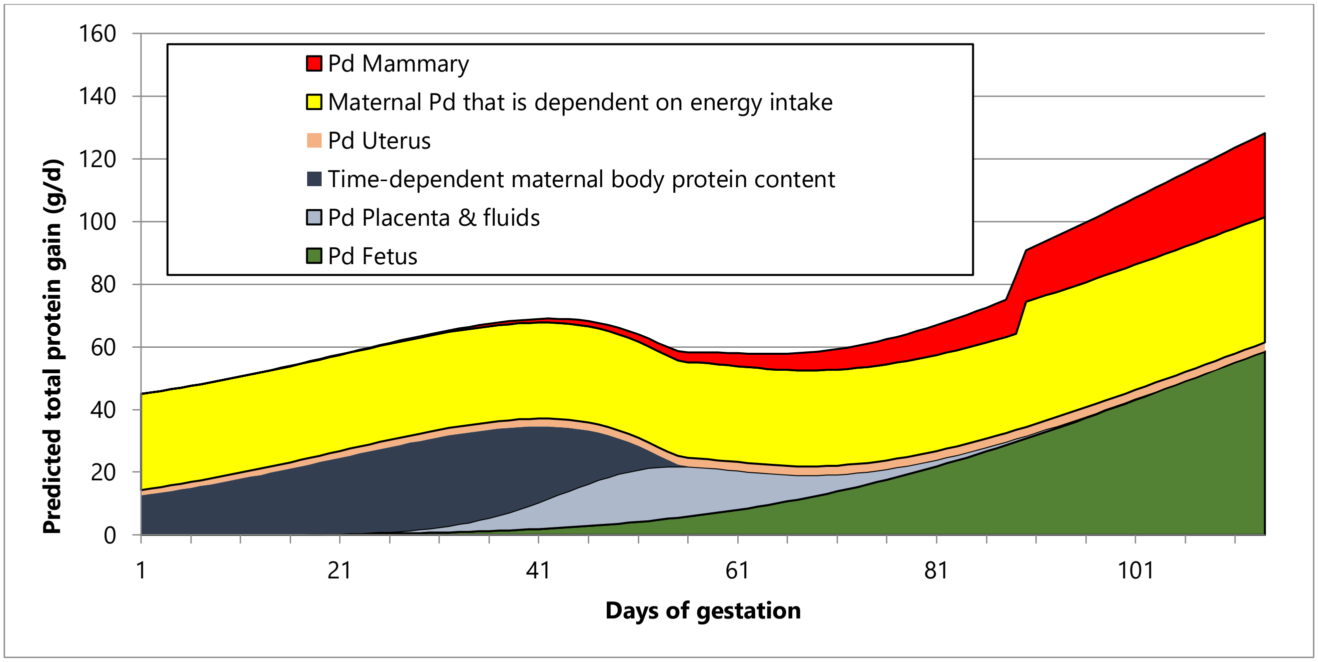

Figure 4. Predicted total protein gain (Pd: g/d) of second parity sows during gestation (Adapted from NRC, 2012).

Table 1. Dietary recommendations for gestating sows

SID amino acids[1]	
Lysine, %[2]	0.60
SID amino acid to lysine ratio, %[3]	
Methionine	28-29
Methionine + Cysteine	68-70
Threonine	74-76
Tryptophan	19-21
Isoleucine	58
Valine	71-76
Total calcium, %[4]	0.80
Available phosphorous, %	0.48
STTD phosphorus , %	0.50
STTD calcium, %	0.59
Ca:STTD P	1.60
STTD Ca:STTD P	1.26
Vitamins[5]	
Vit A, IU/ton	10,000,000
Vit D, IU/ton	1,500,000
Vit E, IU/ton	60,000
Vit K (menadione), mg/ton	3,000
Vit B12, mg/ton	30
Niacin, mg/ton	45,000
Pantothenic Acid, mg/ton	25,000
Riboflavin, mg/ton	7,500
Biotin, mg/ton	200
Folic acid, mg/ton	2,000
Pyridoxine, mg/ton	900
Choline, mg/ton	500,000
Carnitine, mg/ton	45,000
Trace Minerals[5]	
Zinc, ppm	110
Iron, ppm	110
Manganese, ppm	33
Copper, ppm	17
Iodine, ppm	0.30
Selenium, ppm	0.30
Chromium, ppb	198

1Minimum levels based on NRC (2012) ingredient loading values; SID = Standardized ileal digestible.
2Minimum lysine level in a diet with 1,123 kcal NE/lb. Lysine level based on 5 lb feed allowance to provide 13.6 g of lys/d.
3Data on amino acid requirements for contemporary sows is limited.

[4]Ca and P recommendations for gestating sows based on a 1,123 kcal of NE/lb diet.
[5]Added levels based on KSU vitamin, sow add pack, and trace mineral premixes.